World Congress
on Industrial Biotechnology

San Diego, CA

APRIL 17–20, 2016

Program eBook

Biotechnology Innovation Organization

REGISTER TODAY: WWW.BIO.ORG/WC2016

2016 World Congress Plenary Program
As of March 16, 2016

Monday, April 18
Luncheon Plenary, 12:00 pm – 2:15 pm

Outer Space: The Next Biotech Frontier & George Washington Carver Award Presentation

Plenary sponsored by: POET HUMAN + NATURE

Award sponsored by: IOWA BIO.org

Our session's highly esteemed panelists will discuss one of biotech's most promising areas of growth: applications in space. Topics will include bacteria growth experiments, examining the ways in which micro-organisms develop differently in space, exploring the potential markets for space biotechnology from enzyme expression to crop and food development.

Moderator
John Cumbers, Founder, SynBioBeta

Panelists
Catherine "Cady" Coleman, Astronaut, National Aeronautics and Space Administration (NASA)
Amor Menezes, Postdoctoral Scholar, California Institute for Quantitative Biosciences, University of California, Berkeley

General Plenary, 4:30 pm – 6:00 pm

Overcoming Challenges to Biorefinery Scale Up

Plenary session sponsored by:

CALYSTA

This panel will explore exactly what is needed to ensure the successful scale up of a commercial scale industrial biotechnology process. We will hear from engineering design experts and industry leaders who will discuss issues from scale up successes and failures to process control of biological systems, project execution, overcoming difficulties, and more.

Moderator
Dan Cummings, Chief Executive Officer, Guidewire Strategies

Panelists
Anthony Bresin, Chief Scientific Officer, ARD
Jeff Lievense, Senior Engineering Fellow, Genomatica
Dennis McGinn, Assistant Secretary of the Navy – Energy, Installations & Environment
Alan Propp, Business Development Manager, Merrick & Company
Joachim Schulze, Head of Biotechnology, Thyssenkrupp Solutions

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Tuesday, April 19

Breakfast Plenary, 8:00 am – 10:00 am

Developing a Renewable Chemical Value Chain in the Face of Low Fossil Fuel Prices

This panel will discuss the latest advances in renewable chemicals, including innovative biological processes, new feedstock inputs, and how strategic partnerships are changing the renewable chemicals landscape.

Moderator
Jim Lane, Editor & Publisher, Biofuels Digest

Panelists
Marcel Lubben, President, Reverdia
John Melo, President and Chief Executive Officer, Amyris
Felipe Pereira, Chemicals Department, Brazilian National Development Bank (BNDES)
Alan Shaw, Chief Executive Officer, Calysta
Minoru Watari, Team Leader, Mitsui & Co. Ltd.

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Luncheon Plenary, 12:00 pm – 2:15 pm

Young Stars of Industrial Biotechnology & Rosalind Franklin Award Presentation

Plenary session sponsored by: Corbion

Award sponsored by: Rosalind Franklin Society

This panel will feature dynamic young stars in the industrial biotech space. Speakers will highlight their technology breakthroughs and the varied applications of biotechnology they are currently deploying.

Moderator
Stephan Herrera, Vice President, Strategy and Public Affairs, Evolva

Panelists
Jeffrey Dietrich, Chief Technology Officer & Founder, Lygos
Reshma Shetty, Co-Founder, Gingko Bioworks
Dan Widmaier, Chief Executive Officer and Co-Founder, Bolt Threads

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Wednesday, April 20

Luncheon Plenary, 12:00 pm – 2:15 pm

Market Growth for Biobased Products in the Consumer Marketplace

Plenary Session sponsored by:

The biobased economy is growing, with companies in the space working to develop technologies to make industrial processes and products more eco-efficient. Technology developers are teaming up with consumer products companies to de-risk and scale up biobased products. From novel food ingredients, to packaging, to biobased car parts, our panelists will highlight recent biobased innovations, and discuss how to achieve a sustainable commercial scale biobased product industry.

Moderator
James Iademarco, Principal, Strategic Avalanche LLC

Panelists
Stephanie Delalande, Materials Innovation, PSA Peugeot Citreon
Claudio Gemmeti, Senior Vice President, Innovation and Strategic Growth, Club Coffee
Michael Knutzen, Global Program Director - PlantBottle, The Coca-Cola Company
Puneet Trehan, Material Innovation & Development Leader, IKEA Group
Jonathan Wolfson, Chief Executive Officer, TerraVia

GREENTECH INVESTOR SESSIONS

Monday, April 18

The BIO GreenTech Investor Sessions provide high visibility to early stage emerging industrial biotechnology companies to present in front of VC investors, analysts, angel investors, strategics. No other GreenTech private equity industrial biotechnology conference is designed with the latest innovation in mind, offering ***networking*** and, ***high quality content*** while creating partnerships, and new business opportunities.

Schedule:

Time		Presenting Company
8:30 AM	9:20 AM	GreenTech Investor Panel
9:25 AM	9:40 AM	Mango Materials
9:45 AM	10:00 AM	Aequor, Inc.
10:00 AM	***10:30 AM***	***Refreshment Break***
10:30 AM	10:45 AM	Kalion, Inc.
10:50 AM	11:05 AM	Agrivida
11:10 AM	11:25 AM	Leaf Resources Limited
11:30 AM	11:45 AM	Sylvatex Inc.
12:00 PM	***2:00 PM***	***Lunch Plenary Session***
2:20 PM	2:35 PM	Manus Biosynthesis
2:40 PM	2:55 PM	KnipBio

- **NETWORKING**

  Connecting with the right people is essential for building relationships and doing deals.

  The upgraded BIO One-on-One Partnering™ System will provide industrial biotechnology companies the opportunity to schedule private meetings with investors, and industry business development and licensing executives.

The GreenTech Investor Sessions brings the right people together, while ensuring there is a pleasant mix of industrial biotechnology attendees and a low percentage of service providers

- **CONTENT**

  An elite group of private and early stage emerging industrial biotechnology companies will present their new technologies, accomplishments, value propositions, business case, and exit strategies during the BIO GreenTech Investor Sessions.

  The BIO GreenTech Investor Sessions provide an opportunity for investors to learn about the latest technologies and connect with executives from innovative companies

  A panel discussion by leading investment firms covering the most recent industrial biotechnologies, financial strategies, useful best practices for improving your business, while also identifying trends, thre

  ats and opportunities on the horizon.

- **GENERAL ATTENDEES**

  The attendees will hear new technologies, unique perspectives building the biobased economy, providing insights into the latest business developments.

REGISTER TODAY

Pre-Conference Workshop

Sunday, April 17, 2016
2:30 PM – 4:30 PM
Location: Room 10

Growing a Billion Ton Bioeconomy in the United States

Sponsored by:

USDA United States Department of Agriculture

Join the Biomass Research and Development Board Operations Committee at a Bioeconomy Listening Session at the upcoming 2016 BIO World Congress on Industrial Biotechnology. Conference attendees are invited to join the listening session, on "Growing a Billion Ton Bioeconomy in the United States," held April 17th at 2:30-4:30 PM to provide thoughts, comments and ask questions on the potential to grow the national bioeconomy. Listening session hosts plan to solicit input from participants on what opportunities may exist and what challenges need to be confronted in order to achieve a focused and successful bioeconomy vision for the United States. This Listening Session will be run using *ThinkTank Collaborative Technology* to gather input from participants. Attendees will be required to bring their own personal devices capable of accessing the internet and entering responses.

In preparation for the session, it is also strongly encouraged that attendees review the recently released Federal Activities Report on the Bioeconomy: http://www.biomassboard.gov/pdfs/farb_2_18_16.pdf. The Federal Activities Report on the Bioeconomy is a product of an interagency collaboration under the Biomass Research and Development (R&D) Board, which includes members from the federal agencies, such as, United States Departments of Energy, Agriculture, Interior, Transportation, Defense, and the Environmental Protection Agency, the National Science Foundation, and the Office of Science and Technology Policy. The report has been prepared to emphasize the significant potential for a stronger United States bioeconomy through the production and use of biofuels, renewable chemicals, biobased products, and biopower. The report also delves into the wide-ranging, federally funded activities that are currently helping to bolster the bioeconomy.

Moderators—
Todd Campbell, United States Department of Agriculture, Policy Advisor, Energy and Bioeconomy
Harry Baumes, United States Department of Agriculture, Director, Office of Energy Policy and New Uses, Office of the Chief Economist

Workshops

Tuesday, April 19, 2016
10:30 AM - 12:00 PM
Location: Room 5A

What Investors Require When Making A Bioeconomy Investment?

Sponsored by:

FAEGRE BAKER DANIELS

KILPATRICK TOWNSEND
ATTORNEYS AT LAW

SternBrothers&Co.

This panel will focus on a series of crucial decisions potential investors consider regarding bioeconomy technology companies and/or their projects when determining whether or not to invest. Some of these considerations include, but are not limited to, the following: (i) areas of technology will they entertain—renewable chemicals, biobased products or biofuels; (ii) levels of technology risk from those that are acceptable to ones that are insurmountable and how acceptable risks must be mitigated; (iii) strength and type of IP and how it is protected or not; (iv) strength and experience of management teams—have they successfully stood up similar technologies and made good use of prior investment dollars; (v) types—common or preferred equity/venture debt/etc. and expected percentage returns on investments; (vi) expected controlling or minority ownership positions including the expectation of one or more board seats; (vii) timing and amounts of funding available in one or more rounds of development; and (viii) timing and types of acceptable exits—are they in for follow-on rounds or not—do they expect an IPO after certain milestones are met or other exit strategies. The financially experienced moderators will control a fast-paced discussion among the panelists of these and other issues that must be considered. Audience participation is strongly encouraged.

Moderators—John May, Managing Director, Stern Brothers; John Kirkwood, Partner, Faegre Baker Daniels LLP; Mark J. Riedy, Partner, Kilpatrick Townsend & Stockton LLP

Panelists

Tom Huot, Managing Director, Vantage Point Capital Partners
Josko Bobanovic, Managing Partner, Sofinnova Partners
Mario Portela, Managing Director, Texas Pacific Group

Workshops (continued)

Tuesday, April 19
10:30am- 12:00pm
Location: Room 5A

Bridging The Gap: Building A Young Scientist Pipeline For A More Diverse Science Future

Sponsored by:

novozymes®

Workshop – title TBA

Sponsored by:

avantium

IP Symposium: Where IP meets IB

Register for the IP Symposium here.

Program as of 3/18/16

Wednesday, April 20

Assessing and Preserving Value in Biotechnology Intellectual Property

8:30 AM – 10:00 AM

ROBINS KAPLAN LLP

Not all intellectual property is created equal. From IP creation, to perfection of rights, to commercialization, care must be taken to ensure that the enforceability of IP is not compromised. In this panel, our experts will provide guidance on maintaining IP value while conducting the business of using and commercializing underlying technology.

Procuring Patents for Industrial Biotechnology Innovations

10:30 AM – 12:00 PM

FINNEGAN

Sponsored By: Finnegan, Henderson, Farabow, Garrett & Dunner, LLP

This panel will focus on the special challenges in securing patents in the industrial biotechnology area, primarily using 3D bioprinting and biofabrication innovations as representative examples to highlight the issues in view of recent developments in patent law.

We will provide an overview of emerging trends in industrial biotechnology innovations including the 3D bioprinting and biofabrication innovations of our panelists, and then turn to the threshold question of patent eligibility for such innovations under the current interpretations and applications of 35 USC 101. In particular, we will discuss the current status of Section 101 rejections during prosecution, and strategies to overcome or avoid the rejections such as claim drafting strategies and other patent prosecution strategies.

We will also discuss strategies to deal with other challenges that the panelists and other applicants in the industrial biotechnology areas face during patent prosecution that arise from the technology, such as enablement and written description.

2016 BIO World Congress on Industrial Biotechnology Breakout Program Abstracts

Track 1: Growing Global Biobased Markets

Session 1: Monday, April 18 8:30am- 10:00am
Policies and Incentives for Industrial Biotech in Brazil

Moderator: Bernardo Silva, Brazilian Industrial Biotechnology Association – ABBI
Felipe Pereira, BNDES

Session 2: Monday, April 18 10:30am-12:00pm

Lee Lynd, Darthmouth College
Patricia Osseweijer, BE-Basic
Jeremy Woods, Imperial College London
Luuk van der Wielen, BE-Basic, TU Delft

Social Development Through Biobased Innovation
Climate change and pollution can be reduced by large scale implementation of bioenergy and production of biobased chemicals and materials. However, while much attention is given to Western implementation and business development, global sustainability can only be achieved when efforts are made to improve social development in less developed countries. Especially here, biomass based energy and materials can provide substantial opportunities for energy security and, if done well, also increase food security, while maintaining biodiversity. This can create business opportunities and improve social development in areas where population growth is dominant. Although crucial, how to achieve such positive synergies for biobased business development is not trivial. In an extensive report from 137 researchers from 24 countries the latest knowledge on biomass availability, biodiversity, yield and conversion technology was presented, with reflections on food security, environmental sustainability and governance. This was further discussed in several meetings around the world, including on 28 September 2015, at the World Bank in Washington DC. Here, World Bank specialists, development aid experts and key politicians agreed that the focus should be on actual deployment and new approaches to cover the financial risks of setting up large scale production units which can make a difference. It was agreed to make a dedicated integrated action plan prioritizing to create positive synergies, increase sustainable biomass production and achieve technology transfer for less developed regions. The session speakers will present and discuss the plan discussing opportunities and agricultural development, governance and biorefinery scales, and development of industry clusters. The format is an interactive panel discussion on provocative propositions, and the stage is set by pitches of the panelists.

Session 3: Monday, April 18 2:30pm- 4:00pm

Moderator: Mario Pennisi, Life Sciences Queensland Limited
Murray McLaughlin, Bioindustrial Innovation Canada
Bas Melssen, Novozymes Malaysia Sdn Bhd
Ian O'Hara, QUT Centre for Tropical Crops and Biocommodities

Biorefineries: Building the Bioeconomy
This session will explore the various biomass and biorefinery infrastructure being developed around the world in order to facilitate economic development as well as address social and political imperatives.

Each speaker will draw on their own experiences and will compare and contrast the various approaches that have been undertaken.

Session 4: Tuesday, April 19 2:30pm-4:00pm
Back to the future: A Rebalancing of the Global Bioeconomy Through Innovation + Manufacturing

Paul Hudman, Industrial Biotechnology Innovation Centre (IBioIC)
Back to the future: A rebalancing of Scotland's economy through innovation and manufacturing.
Scotland was one of the industrial powerhouses of Europe from the time of the Industrial Revolution onwards, being a world leader in manufacturing. This has left a legacy in the diversity of goods and services which the Scottish economy produces today, from textiles, whisky and shortbread to jet engines. Akin to many advanced industrialised economies there has been a shift away from manufacturing and into the service industries, although the food and drink and oil and gas sectors still remain vital to the country as a whole. The focus of government is to re-invigorate the manufacturing sector, with the development of a bio-based economy central to this initiative.

Scotland's "National Plan for Industrial Biotechnology" published in 2013 set out goals for the life and chemical sciences sectors to embrace more sustainable technologies and feedstocks. At the same time the Industrial Biotechnology Innovation Centre (IBioIC) was funded to be the hub of a growing community of industry, academia and government to drive this nascent industry forward.

This talk will explore the model used for the Innovation centre, outline its strategy for the next 5 years and detail how the bio-economy is predicted to expand, augmenting the already well established infrastructure within the chemical industry but altering its reliance on the oil and gas industry for feedstock.

Paul Lansbergen, Forest Products Association of Canada
Update on Canadian Policy on the Bioeconomy
This presentation will highlight the latest developments in Canadian policy relating to the bioeconomy. A special focus will be on federal policy but some provincial developments will be included. The policy thrusts of the new Liberal majority government will be highlighted. Their election platform indicates support for innovation, sustainable development, and clean tech. By the time of the Congress, more information will be available from Speech from the Throne, Federal Budget, and other potential initiatives.

The presenter is deeply engaged with the relevant departments on this policy discussion. As such, the presenter is well informed on the relevant developments and the implications for companies active in the bioeconomy supply chain.

Nelo Emerencia, Bio-based Industries Consortium
A global circular bioeconomy to deliver on our Sustainable Development Goals
The UN adopted in September 2015 Sustainable Development Goals (SDGs) to end poverty, protect the planet and ensure prosperity for all by 2030. The bioeconomy and new/optimised bio-based industrial value chains can play an important role in enabling and delivering the needed transformational change across business and society.

The €3.7 billion EU Public-Private Partnership on Bio-based Industries (BBI Joint Undertaking) is one effort among others across the world to deploy new industrial value chains that can replace petroleum-based products with sustainable and competitive bio-based alternatives.

Accelerating the uptake of bio-based products, materials and processes and achieving critical mass are essential to establish bio-based as a true global competitive alternative to petroleum-based products.

Which concerted efforts should be considered to achieve global political, economic and social impacts? Which policies should be prioritized and synergized (e.g. a global BioPreferred program)? How to ensure growth of global bio-based markets effectively means 'sustainable development'?

Mervi Toivari, VTT Technical Research Centre of Finland Ltd
Fungi – excellent hosts for production of organic acids in Finland
Biotechnological production of organic acids has gained significant interest in providing bio-based platform chemicals for various applications. Fungi, both yeast and filamentous fungi, offer a possibility for low pH

biotechnological production, advantageous for downstream processing. Many filamentous fungi produce hydrolytic enzymes, allowing polymeric carbohydrates to be used as raw material in bioprocesses.

We have engineered various yeast and filamentous fungi for production of organic acids e.g. lactic, glycolic, xylonic, and mucic acids. In addition to using lignocellulosic sugars glucose and xylose as carbon sources, we have addressed pectin-derived galacturonic acid as a raw material for acid production, while characterising the catabolic pathway.

For efficient conversion a number of enzyme candidates were identified by bioinformatic data mining, and their properties characterized. Structure determinations and site-directed mutagenesis have also been carried out. NMR methods have been used to monitor the kinetics of selected pathway enzymes and in vivo reactions. Studies on xylonic acid production have highlighted global transcriptomic responses and intracellular accumulation of acid.

Intracellular acid accumulation was studied at the single cell level in relation to acidification and loss of viability. To overcome this obstacle we are investigating the design of an acid responsive control circuit. Our efforts have led to the development of efficient production hosts for several organic acids, in the best cases reaching titres up to 170 g/L.

Choice of host, gene, pathway and production process (typically batch or fed batch) have all been found to be important in achieving high levels of organic acid production.

Session 5: Wednesday, April 20 8:30am-10:00am

Kathryn Sheridan, Sustainability Consult
Marcel Lubben, Reverdia
Plant-To-Plant… To Brand - The Relay Race To Commercialize Bio-based Products
While the bio-based industry is developing rapidly and multiple materials have been commercialized, it is time to define what success means to the bioeconomy. The challenge is to go from being an emerging industry with a few good stories to achieving mainstream commercialization. What will it take?

The challenge is not just to find a buyer (or several) for a bio-based product but to build new value chains in partnership with brand owners, bio-based chemical and polymer producers and compounders. Chemical industry business as usual will not work. Without committing to building new value chains in partnership, the bioeconomy will not reach its potential of enabling new and innovative materials, thereby creating jobs, and reducing the carbon footprint of the chemical and polymer industry.

Life-cycle, feedstock, energy supply and company ethics all play an important role for brand owners and consumers. Reverdia's President will share best practice from the bio-based industry and share the company's vision for more renewable consumer products, as well as showing the versatility of bio-succinic acid as a platform chemicals for both durable and biodegradable applications.

Working across the value chain is key to the commercial development of sustainable products. With its patented Biosuccinium™ technology proven at commercial scale at its 10,000 MT plant in Cassano, Italy, Reverdia's low pH yeast fermentation process has best-in-class carbon performance for bio-succinic acid.

Hans van der Pol, Corbion Purac
New business way of thinking to move the biobased industry forward
As a leader in the biobased products industry, Corbion has developed a strong business position in a variety of markets based on its leading lactic acid technology. Recent innovations further drive the development of sustainable lactic acid technologies and positioning of lactic acid as a platform building block in chemicals and plastics industries. Furthermore, Corbion is leveraging its technology position for lactic acid to initiate the development of new product platforms. This presentation will also present new idea's for integrating these new products in a biorefinery concept.

Session 6: Wednesday, April 20 10:30am- 12:00pm

Moderator: Joel Stone, Convergince Advisers
Matthew Engler, Verdezyne

Damien Perriman, Genomatica
Cindy Thyfault, Westar Trade Resources
Todd Campbell, USDA

Innovation in Collaborations Makes a Difference
We will have a panel of Collaboration Leaders across commercial business, academia, development labs, and NGO's discuss how they have been creative in developing successful project collaborations where the measurement of success will be a commercial business. A briefing will be provided by each panelist followed by significant Q&A led by the panel moderator with focused interaction with attendees. The focus of the discussion will be:

-How were collaboration partners selected

- Key success factors

- Project management goal setting

-Risk Management

-Key Learnings

-What would you do different next time around

-What is your future view for growth in the renewable and biobased markets

Track 2: Research Presentations

Session 1: Monday, April 18 8:30am- 10:00am
Model Studies, Sustainability Factors, and Techno-Economic Analysis

Moderator: Lee Walko, Omni Tech International, Ltd.
Bio-Chemicals, Shale Gas and Crude Oil: Partners in the New Chemical Industry Economy What are the implications to biochemicals with the dramatic fall in crude oil prices? Additionally, how does this impact shale gas. Will this open up opportunities for biochemicals or is there the potential for biochemicals to slow down? Are petroleum chemicals more competitive as a result? Are there market segments where biochemicals will prosper? This talk will review the implications of lower crude oil on the chemical industry. There are many dynamics underway such as profitability when prices are low. By April of next year when this talk is given, we will have seen some of the longer-term fallout and how biochemicals are thriving or worst case surviving in this new economy.

Robert Natelson, North Carolina State University
Biological-Technoeconomic Analysis of Biofuels and Bioproducts The use of technoeconomic models that combine process modeling with financial parameters is common in the petrochemical industry and has been introduced into the biofuels industry. The use of enterprise budgets for farming is standard and can be used for biofuel and bioproduct crops. Crop yield is the largest cost factor in most biofuels and bioproducts. One way to model crop yield is econometric crop modeling that integrates biophysical crop growth, explained by weather and soil variables, with farm management decisions. Logistical models for transportation and storage have been identified as important factors in modeling real-world biofuel costs. Integration of refinery technoeconomics, crop enterprise budgets, crop yield models, and logistics results in local feedstock supply functions, as referred to in standard economics terms. Economic theory is used to design quantitative models of biofuels and bioproducts prices and application of econometrics to market data allows for the estimation of demand functions. We present our work in biological-technoeconomic analysis (BTEA), where we integrate supply and demand functions to design comprehensive models useful for economic modeling of biofuels and bioproducts. Production risk is added by including crop yield probability distributions. Revenue and profit risk is incorporated via predictive analytics for product prices, based on historical data. We illustrate several examples including results for camelina jet fuel and co-products, and algae jet fuel and co-products. BTEA is useful in identifying the probability of profit for next-generation biotechnology concepts, for identifying the dominant cost factors, and for investigating optimal refinery scale and other deployment factors.

Mark Warner, Warner Advisors LLC
Techno-Economic Models - Friend or Foe?
Techno-Economic Models are a valuable tool for any technology startup, playing a key role in fundraising and process planning. Depending on how the models are developed and used, they can either be a tool to help lead the strategic vision of the company, or an abyss of time and effort that ends in frustration. The author will share his real world experience taking processes from early stage bench testing to commercial production, focusing on the role that the Techno-Economic Models have played.

Mark Warner is a registered professional engineer with 30 years of experience in process commercialization, focusing for the last 10 years on taking first-of-a-kind-technologies from bench-top to commercial operation. He has worked for four companies who have held the #1 spot in biofuels digest's top company list, in a range of advanced biotechnologies including biodiesel, cellulosic ethanol, phototrophic algae, heterotrophic algae and innovative food products. He is the founder of Warner Advisors, providing consulting services and acting in interim engineering leadership roles for advanced bioeconomy clients. He can be reached at mark@warneradvisorsllc.com

José Vitor Bomtempo, UFRJ
Challenges in Platform Chemicals Development
The advance of biobased industry is driving a great emphasis on the development of platform chemicals, understood as chemical intermediates with the potential to develop new products families. The exploration of opportunities related to these molecules is not simple, since it involves a complex development process, including value chain building and market adoption strategies. From this perspective, understanding platform chemicals from a broad perspective, considering not only technological but also strategic aspects is essential to analyze its potential. The literature on platform chemicals is quite rich on the technological and market potential (Bozell and Petersen, 2010; Broeren et al., 2012) but until now has failed in understanding the critical strategic dimensions involved in a platform chemical building. Our discussion focus on the challenges to explore these new molecules through the application of an analytical framework developed by the Bioeconomy Study Group (De Araújo, Oroski, Alves, Bomtempo, 2015). This framework sets five variables seen as levers that may be able to define a coherent way to lead the development of a new platform chemical: firm background, technology design, firm scope, value strategy and external relationships. Different examples , such as biosuccinic acid, farnesene and biobutanol, were explored using the referred framework. The methodology leads to evaluate the potential of each example as a platform chemical and allows the study of the challenges to its development. In addition, the analytical framework, when applied to each producing firm, shows the diversity of technological and strategic options co-existing, the efforts to develop new applications, and the diversity of collaboration among the value chain players. Our research shows that the challenges of structuring chemical platform are large and complex and require a thin understanding of focal firms' nature, and coordination capacity of a multivariate environment.

Session 2: Monday, April 18 10:30am-12:00pm
Process Improvement for Biobased Materials

Moderator: Jian Yu, University of Hawaii
A Biorefinery of CO2, Water and Solar Energy for Bio-based Plastic and Gasoline-grade Fuel
Conventional biorefineries produce bio-based chemicals and fuels from plant biomass or microalgae. A novel biorefinery can directly harness CO2 by using water and solar energy, but not affected by the intermittency of renewable energy as encountered with microalgae. Sunlight is first converted into hydrogen as a stable energy source that is used by a hydrogen-oxidizing bacterium to fix CO2 in dark conditions. In a gas fermenter, the CO2 fixation rate was enhanced to about 1 g L-1 hr-1, about 10 times faster than photosynthesis of typical microalgae and cyanobacteria. A large portion of the reduced carbon (about 50 wt%) is stored as polyhydroxybutyrate (PHB) in microbial cells and can be recovered conveniently from the cell mass. PHB is a thermoplastic that can find various environmentally friendly applications. The biopolyester can also be converted into small chemicals (C3-C4) with functional groups. Specifically, PHB is degraded and deoxygenated on a solid phosphoric acid catalyst into a hydrocarbon oil (C6-C18) from which a gasoline-grade fuel (77 wt% oil) is obtained via distillation. Aromatics and alkenes are the major compounds, depending on the conditions of the one-pot reaction. By comparing this artificial photosynthetic system with a representative cyanobacterium (Spirulina platensis) in a flat

photobioreactor, this work shows an efficient biorefinery for bio-based plastics and high-grade fuels from carbon dioxide, water and renewable energy.

Yinhua Wan, Institute of Process Engineering, Chinese Academy of Sciences
Higher molecular weight β-poly(L-malic acid) production by A. pullulans with Ca2+ added repeated batch culture
β-Poly(malic acid) (PMLA) has attracted increasing attentions because of its potential applications in medicine and other industries. In this study, the variation of the weight average molecular weight (Mw) of PMLA in the batch culture and the strategies to enhance PMLA Mw were studied. It was found that pH and Ca2+ were two main factors affecting PMLA production. Adding exogenous Ca2+ (0.1 g/L CaCl2) to the medium caused a significant increase in both PMLA concentration and Mw (11.4% and 26.3%, respectively) when Na2CO3 was used as the neutralizer. The Mw of PMLA during the process of batch culture was associated with the specific PMLA production per unit cell mass (Yp/x) before glucose was depleted, and it increased from 12.52 KDa to its maximum 18.69 KDa and then kept decreasing until the end of the culture. Compared with the results in batch culture, Mw increased by 84.4% (up to 19.51kDa) with a productivity of 1.1 g•h-1•L-1 when the cells were maintained in exponential growth phase during Ca2+ added repeated batch culture. The present work could provide an efficient approach for producing PMLA with higher Mw.

Manju Misra, University of Guelph
Novel Biopolyester from Co-Product of Biodiesel Industries for Creating Low Cost Toughened Polylactic acid (PLA)
Glycerol is an abundant co-product of biodiesel industries with an estimated worldwide production of nearly 6 billion lbs by 2020. Finding new applications for glycerol and its derivatives is of major importance in a bioeconomy context for allowing the sustainable expansion of biodiesel industries. Glycerol polyesters are a type of biobased polymer which can be produced through simple polycondensation reactions yielding elastomeric materials. In the present research, glycerol polyesters have been synthesized using technical glycerol, a semi purified industrial glycerol obtained from biodiesel industries with a glycerol content of about 97%. These polyesters can be used in applications where glycerol purity is not very critical. Using reactive melt extrusion, these glycerol polyesters were employed as blending partners for polylactic acid (PLA) aiming to improve the toughness of PLA, evidenced as a higher elongation at break. Upon the addition of 20 wt% of glycerol polyester to PLA, the elongation at break of the material was increased from 4% to 150%. The main synthesis conditions for producing glycerol polyesters have been explored and the molar ratio of reactants, temperature of synthesis and viscosity of the final product have been optimized to yield a polyester suitable for the toughening of PLA. These results demonstrate a new alternative for the utilization of industrial technical glycerol as a precursor for the synthesis of biobased polyesters which can be further blended with commercially available polymers yielding novel materials with tailored mechanical performance.

Amar Mohanty, University of Guelph
Sustainable Lightweight Carbonaceous Green Composites from Pyrolyzed Biochar: Opportunities in Green Automotive Parts Uses
Sustainable lightweight green composites from renewable resources are the wave of the future. Every pound of weight saving is beneficial to automakers as they strive to achieve new corporate average fuel economy (CAFE) standards, a fleet average of 54.5 mpg by 2025. To exploit the benefits of greener composite materials in terms of their lightweighting, renewability, low carbon footprint and reduced greenhouse gas (GHG) emission this presentation aims to provide innovativeness of pyrolyzed co-product, biochar in value-added sustainable carbonaceous materials development in auto-parts manufacturing.

This work deals in the design and engineering of innovative biobased and greener composite materials comprising traditional polypropylene to nylons and biomass pyrolyzed co-product, the biochar.

Industry-prevalent extrusion and injection moulding processing have been adopted in manufacturing the targeted biobased composite materials. Up to 30% biochar could be reinforced with plastic including biobased plastics in designing a new class of carbonaceous green composites. Results from these biocomposites showed improved performance including significant improved heat deflection temperature (HDT) suitable for auto-parts uses. The results also showed innovativeness in stiffness-toughness balance through compatibilization chemistry and reactive extrusion processing.

Significant weights saving (up to 20%) as contrast to mineral filled/glass fibre-reinforced counterparts pose a strong commercial attraction of these emerging biochar based carbonaceous composites. The reduction of GHG emission is estimated in hybrid biochar-based composites at ~3.952 kg of CO2 per kg of virgin material counterpart. There is massive global application potential for these successful materials. This presentation will highlight the potential opportunities of such biobased composite materials for certain automotive parts uses.

Amit Goyal, Southern Research Institute
Acrylonitrile production from non-food biomass derived sugars for synthesis of carbon fibers
The industrial sector anticipates an 11-18% annual increase in the market for carbon fiber, specifically driven by motivation to reduce weight for vehicles. Currently, micron-sized carbon fibers used are mostly produced by heat treatment or controlled pyrolysis of polyacrylonitrile (PAN). In order to obtain PAN which results in high fiber mechanical properties, precursor acrylonitrile (ACN) is required which is currently obtained from ammoxidation of propylene. Propylene accounts for approximately 70% of total cost, a highly volatile petrochemical. The goal of this work is to develop an alternate cost-effective, low environmental impact process for production of ACN utilizing biomass-derived sugars with comparable chemical specifications that can directly replace conventional propylene-based ACN.

Southern Research (SR) is developing the biomass to ACN (B2ACN) process under a cooperative agreement with the Department of Energy. B2ACN is a multi-step catalytic process for conversion of sugars from non-food biomass to ACN at mild conditions. The process utilizes known pretreatment methods for recovery of sugars from any type of biomass. In the first reaction step, sugars are converted to oxygenates using a novel multi-functional catalyst, oxygenates are then converted to a gas phase intermediate followed by conversion of the intermediate to acrylonitrile. The results and initial estimates show a significant reduction in greenhouse gas (GHG) emissions of up to ~37% and cost reduction of up to ~22% compared to conventional ACN. This paper will discuss the conversion and selectivity results of the individual reaction steps of the B2ACN process using various promising multifunctional catalysts synthesized at SR carried during Phase I of the project, using biomass derived hydrolyzates as feed. Following successful Phase I development/testing, a scaled up integrated bench-scale reactor system will be designed and demonstrated.

Session 3: Monday, April 18 2:30pm- 4:00pm
What is Required to Protect Research and Innovation in Industrial Biotechnology?

Moderator: Andrew Varcoe, BIO

Session 4: Tuesday, April 19 2:30pm-4:00pm
Pretreatment and Separation Methodologies

Kasiviswanathan Muthukumarappan, South Dakota State University
Development of Novel Continuous Oil Extraction Method for Jet Fuel Production
Currently, hexane-extraction is the most cost-effective process to extract oil from oilseeds, which reduces the oil content to <1%. However, several safety concerns are associated with the use of hexane; it occasionally causes extensive property damage, injury and loss of life; it is a volatile organic compound that interacts with other pollutants to form ozone and other photochemical oxidants; it contains high contents (~60%) of the neurotoxic and hazardous air pollutant n-hexane. Therefore, alternative oil-extraction technologies are needed. Today, the only viable alternatives are inefficient screw pressing and extruding-expelling. These technologies reduce the oil content of the meal to only 6-8% (~70% oil

recovery from soybeans). This presentation will cover the development of a novel and continuous oil extraction method by using several biodegradable plant-based solvents during the extrusion-expelling.

Pramod Kumbhar, Praj Matrix
Effects of Low-Cost Anionic and Other Polymer Additives on the Enzymatic Hydrolysis of Pretreated Sugarcane Bagasse
In cellulosic ethanol production processes, for achieving higher enzymatic conversion low substrate loadings, higher hydrolysis retention time and higher enzyme loadings are required. Since the cost of enzymes are very high, there is a greater need to reduce the enzyme dosage and still keep the hydrolysis efficiencies to a competitive level. Therefore, efficient strategies to increase the hydrolysis efficiencies through the addition of some low cost non ionic additives provide efficient, cheap, scalable and more economic method. Towards realizing these objectives, this work reports the effect of addition of anionic salts such sulfites, carbonate, and oxides on the enzymatic hydrolysis of acid pretreated bagasse. The costs of these additives are 2-3 times lower compared to proteins or surfactants, which are typically added in most of the reported studies. Unlike other reported work, here, additives were tested for two different post-pretreatment configurations of whole slurry hydrolysis and wet cake hydrolysis at 14 -15% total solids. Pretreatment experiments were conducted on a pilot scale 1 ton per day steam explosion pilot plant used for pretreatment of sugarcane bagasse operating at high solids content (18-20%), using fresh bagasse without prior washing. The current pilot scale experiments were performed using dilute mixture of acids involving sulfuric acid and oxalic or phosphoric acid under applied heat and pressure. The added additives shows favorable effect on enzymatic conversion efficiency and the whole process is feasible for scale-up. The effect of adding anionic additives at an intermediate stage also helps in raising the pH (by around 1 unit) of the dilute acid pretreated, providing potential benefit for the reduction in the caustic requirement for the neutralization. The positive effect of additives was observed with unwashed sugarcane bagasse pretreated slurry and the yield of ethanol has increased by 10-20% compared to the conventional process.

Niloofar Abdehagh, University of Ottawa
Using combination of adsorption and gas stripping techniques to separate biobutanol from ABE model solutions
Butanol is considered as a promising sustainable biofuel to partly replace petroleum-based fuels. However, to become an economically viable biofuel, some challenges need to be overcome in the biobutanol production process. Low product concentration isone of the main issues in biobutanol production which is caused by product toxicity to the microorganism. There are a few separation techniques that have been proposed to extract biobutanol from dilute fermentation broths. In the present study, butanol separation from binary solutions, ABE model solutions and fermentation broths have been investigated using the combination of gas stripping and adsorption processes. CO2 was used as the carrier gas for the gas stripping process since it is produced in the ABE fermentation process and can be used as the stripping gas to make the process more economically viable. The adsorbent used in the adsorption process was AC F-400 that is highly selective to butanol and has a high adsorption capacity for this component.

The results showed that this combined method of separation is an effective technique for biobutanol separation since the adsorption capacity of biobutanol is relatively higher than the values reported in the literature. Also the competing effect of the presence of sugars and organic acids on the adsorption capacity are eliminated since these components are not stripped to the gas phase and therefore do not have any negative effect on biobutanol adsorption in the packed column. It is strongly believed that this method could be considered as one of the most efficient biobutanol separation techniques benefiting from advantages of both gas stripping and adsorption processes.

Daniel Pleissner, Leibniz-Institute for Agricultural Engineering
Membrane based downstream processing of 2nd generation lactic acid fermentation broth
Lactic acid, its salts and esters have a wide range of potential uses and are extensively used in diverse fields. Originally, lactic acid was produced from starch-based substrates like glucose. Increasingly, however, non-food biorenewables such as lignocellulosic feedstocks, agri-food residues and by-products are also being used as raw materials for the production of microbial lactic acid. The goal is to develop a fermentation process based on the substitution of expensive nutrient supplements by cheaper materials due to their main proportion of the whole process costs.

A high-productivity lactic acid bacterium strain was selected, process parameters were optimized for the fermentation on a laboratory up to pilot scale, and its lactate productivity at cultivation on lignocellulosic hydrolysates was examined. The strain is able to accumulate more than 100 g of lactate per litre in the medium and the product yield can be higher than 90%. The objective was to test the suitability of alternative feedstocks for use as raw materials in lactic acid fermentation processes. First results of the utilization of lignocellulosic biomass after enzymatic pre-treatment will be presented up to a 450-L-bioreactor.

Exploitation of high quality lactic acid for the production of biodegradable polymers is one of the recent applications. Conventional processes for down-streaming are based on precipitation steps that generate large amounts of chemical effluents. Consequently the environmental impact and the operating costs of traditional processes can be reduced by using alternative technologies, such as electrodialysis with monopolar and bipolar membranes. Desalination, purification and concentration of sodium lactate after fermentation are possible by conventional electrodialysis and the concentrated sodium lactate can be converted into lactic acid and cleaned further by means of water-splitting electrodialysis with bipolar membranes.

Session 5: Wednesday, April 20 8:30am-10:00am
Enzyme Development for Improved Production Performance

Moderator: Timothy Durrett, Kansas State University
Targeted metabolic engineering of Camelina sativa to synthesize high levels of acetyl-TAG oils with reduced viscosity and crystallization temperature
Vegetable oils have long been used as sources of energy and chemical industry feedstocks. However, metabolic engineering to improve the chemical and physical properties of plant oils for these application has proven difficult. Through the expression of a novel acyltransferase and the downregulation of competing reactions, we have been able to transgenically engineer Camelina sativa plants with the highest accumulation of unusual oil achieved so far.

EaDAcT, a diacylglycerol acyltransferase (DGAT) with sn-3 acetyltransferase activity synthesizes the abundant 3-acetyl-1,2-diacylglycerols (acetyl-TAGs) found in the seeds of Euonymus alatus. Expression of EaDAcT in Camelina sativa, combined with the RNAi-mediated suppression of endogenous TAG biosynthesis, led to acetyl-TAG levels as high as 85 mol% in the best transgenic lines. These high acetyl-TAG levels led to an overall increase in the moles of oil produced, were stable across multiple generations and did not affect seed viability.

The presence of an sn-3 acetate group modifies the physical properties of these unusual triacylglycerols. For example, acetyl-TAGs possess a lower viscosity and improved cold temperature properties compared to other vegetable oils. Acetyl-TAGs are similar in structure to the emulsifier ACETEM used in foods, and to plasticizers used for PVC food packaging. To expand the utility of acetyl-TAGs, we have combined the expression of EaDAcT with the synthesis of unusual fatty acids. For example, acetyl-TAGs with medium chain fatty acids (MCFA) at the sn-1/2 positions are predicted to possess further reductions in viscosity, potentially allowing their use as an improved straight vegetable oil (SVO) biofuel. These acetyl-TAGs could also be useful as biodegradable lubricants with improved oxidative stability and cold temperature performance.

Chunzhao Liu, Institute of Process Engineering, Chinese Academy of Sciences
Laccase: large-scale fermentation and direct capture by functional magnetic nanoparticles for enhancing biocatalysis
Laccase, belongs to a well-studied family of copper-containing blue oxidases, which are mainly produced by fungi. The major role of laccase in lignin and phenolic compound degradation has attracted significant interest in a large number of industrial applications, such as paper manufacturing, food processing, bioremediation, biosensors, fuel cells, organic synthesis, etc. In the current study, laccase fermentation was successfully scaled up to a 2 m3 stirred-tank reactor, and a promising farnesol addition strategy was developed to enhance the laccase production from Trametes versicolor. An emphasis is highlighted on direct capture of laccase from T. versicolor fermentation broth using magnetic mesoporous silica nanoparticles with metal affinity ligands. The Cu2+-chelated magnetic mesoporous silica nanoparticles

with an average pore size of 14.5 nm provide 60.6-fold purification of laccase and 114.6% recovery yield of enzyme activity. Storage stability and temperature endurance of the adsorbed laccase on MMSNPs-CPTS-IDA-Cu2+ increased significantly, and the adsorbed laccase retained 86.6 % of its initial activity after 10 successive batch reactions operated with magnetic separation. The immobilized laccase on the magnetic mesoporous silica nanoparticles has been developed for efficient phenol degradation. The degradation rate of phenol by the immobilized laccase was 2-fold higher than that of the free laccase, and the immobilized laccase retained 71.3 % of its initial degradation ability after 10 successive batch treatments of coking wastewater.

Ikram Haq, GC University
Thermodynamic and saccharification analysis of a cloned, highly thermostable GH12 endo-1,4-β-glucanase from Thermotoga petrophila
The thermotolerant endo-1,4-β-glucanase gene of Thermotoga petrophila RKU-1 was cloned and over-expressed in E. coli. Enzyme was purified to homogeneity (38 kDa) by heat treatment combined with ion-exchange column chromatography. The purified enzyme was optimally active with 530 Umg-1 of specific activity against CMC at pH 6.0 and 95°C and was also stable up to 8h at 80°C. The enzyme also showed activity against β-Glucan Barley: 303%, Laminarin: 13.7%, Whatman Filter Paper: 0.017% with no activity against Starch and Avicel. The Km, Vmax and Kcat of the recombinant enzyme were found to be 12.5mM, 842 µmol mg-1min-1 and 1076.72 s-1, respectively against CMC substrate. The recombinant enzyme was very stable and exhibited half life (t1/2) of 6.6 min even at a temperature of 97°C, with enthalpy of denaturation (ΔH*D), free energy of denaturation (ΔG*D) and entropy of denaturation (ΔS*D) of 528.9 kJ mol-1, 98.2 kJ mol-1 and 1.17 kJ mol-1K-1, respectively. The enthalpy (ΔH*), Gibbs free energy (ΔG*) and entropy (ΔS*) for CMC hydrolysis by the enzyme were calculated as 48.2 kJ mol-1, 54.6 kJ mol-1 and -17.4 J mol-1 K-1, respectively. The recombinant enzyme saccharified pre-treated wheat straw and baggase to 9.32% and 11.2%, respectively after 12h at 80°C.

Selim Kermasha, McGill University
Enzymatic Synthesis Of Novel Biomolecules Of Phenolic Lipids: A Biotechnological Approach
There has been a growing interest in the use of nutraceuticals as food supplements as well as natural bio-ingredients in food industries. Phenolic compounds represent an important group that possesses antioxidant and many functional properties. On the other hand, the numerous health benefits of the ω-3 polyunsaturated fatty acids (PUFAs) have been recognized in the modulation of risk of a variety of diseases and disorders. The incorporation of phenolic compounds into triacylglycerols, via the use of lipase transesterification process, could potentially result in novel biomolecules, structured phenolic lipids (SPLs), with enhanced anti-oxidative and functional properties. Using a wide range of edible oils, including flaxseed oil, fish liver oil and krill oil and a phenolic acid model, the SPLs demonstrated radical scavenging activity higher than that of phenolic acid model, but comparable to that of α-tocopherol. In addition, the experimental findings indicated that SPLs exhibited higher antioxidant capacity (AOC) as compared to that of the edible oils. The experimental findings also showed that SPLs demonstrated an enhancement in the oxidative stability, when they were exposed to light, oxygen and high temperatures, as compared to that of the edible oils. Work also in or laboratory succeeded in the encapsulation of SPLs. The presented work will highlight the development of a novel biotechnological approach using enzymes for the production of selected phenolic lipids, using edible oils and endogenous phenolic extracts. The structural, anti-oxidative stability characteristics and the encapsulation of these novel biomolecules will be presented.

Vikas Kumar, Kentucky State University
Potential Of Improved Soybean Meal In Aqua Feed
Currently, aquaculture is the fastest-growing sector of food production. According to the Food and Agriculture Organization (FAO), almost half of the world's fish supply for human consumption derives from aquaculture production. Ongoing intensification of aquaculture has made it essential to develop suitable diets for fish using alternative protein sources. Therefore, we have developed a tandem chemical and enzymatic treatment of commercial soybean meal (SBM) to reduce the antinutritional factors (ANFs), and to produce improved soybean meal (ISBM) for aqua feed. Using fish (yellow perch, *Perca flavescens*) fingerlings, a 10-week experiment was conducted to evaluate the nutritional quality of the ISBM to compare with that of fish meal and SBM. Overall, fish fed with ISBM grew 21% faster than fish fed with commercial SBM.

Another experiment was the second in a series of previous project focusing on the long term effects of ISBM for commercial production of Pacific white shrimp (*Litopenaeus vannamei*). The long term goal of this project was to compare the ISBM-based diets with fishmeal based feed (commercial shrimp feed). Based on the results 100% fishmeal protein can be replaced by ISBM-based diets without compromising the growth and health of shrimp.

The results of both studies enlarge the portfolio of improved soybean meal that can be used in aqua feed and open a new market opportunity for use of a new feed resource in the feed industry.

Vikas Kumar[1†], Ramanathan S. Lalgudi[2], Rob J. Cain[2], Richard Hulefeld[1] and Barry McGraw[3]

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Session 6: Wednesday, April 20 10:30am- 12:00pm
Enhancing Microbe Performance, Selecting Feedstocks, and Piloting

Moderator: Carole Molina-Jouve, Engineering of Biological Systems and Bioprocesses

Metabolic flexibility of Rhodotorula glutinis: lipid accumulation from various carbon sources, for Bio Kerosen application

As the use of lignocellulosic substrates and industrial by products is a new way to diversify carbon resources for biofuel production, scientific challenges deal with the production of an alternative lipid feedstock with oleaginous yeasts: R.glutinis is a microorganism of interest with its capacity to accumulate more than 70 % of lipids on glucose. However its capacity to convert xylose or glycerol in lipids, pure or mixed with glucose, is an area few explored. Cofactors, their interconversion and their intracellular distribution are key elements of these substrates co-consumption.

The purpose of these works is to improve the fundamental knowledge of R.glutinis metabolism to identify its maximal potential of growth and lipid production. Our experimental approach consists of the quantification, under perfectly controlled culture conditions, of the dynamics of growth and lipid production of R. glutinis, from glycerol and xylose, in pure and co-substrate conditions with glucose. The metabolic flexibility of the strain was revealed by its ability to quickly adapt its metabolism under changes of the ratio glycerol/glucose or xylose/glucose in the carbon supply. The co-consumption of xylose and glucose or glycerol and glucose as well as the use of glycerol and xylose as pure substrates was quantified in terms of rates and yields: on glycerol and xylose, a decrease of the kinetic parameters was observed compared with results on glucose. In terms of lipid accumulation, it was highlighted that the process performances remain interesting for a ratio of 20 % of co susbtrate and 80 % of glucose compared with those on pure glucose. The lipid profile was very slightly impacted. The macromolecular pools of the biomass components were not affected. Metabolic assumptions were proposed : the metabolic key factors were linked to glycolytic fluxes from PPP, neoglucogenese and co factors demand. Mitochondrial shuttles obviously present a fundamental role in the regeneration of NADPH,H+.

Natthiporn Aramrueang, University of California, Davis

High-solid anaerobic fermentation of organic waste for volatile fatty acid production

Low cost production of volatile fatty acid (VFA) and lactic acid from organic wastes has received much more attention as VFA is a substrate for microorganisms in the production of biodegradable plastics and bioenergy, and also involved in the biological nutrient removal processes. High-solid anaerobic fermentation of organic waste was developed to achieve high VFA yield at a short fermentation time. The VFA production from corn stover was studied at high-solid loadings. Pretreatment of the biomass allowed an increase in the solids loading up to 13% total solids (TS), leading to the production of total acid up to 79 g/L after one week of digestion. Without pretreatment, the solids loading was limited to 6% and total acid concentration after fermentation was 18 g/L. The major acid component changed over the course of

fermentation for the pretreated samples. The major acids were lactic and acetic acids in the first week, and acetic acid and butyric acid in the second week, respectively. The biogas yield varied in the range of 22-143 mL/g volatile solids (VS). Hydrogen yield for the pretreated samples after two weeks of was in the range of 15-42 mL/gVS under the tested conditions.

Kari Koivuranta, VTT Technical Research Centre of Finland
Oleochemicals with microbial platform
Oleochemicals are chemicals made from lipids. They are used e.g. in production of soaps, detergents, lubricants, solvents, biodiesel and bioplastics. In addition to plant and animal fats oleochemicals can be produced biotechnically with microbes. Microbial triacylglycerides can be used as raw material in biodiesel production, and diacids synthesised by microbes find applications in production of bioplastics.

We have enhanced the production of lipids (triacylglycerol) in oleaginous yeast and filamentous fungi by genetic engineering. One to four exogenous genes were expressed to enhance triacylglycerol production, especially the yield per carbon consumed. At the same time, a metabolic pathway which did not exist in these species was established. The genetically modified strains were cultivated in bioreactors with glucose or xylose as carbon source. With glucose (xylose) as carbon source, the genetically modified yeast produced up to 25% (19%) more triacylglycerol (g/l) with 24% (12%) higher yield per used glucose (xylose) than the control strain, which itself already had good triacylglycerol production. The modified filamentous fungus produced up to 9% (18%) more triacylglycerol with 19% (7%) higher yield per used glucose (xylose) than the control strain.

We have also genetically modified a yeast strain to produce diacids from fatty acids. The omega oxidation of the yeast strain was enhanced and degradation of fatty acids and diacids was blocked. The modified strains showed enhanced production of C9:0 and C18:1 diacids.

Hendrik Waegeman, Bio Base Europe Pilot Plant
Bio Base Europe Pilot Plant: Closing the gap in the innovation chain
Bio Base Europe Pilot Plant is multipurpose pilot facility for the development, scale-up, demonstration and toll manufacturing of bio based products and processes at a kilogram to ten ton scale. The wide range of state-of-the-art industrial equipment, and the experienced and flexible team of 45 employees, serve customers from around the world in the field of biomass pretreatment, fermentation, downstream purification, biocatalysis and explosion proof green chemistry.

What is hampering IB and more in general the bio-based economy to take off? Well, although, SMEs and large companies can obtain financial support to scale-up their processes, for many of these companies and especially for SMEs, piloting is not the core of their activities. SMEs typically do not have the infrastructure to accommodate pilot lines, nor have the skilled personnel to run the tests. To obtain faster learning curves and shorter time to market, these activities are better outsourced. To allow this outsourcing, the necessary pilot infrastructure should be readily available, and companies should have easy access, without conflicts of interest with the organization or company that is running the pilot plant. Furthermore, the infrastructure available should be diverse and comprehensive, to allow the scale-up of a wide range of processes and finally, the pilot plant organization should have a critical mass of people to cover the many aspects of the bio-based economy.

With fermentation units up to 15 m3 scale, pilot scale biomass pretreatment equipment, chemical reactors up to 5 m3 and an extensive set of pilot scale downstream processing equipment, BBEPP is often the missing link for companies to bridge the gap in the innovation chain.

This presentation will show how Bio Base Europe Pilot Plant addresses these concerns, how the pilot facility is set up, what bio-based processes are run and how it can help companies to bridge the gap in the innovation chain. Several case studies will be presented.

Track 3: Advanced Biofuels and Biorefinery Platforms

Session 1 Monday, April 18 8:30am- 10:00am
Cellulosic Biorefineries - Where Are We Today and Where will We Be Tomorrow

Moderator: Steve Hartig, ICM
Cellulosic Ethanol--Where are we today and where will we be tomorrow?
2014 and 2015 were supposed to be the years of large scale production of cellulosic ethanol which has not happened. This talk will give an overview of industrial progress in this field on a global basis highlighting some of the issues and challenges that have occurred along with giving a view on the future. It will then review ICM's progress on both 1.5G corn fiber cellulosic ethanol and 2.0G cellulosic ethanol from crop wastes and give our view for the future.

Yinbo Qu, Shandong University
Combined Pulp-Ethanol-Fulvate Production By A Biorefinery Platform Of Agricultural Residues
For improve economic feasibility of cellulosic ethanol from agricultural residues, such as corn stover and wheat straw, all components of the biomass should become products instead of to be wastes, and at least one of them should have a relative higher value. A Chinese pulp and paper company, Shandong Tranlin Group has developed a set of technologies to produce pulp and paper from about million tons of straws by ammonium sulfite process, and produce fulvic acid as fertilizer from the waste pulping black liquor. A very large amount of waste straw (small piece of straw or chaff, about one third of feedstock) was leaved there without valuable usage. A new process was proposed to produce ethanol from those waste straws. Since the black liquor contains a large amount of oligosaccharides and nitrogen, it was fed into bioreactors as inducer and nutrients for cellulase production on-site by a fed-batch fermentation process with very low cost. The xylose from hemicellulose hydrolysis also was fermented to ethanol by an engineered yeast strain constructed in our laboratory to increase ethanol concentration and yield. A pilot plant with a capacity of 2,500 tons cellulosic ethanol per year was designed and is constructing now, with expectation to built three commercial facilities with capacity of 100,000 tons ethanol per year accompany with pulp, paper and fertilizer products.

Murray McLaughlin, Bioindustrial Innovation Canada
Industrialization of the Cellulosic Sugar Supply Chain
An economic, long-term sustainable and reliable supply of feedstock is critical for all value chains. The continued development and industrialization of the supply chains required considerable investment, piloting and innovation that starts from the farm or wood lot to production of high quality C5 and C6 cellulosic sugars that are competitive to non-cellulosic alternatives. This panel examines the development of the emerging cellulosic supply chain for renewable energy and bio-based chemicals from the farm to high quality C5 and C6 sugars for energy and chemicals.

Martin Mitchell, Clariant
Clariant's sunliquid® Process: Cellulosic Biorefinery – Key Technology Features, Applications and Economics
More and more economies are looking at possibilities to substitute fossil resources by renewable ones. Lignocelluloses show a huge potential as a new feedstock for the production of advanced biofuels and biobased chemicals globally. Clariant's entirely integrated sunliquid® process converts lignocellulosic agricultural residues, such as cereal straw, into cellulosic ethanol or other biobased chemicals in a way that is highly efficient, economic and sustainable. An integrated enzyme production from the cellulosic material itself, results in lowest enzyme costs as it eliminates additional formulation and transportation and makes plant operators independent from external suppliers. The production cost can compete with those of first-generation bioethanol and the greenhouse gas savings of the sunliquid® ethanol are 95% compared to fossil fuels.

Since July 2012 Clariant has successfully been operating a pre-commercial plant in Straubing, Germany, with an annual capacity of 1,000 tons (1.25 million litres/330,000 gallons), converting approximately 4,500 tons of lignocellulosic feedstock per year. In collaboration with Mercedes-Benz and Haltermann, Clariant has successfully tested its sunliquid®20 –a premium-grade E20 blend that contains 20% cellulosic ethanol from the pre-commercial plant in Straubing, in a fleet test with Mercedes-Benz series vehicles. The fuel showed excellent performance and sustainability properties without being in competition with food- and feed production.

In addition to the application in the transport sector, sunliquid offers a platform for conversion of agricultural residues into a range of chemicals for different applications. Clariant finished a technology

integration package with its joint-venture partner Scientific Design to convert bio-ethylene from cellulosic ethanol into derivatives such as ethylene oxide, bio-MEG and other biobased products. Furthermore, sunliquid® offers access to low cost cellulosic sugars for further conversion.

Session 2: Monday, April 18 10:30am-12:00pm

Moderator: Christophe Luguel, IAR
Christian Magro, Processium
Jean Christophe Duval, ARD
Guy Helin, Syngulon

Filling The Gap From Lab Scale To Commercialization: De-Risking Investments And Reducing Time To Market

In the field of the industrial biotechnologies, designing, building and testing new microorganisms is a key activity at the basis of number of innovations. During the past decades, progress and breakdown in the biology have been so important until hydrocarbons are now produced by fermentations. Number of start-ups together VC's have set up their business on this type of innovation. But what about process development?

By experience, we have notice a real need for accompanying customers when their projects reach a certain level of maturity.

Succeeding in a scale-up not only requires efficient equipments, pilot and demo facilities, but also skilled people with specific competences who are able to manage the interface between metabolic engineering and bio process engineering (including DSP).

Modelling, simulation, physico-chemical characterization is an essential steep to select the most adapted technologies to customer case before entering into a costly scaling up process

When it comes to validate an industrial investment (+/- $100 M) it is essential to reduce uncertainties in terms of process robustness and economics.

There is a need to insure the robustness of strains, to test industrial substrates and often to scale-down.

flexible and multi-purpose demo plant have proven to be the best way to produce first tons to promote and qualify product in the markets.

Finally microbial technologies may require genetic technologies tools to make microbial strains involved in industrial process more efficient and safe:

- Genetic Security (industrial microbes will not duplicate in another manufacturing plant)
- Yield increase by industrial Genetic Bio-control (industrial microbes of interest will dominate in the production fermentor)
- Contamination prevention: protection of the micro-refineries against microbial invaders
- Genetic Safety or gene containment (industrial microbes will not be able to reproduce in the environment)

Session 3: Monday, April 18 2:30pm- 4:00pm
Radical Approaches to Conversion Technologies

Moderator: Alex Baker, Leaf Resources Ltd
Glycell – a pretreatment process platform for the conversion of lignocellulosic biomass to fuels and chemicals

Development of effective low cost lignocellulosic biomass pre-treatment has been a significant challenge for the emerging biofuel and green chemical industries. Here we present a biorefinery concept that uses crude glycerol from biodiesel production as a renewable solvent for effective deconstruction of a range of

wood and grass lignocellulosic fibre sources. The continuous pretreatment process has been demonstrated at the pilot scale. Advantages of this process over dilute acid pretreatments include

- higher yields of cellulose,
- separation of hemicellulose and cellulose sugars,
- faster and more quantitative enzymatic hydrolysis of the cellulose fraction, and
- reduced formation of sugars decomposition products that inhibit fermentation.

Optional deacetylation in the Glycell preconditioning step further reduces inhibitory compounds in sugars products. Glycerol recovery is central to the platform and can demonstrate attractively short pay-back time on the additionally capital cost of glycerol recovery. The advantage of a clean stream of pentose sugars and a refined glycerol also add options to the co-product mix, and when used together demonstrate very attractive techno-economic outcomes.

Perry Toms, Steeper Energy
Hydrofaction™: Renewable fuel oils from Steeper Energy's HTL technology – game changing economics to power and decarbonize the transport sector
With offices in Denmark and Canada, Steeper Energy, is commercializing its proprietary hydrothermal liquefaction technology, Hydrofaction™, and showing the path to sustainable lignocellulosic-derived transport fuels.

Hydrofaction™ utilizes supercritical water chemistry and homogenous catalysts to convert biomass residues directly to renewable fuel oil or Hydrofaction™ Oil. This oil has similar fuel characteristics to high-grade ultra-low-sulfur marine fuels and it is amenable to refinery upgrading to diesel, jet and HFO fuels as well as renewable lubricants and chemicals.

Focusing on all aspects of the value chain from feedstock flexibility to process efficiency and upgrading as well as validating market acceptance, process scale-up and economic feasibility, Steeper has engaged in strategic collaborations and targeted research demonstrating its unique value proposition. Hydrofaction™ has proven its superior conversion chemistry, at pilot-scale, in Denmark and Steeper has completed commercial engineering designs for future large-scale (2000+ barrel per day) projects. The next step in the commercialization of Hydrofaction™ is an industrial scale demonstration facility.

Upgrading of Hydrofaction™ oil to finished transport fuels has been shown at bench-scale and is being scaled-up at a pilot in Calgary, Canada. Along with advances in the core technology, support systems and oil upgrading, Steeper is engaged with potential end-users and market regulators to ensure a high value path-to-market for its renewable fuel oil.

Hydrofaction™'s high conversion efficiencies result in compelling economic returns and over 80% GHG emission reductions over conventional energy. This is achieved by a unique platform that exploits supercritical water chemistry while maximizing oil yield and oil quality. The presentation will provide an overview of Steeper Energy's technology validation activities with emphasis on market opportunities, economics and GHG emissions savings.

Frederic Clerc, Polytechnique Montreal
RISK-BASED APPROACH FOR DESIGNING SUCCESSFULL BIOREFINERY STRATEGIES
There is little argument whether the forest products industry must transform in order to restore or maintain its competitiveness over the longer term while taking advantage of the bioeconomy. In recent years, forestry companies have been driven by cost-cutting strategies, however several mills around the world are now engaged in the identification of transformative solutions, through the so-called forest biorefinery.

A particular company could consider many possible biorefinery routes for implementation, and decision-making regarding the most promising route is not obvious especially at this early stage of design. To be successful, a focus on strategic planning at the corporate level is essential considering not only technology

opportunities assessment, but also the assessment of market and value chain strategies for competitive position in the longer-term.

A phased-approach for implementing the biorefinery will be presented, where for each phase, technology and market risks are identified and addressed, and where the technology strategy serves the business strategy. A systematic tool for decision-making will also be presented where not only typical economic metrics are used to assess the potential of a biorefinery strategy, but also a combination of risk-based metrics considering economic, business, environmental and financial risks, at the early design stage.

Through a case study, this poster also outlines a systematic approach for defining transformative strategies considering critical factors such as biorefinery technologies, proven production scales, emerging market opportunities, market competitive advantages, market value proposal associated with product portfolios, the integration potential of the biorefinery strategy at the corporate and mill level, the identification of the level of technology, market and business risk of each strategy at an early-design stage, and the economic viability of each biorefinery strategy option.

Session 4: Tuesday, April 19 2:30pm-4:00pm
The Aviation Biofuels Opportunity

Luuk van der Wielen, BE-Basic and TU Delft
Darrin L. Morgan, Boeing, Director Sustainable Fuels Strategy

Sustainable biofuels critical in reducing the GHG-reduction targets of the global aviation sector in 2050 to 50% of that in 2005, and to grow carbon neutral from 2020 onwards. This is a huge ambition from a sector that still grows 4-5% annually.The global scenario is roughly a doubling of fuels consumption towards 2050, of which the majority has to be sustainable biofuels with GHG-savings of 80+%. Todays aviation biofuels are mostly based on hydrotreated used cooking oils and other oil residues, but the required scale and nett GHG-savings require availability of biorenewable and lignocellulosic biofuels. These are emerging. This development represents a huge opportunity for the biobased industries, a very attractive and significant investment possibility and a significant challenge for all stakeholders involved.

Most scenario's indicate that this development can only be successful with joint efforts of all stakeholders involved: aviation and fuels industries, agro-sector investors, governments and technology providers. Several countries have produced national strategy documents to cope with this opportunity. The proposed session brings together industry and academic leaders from the aviation sector to address bottlenecks to reach this global goal, discuss options to solve those, and map the path forward. The session will discuss impacts from logistics and scale, feedstock-technology combinations, biorefinery and cascading, and integrated development in industry clusters. The format is an interactive panel discussion on provocative propositions, and the stage is set by pitches of the panellists.

Session 5: Wednesday, April 20 8:30am-10:00am
Mitigating Commercialization Risks through Diversification and Partnerships

Mark Kirby, S2G Biochemicals Inc.
Strategic Partners, Trials and Demonstrations – A Successful Path to Commercialization
S2G Biochemical Inc. (S2G) has developed a proprietary technology process that converts low-cost byproducts of the biodiesel, agricultural and forest products industries such as glycerine and cellulosic sugar into high-value biochemical glycol and related materials. Started in 2009 with founding technology and financial investment, S2G and partners have invested over $16 MM to progress the viability and stability of the sugar to biochemicals process. Following a deliberate path to commercialization, S2G's technology has been successfully proven and de-risked at lab, pilot and commercial scale. Commercial production of biochemicals is expected to be online by the end of 2016.

It is challenging for technology companies to navigate the complex path to commercialization. Entrepreneurs, starting with innovative technology, processes and lab results, have the goal of quickly

building a viable commercial business, but in reality this journey takes longer and turns in unexpected directions. In addition to the technical challenges, building viable biochemical plants often takes hundreds of millions of dollars that are not easily available to small companies for unproven (at commercial scale) technologies. The key to moving forward with commercialization for S2G was the active engagement of a consortium of strategic partners, including Fortune 100-sized companies, that bring financial strength, market pull and resources to bear on the commercialization challenges, including analytical capabilities, market knowledge, operating experience and equipment. The partners provide focus with intensity and professionalism, but also value the contribution of a smaller, nimbler technology company.

This session explores the journey of a technology company through lab, pilot, demonstration and commercialization of an innovative technology with a powerful strategic partner.

Gilles Amsallem, Arbiom
Changing the second-generation paradigm: mitigating development risk through product diversification
Industrial scale second-generation technologies have focused on production of bio-ethanol and have led to technologies limited to this application. As a consequence the relevancy of these technologies and of the efforts invested in their development is directly dependent on the respective prices of biomass and ethanol. This significant risk can be mitigated by developing ligno-cellulosic fractionation technologies capable of sourcing sustainable carbon to an array of markets and applications. A process tailored to accommodate multiple applications for each fraction of the biomass enables selection of best fitting/higher margin applications in each deployment, thereby enabling further and wider deployment. Arbiom has developed a low temperature, phosphoric acid based process allowing the recovery of each fraction of the biomass (C6, C5, lignin) in a state compatible with a wide variety of sensitive downstream conversion technologies. Furthermore, Arboim has established an Application Platform aimed at demonstrating and optimizing the compatibility of its renewable carbon intermediates with downstream applications to build a complete applications portfolio.

Ian McGregor, Drystill
Pass-through Distillation: A New Low Temperature, Low Energy Separation Technology
Conventional distillation is a key unit operation in most biofuel plants and biorefineries, figuring prominently in capital and operating costs. It is such a mature and well-established technology that its drawbacks, notably high temperatures and high energy demand, tend to be accepted as unavoidable process constraints.

A breakthrough, however, is now at hand. Major economic advancements result when the familiar “boil/condense” process becomes "boil/absorb/desorb/condense”. The new method is in the public domain and has been given the name "Pass-through Distillation (PTD)". As an example of its relevance to the Biotech Industry, PTD is able to boil a fermentation broth at room temperature - preserving enzymes and biocatalysts - using less than half the energy of a conventional beer column.

Drystill Technologies of Mississauga Canada has developed proprietary equipment that makes the PTD process affordable, compact and easy to service.

This paper presents the many obvious and not-so-obvious benefits of low temperature, low energy distillation, along with Drystill's pilot plant experience.

Sam Jackson, Genera Energy Inc.
Cellulosic Feedstocks: Mitigating Risk and Cost Through a Portfolio Approach
Risk and cost. These are the two primary factors facing the wide scale production of cellulosic feedstocks. Risk is associated with farmer recruitment, productivity/availability of the desired crop, and impacts of climatic or biological factors. Costs are impacted by those same factors along with supply chain operations, logistics, storage, and loss. Mitigating these concerns is critical for moving the bio-based industry forward. Dedicated energy crops can offer significant supply chain flexibility. This flexibility increases with the inclusion of crop residues. Genera Energy has actively developed feedstock supply chains that incorporate a portfolio of feedstocks to reduce both cost and risk to the end user. Portfolio approaches to feedstocks can reduce overall costs by more than 10% and reduce risk associated with

relying on a single feedstock. Significant reductions in feedstock storage and loss, greater equipment efficiencies, and improved logistics will all provide additional value to a biomass user.

This presentation will review commercial feedstock supply chain implementation incorporating multiple feedstocks. A case study of both single feedstock and a portfolio supply chain solutions will be presented to compare and contrast to two approaches. The lessons learned in actual on-the-ground operations of these supply chains will be reviewed. This innovative approach to feedstock supply has been developed by our company to advance the biomass supply industry and it will increase the likelihood of success of any biomass-dependent facility or project.

Genera Energy has developed efficient, economical supply chains for a variety of clients and users. The company works to optimize crop portfolio selection and production as well as downstream operations including harvesting, logistics, storage, and preprocessing. With the most experience of anyone in the industry with multiple feedstocks, Genera has developed industry leading feedstock supply chains.

Joe Regnery, ZeaChem Inc.

Session 6 Wednesday, April 20 10:30am- 12:00pm
Developing Carbon Neutral Fuels in an Era of Low Price Crude

Moderator: Victor Oh, Lux Research
Highlighting Global Trends and Emerging Technologies in Alternative Fuels in an Era of Low Priced Crude
The alternative fuels industry is maturing, commercializing, and realigning to adjust to an era of lower priced crude, limited infrastructure, and wavering policies. Leading technologies differentiate from competitors in the ever evolving space by leveraging strategic partnerships and implementing innovations along the entire value chain. We explored over 1,800 alternative fuel production facilities around the world that were planned, operating, or shuttered between 2005 and 2018 to identify emerging producers and global trends in the alternative fuels space. As the industry transitions away from first-generation biofuels we also highlight the role of novel fuels and novel feedstocks in driving future capacity expansion and outline various commercialization strategies to transition these technologies into reality.

Peter Matrai, Joule Unlimited
Recycling Waste CO2 into Liquid Fuels: A Path to Carbon Neutral Mobility
We live in a combustion-centric world, dependent on a cycle requiring millions of years to convert carbon into fuels that enable global mobility. Today it is possible to reduce this conversion to a single step; recycling waste CO2 directly into sustainable, drop-in fuels. Because their production consumes as much CO2 as they emit when burned, these fuels offer a viable path toward carbon-neutral mobility. The process recycles CO2 directly and continuously from industrial emitters, converting otherwise harmful greenhouse gases into the transportation fuels upon which our global economy depends.

The IEA projects that 10% of fuels must come from low carbon sources by 2030 if we are to satisfy economic growth while limiting global warming to below 2° C. If broadly deployed, this technology alone could meet this entire demand with limited acreage of non-arable land and recycling 3.8 gigatonnes of CO2 into carbon-neutral fuels.

This presentation will address the current status and potential of this novel production platform, including:

- Reversing combustion: how it works

- Advancement from lab to field demonstration

- Global applicability

- Advantages as a carbon mitigation solution

Thomas Buhl, Global Bioenergies
From Carbohydrates To Cost-Competitive Drop-In Hydrocarbons
Many governments would like to push bio-fuels beyond the current ethanol blendwall. The presentation

will show how this can be achieved through a solution, which, on top, allows blending significant amounts of very cheap (fossil) butane, yielding isooctane, a molecule with excellent vapor pressure properties.

Isooctane can be blended into gasoline at very high ratios. It can e.g. be synthesized from 1 molecule of bio-isobutene + 1 molecule of isobutane (from butane). The bio-isobutene fermentation process is currently in the industrial pilot process, with the construction of the demonstration facility ongoing - expected start of operations of the demonstration facility: mid 2016.

Timothy Cesarek, Enerkem Inc.
Renewable Chemicals And Biofuels From Waste To Close The Loop Of The Circular Economy
"We are proud that municipalities around the world are looking at the City of Edmonton and the Enerkem facility to see how they too can divert waste from landfill while producing clean fuels and chemicals through this innovative technology." – Mayor Don Iveson, City of Edmonton, Alberta

The world's very first full-scale biorefinery to use non-recyclable municipal solid waste (MSW) as a feedstock recently reached a pivotal milestone when it initiated biomethanol production at the commercial scale – a game-changing success which had never been accomplished before anywhere in the world.

This facility, called Enerkem Alberta Biofuels, will soon begin delivering commercial quantities of renewable methanol, a tangible step towards closing the loop of the circular economy.

In 2009, Enerkem and the City of Edmonton signed a 25-year agreement. The agreement followed a highly competitive global technology review and qualification process in which the City evaluated more than 100 waste diversion technologies.

Under the agreement, the City of Edmonton agreed to provide Enerkem with 100,000 dry, prepared and sorted metric tons of non-recyclable MSW for a 25-year period while Enerkem committed to take the feedstock as well as build and operate a waste-to-biofuels facility in Edmonton.

This is the first collaboration between a waste-to-biofuels producer and a metropolitan center to address waste disposal challenges. This facility is becoming a model for other municipalities, urban and rural, on how to sustainably manage their waste and increase waste diversion rates.

The company has developed the first technology capable of breaking down chemically and structurally heterogeneous waste materials and convert them into a pure, stable and homogeneous syngas. This syngas is then converted into renewable fuels and chemicals which can help reduce carbon dioxide emissions, aid in extended producer responsibility and meet the growing world demand for renewable chemicals.

Track 4 Algae, Biomass Supply, and Specialty Crops

Session 1: Monday, April 18 8:30am- 10:00am

Moderator: Len Smith, Heliae
Matt Carr, Algae Biomass Organization
Peter Lammers, Arizona State University, Arizona Center for Algae Technology and Innovation (AzCATI)
John Carney, Consultant-Mars Inc.
Ross Zirkle, DSM

Charting the New Algae Industry Roadmap
Is algae's place in industrial biotechnology going to be secure any time soon? The algae industry underwent explosive growth in the late 2000's with many organizations formed and funded with the aim of opening an alternative pathway to biofuel production. However in the years that followed the "summer of algae" many organizations that once looked so promising went bust or slimmed down, funding became scarcer, and many of the survivors have abandoned the dream of algae biofuels in hopes of finding success in health and nutrition. While promising on paper, quick wins from algae technology have proven challenging, if not elusive.

This panel of industry leaders taken from a leading consumer products company (Mars, Inc. and DSM), algae production and platform development (Heliae), algae research (ASU/AzCATI) and algae policy (ABO) will look at where the algae industry is at today and where it is going from a number of perspectives. Attendees can anticipate and participate in an open discussion exploring the challenges the industry faces, where progress has been made, and what is likely up ahead for the fledging industry as it tries to secure its place in industrial biotechnology.

Session 2: Monday, April 18 10:30am-12:00pm
Solving the Biorefinery Feedstock Supply Conundrum

Moderator: Allen Julian, MBI
AFEX™ solves the biorefinery sustainable feedstock supply conundrum
Despite the groundbreaking importance of the current cellulosic biorefineries operated by DuPont, Poet/DSM and Abengoa, these plants are too small to be commercially relevant. The size of these plants is limited by the sustainable feedstock supply.

Decoupling the production, harvesting and transport of feedstock from the siting of the biorefinery using an Advanced Logistics System, as described by the BETO Multi-Year Program Plan (November 2014), is critical in achieving economically scaled cellulosic biorefineries.

The paradigm changing AFEX™ pretreatment technology (compatible with multiple crop residues and energy crops) enables the development of a distributed AFEX depot system that is compatible with the Advanced Logistics Supply model and can support feedstock supply to commercial scale cellulosic biorefineries.

AFEX generates a dense, digestible and shippable commodity intermediate which can be blended to standardized specifications and which can hydrolyzed at high solids concentration (>20% solids loading) to produce concentrated sugar streams that are compatible with microbial fermentation without significant further processing (pH adjustment, detoxification etc.). The digestibility of the AFEX pretreated biomass also makes this material valuable as a high energy cattle feed.

The scalability of both the AFEX technology itself and the use of the pelleted AFEX treated biomass (the AFEX commodity product) in fermentations to make both second-generation bio-fuels (ethanol) and bio-chemicals (succinic acid) have been proven at the MBI facility in Lansing Michigan.

Romain Fouache, Arbiom
Reducing industrialization risk of bio-refineries through integration within the woody biomass value chain
Woody biomass applications such as pulp and paper, energy or construction currently face difficult market conditions. The companies in these markets, however, possess significant assets in the form of their control over the biomass supply chain, industrial know-how and sites, as well as underleveraged biomass residues. In parrellel, innovative bio-refinery technologies offer significant market opportunities but are still to be demonstrated at large industrial scale. Common interest guides co-location/development partnership that can lead to improved margins across industrial sites and significantly reduces the industrial deployment risk for new technologies. Arbiom, a second generation bio-refinery technology company, has engaged in such a partnership with paper company Norske Skog Golbey to develop a joint bio-refinery concept using locally available biomass from France and the industrial installation available on site.

Sarah Hickingbottom, LMC International
Feedstocks - crude oil's influence and what price and where
How has crude oil's influence on agricultural feedstocks evolved over the past 5 years -particularly since the crude price has fallen? How might this influence further evolve over the coming decade? Do biofuels influence the price of feedstocks directly? Or indirectly? Or not at all? If so, how exactly? And how might this influence further evolve given changing government policies and agricultural dynamics?

This presentation will clearly lay out the price realities of feedstocks to conference delegates - how grains are influenced as compared to sugarcane and sugar beet as well as vegetable oils. Plus, how different countries around the world shape local price dynamics.

Supply, demand, policy, land and logistics will play into the analysis - as new land is drawn into supplying new demand to influence global prices. And to what degree investment levels are hindering or supporting development of agriculture. Where in the world should be supplying the cheapest feedstocks in 2016, in 2020 and 2030? And where in the world is trending towards more expensive supply?

Whilst these are issues which have been discussed previously, it is useful to re-assess the economics of feedstocks in 2016 as the bio-based chemicals industry moves towards commercial scale. Once capital costs have been spent, the realities of variable costs will be dominated by feedstocks. Hence, it is fundamental to think about the world feedstock supply and North America's role within that world.

Can bio-based chemicals compete against petrochemicals - given scenarios based on crude oil prices and the associated price points of crops?

LMC INTERNATIONAL is the leading independent economic and business consultancy for the agribusiness sector around the world. From crops and agricultural commodities to agro-industrial products and downstream end-uses, we provide global business intelligence and market analysis on issues of production, demand, prices (including forecasts), trade and policy.

Frederic Peilleron, Cascade
Innovative Optical Technology for Improved Algae and Agriculture Production
Algae are considered to be a promising long-term sustainable source of biomass and biofuel but large scale commercial adoption will require improved economics. Similarly, agriculture is continuously looking to improve yields. One approach to reduce the costs of algae or agriculture production involves the use of special agricultural films or photobioreactors which promote increased levels of photosynthesis for autotropic algae and plants.

Exploiting more than twenty years of research on light cascade effects by the French research laboratory LPRL, the company Cascade has developed optically active additives for greenhouse films or photo bioreactors which accelerate the natural process of photosynthesis. Only a fraction of natural solar radiation is in the wavelength range useful for photosynthesis, particularly light with wavelengths between 400 and 500 nm (blue light) and 600 to 700 nm (red light). Cascade’s optically active additives convert a portion of the solar spectrum not advantageous to plants into wavelengths that stimulate photosynthesis, leading to improved algae growth and crop productivity. The additives have been designed for incorporation in polyolefins used in agricultural greenhouse films or PMMA used in photobioreactors.

Preliminary tests employing low tunnel plastic films doped with Cascade additives have demonstrated promising results for crops including tomatoes, melons and strawberries, including 10-20% increased biomass, improved crop precocity, and enhanced crop quality (improved sugar levels in fruits). For algae, initial tests on chlorella have shown significant yield improvements.

Cascade is closely working with the French academic laboratory INRA and leading agricultural film manufacturers to complete further field tests involving algae cultivation, such as spiruline, as well as crops such as melons, strawberries… in order to optimize and industrialize its technology.

Session 3: Monday, April 18 2:30pm- 4:00pm
Latest Technologies in Algae Cultivation

Moderator: Valerie Harmon, Harmon Consulting Inc.
Mark Huntley, Cornell University
Packo Lamers, Wageningen UR, AlgeaPARC
Peter Lammers, Arizona State University, Arizona Center for Algae Technology and Innovation (AzCATI)
Braden Crowe, California Polytechnic State University

Current State of Technology in Algae Cultivation
Valerie Harmon1, Peter Lammers2, Tryg Lundquist or Braden Crowe3, Dorinda Kleinegris or Packo Lamers4, Mark Huntley5

1Harmon Consulting Inc., 2Arizona State University, 3California Polytechnic State University, 4Wageningen University and Research Center, 5Cornell University

Key improvements and progress in production methods is vital to the expansion of the algae industry to meet our increasing needs for sustainable alternatives for production of biofuels and bioproducts. As a biomass source that can be produced at high production rates and without conflict for water and land currently utilized for food production, research into cost effective production methods of the biomass is critical for the expansion of this industry. Experts researching means to improve productivity from various algae production systems will come together to discuss their approaches to microalgae production, and research results.

Presentations in this session will cover the diversity and richness of microalgae species and production systems. Specific topics will address progress in: open pond biomass productivity and methods; extremophiles and mixotrophy; algae production in reclaimed waste water and nutrient recycling; and progress and developments in photobioreactor cultivation systems, both for inoculum and final stage production systems. The experts involved in this research will speak directly to the benefits of the various production systems for various products and markets.

Session 4: Tuesday, April 19 2:30pm-4:00pm
Regulatory Growth and Commercial Development in Alternative Feedstocks and Algae

Moderator: David Glass, D. Glass Associates, Inc.
Updating the Coordinated Framework: What does it mean for biofuels and bio-based chemicals?
On July 2, 2015, the White House Office of Science and Technology Policy announced that it had issued a memorandum to the heads of the EPA, the U.S. Department of Agriculture, and the FDA, directing these agencies to begin a review of their biotechnology regulations under the 1986 "Coordinated Framework", to determine whether revisions, updating, or other changes might be needed in view of new technologies and other developments since the adoption of the framework. As stated in the memorandum, the goals are "to modernize the Federal regulatory system for the products of biotechnology and to establish mechanisms for periodic updates of that system". In the latter half of 2015, these agencies began this process by holding a series of public meetings and posing specific questions to solicit public comment.

Over the years, the Coordinated Framework has provided a sound basis for science-based regulation while creating a path to the market for products judged not to have unreasonable risks. Under the Framework, industrial biotechnology activities have been subject to EPA regulation under TSCA, USDA regulation under the Plant Pest Act, and FDA oversight over animal feed ingredients. How will this ongoing regulatory review and possible revisions affect industrial biotechnology companies? Will there be significant changes to those rules covering bio-based production of fuels and chemicals, and if so, will the impact be positive or negative? This presentation will summarize the government's actions to date and will assess the impact of this review process on industrial biotechnology.

Keith Matthews, Sidley Austin LLP
Regulation of Genetically Engineered Crops in the United States
Globally the area under cultivation with Genetically Engineered crops has risen continuously for nineteen straight years. In 2014, there were 181.5 million hectares planted with genetically engineered crops, 73.1 million of which were in the U.S. The global market value of these crops was $15.7 billion. While the safety of GE crops, and the sustainability benefits that accrue from their cultivation, are not questioned by those who know the science, these crops are, nonetheless, subjected to strict regulatory scrutiny. The United States, which has the most rigorous and effective Ag Biotech regulatory program worldwide, has recently initiated a comprehensive evaluation of its Ag Biotech regulatory scheme (The Coordinated Framework), with the intent to update its regulatory approach to "ensure that the system is prepared for the future products of biotechnology". This presentation will elucidate aspects of the Ag Biotech regulatory system in the U.S., and will provide insights on possible changes that may result from the comprehensive evaluation of the Coordinated Framework.

Kristi Snell, Metabolix, Inc.
Enhancing Crop Yield and Value Through Transcriptome Metabolic Engineering
The expected growth in global population from the current 7 billion people to 9 billion by 2050, together with changes in diet in developing nations, requires that agriculture increase crop productivity by 70%. This growing population and the infrastructure required to support it will place further pressure on land and scarce water resources. In addition, changing weather and precipitation patterns associated with global climate change has the potential to further reduce food production areas. To meet these challenges, new approaches for enhancing food crop yield will be necessary. Metabolix is a pioneer in the field of metabolic engineering in both microbial systems and in the deployment of microbial metabolic pathways in crops. The Company's crop activities were initiated to produce a microbial polymer PHB. The key technical hurdle in these efforts was to shift 10-20% of the fixed carbon in the plant to this new molecule. In addressing these challenges the Company initiated a series of research activities to enhance plant photosynthesis and improve the efficiency of carbon utilization in plants. The Company uses advanced metabolic engineering to debottleneck key steps in plant photosynthesis and carbon conversion pathways in combination with global transcription factor genes to address these challenges, creating a new paradigm for crop science to enhance global food security. Based on a series of yield enhancing traits developed in the program, Metabolix announced its intentions to spinout its crop science programs into a new company to be called Yield10 Bioscience. Yield10's mission is to enhance global food security by enabling step changes in food crop yield. Aspects of the new company's approach and objectives will be discussed.

Gwendolyn McClung, EPA
Regulation of Genetically Engineered Algae under the Toxic Substances Control Act
EPA's Office of Pollution Prevention and Toxics (OPPT) is responsible, under the Toxic Substances Control Act (TSCA), for regulating certain genetically engineered microorganisms (GEMs) manufactured, imported, or processed for commercial purposes. TSCA regulates "intergeneric" microorganisms which means a microorganism formed by the deliberate combination of genetic material originally isolated from organisms of different taxonomic genera. GEMs subject to TSCA include a wide variety of applications such as fuel production, biomass conversion, waste treatment, biofertilizers, bioremediation, and enzyme and chemical production.

Information/data on a GEM, its manufacturing process, and intended use are needed for OPPT to conduct a risk assessment of a GEM. To assist companies in providing information, there is a guidance document, Points to Consider (PtC) in the Preparation of TSCA Biotechnology Submissions for Microorganisms. The PtC was last revised in 1997 accompanying promulgation of the rule, Microbial Products of Biotechnology. OPPT is revising the PtC to cover other microorganisms such as algae, viruses, and protists, and new genetic engineering techniques that were not on the horizon for TSCA uses three decades ago. PtC revisions are addressing the emerging industry of commercial-scale cultivation of algae for biofuels and bioproducts. OPPT held a public workshop on Sept. 30, 2015 to allow the algae industry and public to comment on whether our "considerations for GE algae" are appropriate. A "Draft Algae Guidance" document is now being developed based upon comments received from that workshop. OPPT will seek public input on our "Draft Algae Guidance" in the fall of 2016.

Session 5: Wednesday, April 20 8:30am-10:00am
Public Private Partnerships in Algae Technology Development

Moderator: John McGowen, Arizona State University, Arizona Center for Algae Technology and Innovation (AzCATI)
Thomas Dempster, Arizona State University, Arizona Center for Algae Technology and Innovation (AzCATI)
Valerie Harmon, Harmon Consulting Inc.
Lieve Laurens, National Renewable Energy Laboratory
Kunal Poorey, Sandia National Laboratory

Algae Technology Development Progress: Algae Testbed Public Private Partnership Progress and Research Results
Algae Testbed Public Private Partnership (ATP3) is a Consortium dedicated to furthering the microalgae

industry through multiple support routes: research, education, testbed facilities and high impact data in support of modeling efforts. Industry utilization of the data and research facilities are vital to progress in the production of biomass from algae for specialty chemicals, food and nutritional ingredients. The Consortium has been focused on a series of long term cultivation trials in 2014 and 2015 involving 5 testbed facilities located in differing climates in the United States: Southwest, Desert; Western, Coastal; Southeast, Coastal; Southeast, Inland; and Pacific, Tropical. All testbed facilities are equipped with identical production systems for inoculum production and open pond operation. A series of focused and well defined experiments have been conducted simultaneously by all sites in year one to determine a baseline strain and production method to optimize in year 2.

Presentations in this session will cover the diversity and richness of the programs and data that the Algae Testbed Public Private Partnership have encompassed. Presentations in this session will encompass: open pond biomass yield and pond reliability from consortium network sites comparing strains, geographic and environmental variation; open pond ecosystems, pond crash forensics, and optimal open pond management strategies; proximate composition of biomass and factors that drive variation in biomass composition ranging from nutrition to pond ecosystem components, and finally, the educational and testbed network system used to generate this data is available for use by the industry. The experts involved in this research are directly available to the industry via regularly scheduled classes and workshops, as well as through utilization of the world class testbed facilities.

Session 6: Wednesday, April 20 10:30am- 12:00pm

Simon Barnabé, Université du Québec Trois Rivières
Pascale Champagne, Queen's University
Patrick Hallenbeck, USAFA
Marc Strous, University of Calgary

Strategies for Sustainable Algal Biofuels Production
This panel will discuss different strategies that are under investigation at the bench to pilot scale for the sustainable production of algal biofuels. These include the use of mixotrophic growth on cheap carbon substrates, the use of wastewater to supply nutrient needs, the synergies in co-location of algal production facilities with industrial plants, in particular the aluminum industry, and the use of highly alkaline conditions to improve cost effectiveness of algal biotechnology. Particular focus will be placed on how these strategies can be applied to improve biomass and biofuels production under the less than ideal conditions, suboptimal temperatures and light intensities, that prevail in Northern temperate climates.

Track 5: Synthetic Biology and Genomics Research

Session 1: Monday, April 18 8:30am- 10:00am
Genomics Pushing the Boundaries of Advanced Manufacturing

Moderator: Robert Walsh, Intrexon
Bioconversion Of Natural Gas To Isobutanol : From Bench Scale To Pilot!
The low cost and abundant supply of natural gas have been motivators for the development of many technologies that convert this low cost carbon feedstock into compounds of greater value. Natural gas bioconversion is an example of a developmental technology which exploits a methanotroph, a methane consuming bacteria, by applying synthetic biology to program it to produce higher value materials of interest, such as biofuels or terpenes. Isobutanol production has increased 2500 fold since early 2014 and rate of improvement is rapidly increasing at bench scale. However, to successfully bring this technology to commercial scale, consideration must be given not only to optimizing the metabolic pathway engineered into the methanotroph, but to key issues in the fermentor design and downstream processing. Our pilot plant will be mechanically complete by year-end, and in April we expect to be able to discuss our initial results from several months of operations.

Jens Schrader, Dechema Research Institute
Methanol: the revival of an alternative feedstock for industrial biotechnology
Methanol represents an attractive alternative feedstock for industrial biotechnology [1]. Methanol can be

efficiently synthesized via syngas from natural gas and other fossil resources, but can also be derived from renewables such as wood, glycerol or biogas. Methanol derived from municipal solid waste or by catalytic carbon dioxide hydrogenation is being investigated as well. All these routes indicate a remarkable flexibility of methanol supply. With a world market of more than 50 million tons/year methanol represents one of the most important commodities of the chemical industry. Methanol-based industrial bioprocesses for single cell protein with methylotrophic bacteria have been successfully operated already in the 1970s up to very large scales. As a biotech feedstock, methanol does not interfere with the use of arable land for food and nutrition, and being a liquid it is much easier to supply and control in bioprocesses than gaseous substrates such as syngas, methane, CO2 or H2. We set out to engineer Methylobacterium extorquens AM1 to produce valuable chemicals from methanol. We focus on dicarboxylic acids and sesquiterpenes, which are of value to different industries, ranging from biofuels to fine chemicals to pharma compounds. We show for the first time, that both compound classes can be efficiently diverted from M. extorquens' unique central ethylmalonyl-CoA pathway not found in conventional hosts. Combining synthetic biology, metabolic and bioprocess engineering, product concentrations in the gram-per-litre scale have already been achieved [2]. Our results build upon excellent research on methylotrophy done by other groups during the last decades [cited in 1], which together may be a promising foundation to revive methanol-based industrial biotechnology in the near future.

[1] Schrader et al. 2009, Trends Biotechnol.; Ochsner et al. 2015 Appl. Microbiol. Biotechnol.

[2] Sonntag et al. 2014, 2015 Appl. Microbiol. Biotechnol., Sonntag et al. 2015 Metab. Eng.

Reuben Sarkar, Department of Energy
Synthetic Biology Foundry: An Engine for Accelerating Advanced Biomanufacturing
The commercial development of a new bio-based renewable chemical can cost between $100-200 million and take 10-15 years based on current state of the art tools and approaches. Synthetic biology tools offer the potential to dramatically reduce the lead time and cost of bringing new renewable fuels and chemicals to market using industrially-relevant organisms. Currently, the industrial biotechnology sector scales up processes on a case-by-case basis, without tools that can be extrapolated for multiple host organisms, pathways, and applications. The Foundry will develop processes for predictable scale-up, improved systems capability, and standards, by establishing a robust biomanufacturing set of principles, which would use standardized DNA elements and commercially relevant and optimized host organisms. These tools would dramatically reduce design, construction, lead-time, and cost for developing biological systems. Ultimately, the Foundry will produce a set of tools and organism development package that would be easily transferred to the biotechnology industry, enabling the scaling of multiple, high-impact chemicals in multiple industrially-relevant host organisms.

Puneet Trehan, IKEA

Jeffrey Dietrich, Lygos
Fermentative production of malonic acid by acid tolerant yeast
Lygos engineers microbes to convert sugar into industrial, high-value chemicals. An important aspect of Lygos' business is identification of market opportunities where biotechnology offers advantages over existing, petrochemical processes. In the case of Lygos' first product, malonic acid, the petrochemical route is based on chloroacetic acid and sodium cyanide, two expensive and hazardous chemicals. A biological route can dramatically reduce production cost, reduce the environmental impact of the production process, and enable a host of downstream market applications. In this presentation, we will discuss new opportunities in bio-chemical manufacturing and how advanced genetic engineering technologies are accelerating development timelines and decreasing the cost of both research and process scaleup.

Session 2: Monday, April 18 10:30am-12:00pm
Computational Prospecting and Enzyme Design

Eric Althoff, Arzeda
New and Improved Chemical Pathways using Computational Prospecting and Enzyme Design
Arzeda is a synthetic biology company focused on providing new bioprocesses for the green manufacturing of chemicals. As a technology development and product company, we leverage our industrially validated enzyme and pathway design technologies to create superior value for our partners in the chemical and biotechnology industries. To this end, we have developed a novel computational technology, Archytas™, and applied it to engineer enzymes toward a wide range of enzyme chemistries and industries. To expand upon our previous technology, we have further developed and applied a technique to rapidly screen through the enormous natural diversity to identify the best enzymes with critical characteristics for industrial success for an application. With new partnerships with Stratos Genomics, for NextGen DNA sequencing, and Mitsubishi Chemical, Arzeda is applying this unique technology to new industries.

In addition to the design of new enzymes, Arzeda has developed a complimentary technology, Scylax™, which is able to design metabolic pathways to new molecules not found in nature. Arzeda is applying its technology to develop Designer Cell Factories to produce these new bio-based chemicals. We have similarly applied the pathway technology to prospect for alternative pathways and enzymes to improve yields of existing pathways. The demonstrated success and wide applicability of our methods open the way for the design of biosynthetic pathways for the industrial scale synthesis of high value chemicals from biomass. In partnership with INVISTA, Arzeda is working on the development of bio-based butadiene production. Additionally in a partnership with DuPont Pioneer, Arzeda has successfully applied its enzyme design technology to develop a novel trait for corn and soybeans and potentially other crops that will increase agricultural productivity. This presentation will delve into these recent successes as well as discuss new opportunities for Arzeda.

Curt Becker, Molecular Assemblies
The Next Step In Genomics: A Next Generation Approach To Writing Genetic Code (Synthetic DNA)
As founding members of Applied Biosystems, Dr. J. William Efcavitch and Curt Becker developed and commercialized the still universally employed chemical method of synthesizing DNA - currently a $1B+ industry, 30 years ago. This contribution to launching the genomics era ($16B in 2015) facilitated the reading of genetic code and led to our deep and growing understanding of biology.

While the short DNA of moderate quality produced by the chemical method has proven sufficient for reading the genome, the limitations in fidelity, length, cost, scale and reliability and the toxic waste produced are an impediment for writing new genomes - engineering DNA and biology.

Curt and Bill have reunited to address these shortcomings by developing a process that uses the enzymes nature has evolved specifically to produce long, high-quality DNA. Molecular Assemblies is developing a revolutionary enzymatic DNA synthesis technology leveraging the way nature makes DNA. As the first generation DNA synthesis method enabled the first era of genomics, this enzymatic method will transform the field again by enabling a host of biological and non-biological applications, markets and the next frontier in genomics. A scalable and reliable process for writing long, high-fidelity, cost-effective DNA will accelerate synthetic biology, precision medicine and a host of next generation applications.

Agricultural, petrochemical and industrial scientists are attempting to re-engineer cells to produce next generation advanced materials, textiles, foods and fuels, while medical scientists place a high demand on the DNA needed to fulfill the precision medicine national mandate.

This enzymatic process utilizes "self-eliminating nucleotide terminator" analogs of each of the four bases that make up DNA.

The Company has an issued patent broadly covering composition of matter, process, and apparatus for enzymatic synthesis of nucleic acids; DNA, RNA and analogs.

Martin Karlsson, Linköping University/InZymes Biotech AB
Metaproteogenomics For Direct Identification Of Industrially Relevant Enzymes And Their Genes
Diverse microbial habitats are expected to hold a great number of yet unclassified microorganisms with

the capability to produce enzymes evolutionarily adapted to the specific conditions. Unfortunately though, due to the pure culturing problem, it is unlikely that the majority of these microorganisms will ever be characterized and hence the potentially valuable enzymes produced by these will remain hidden to us.

However, rapid technology development in mass-spectrometry and next generation sequencing have opened up for large scale metaproteomic and metagenomic studies of microbial communities without the need for pure culturing. Nevertheless, although the methods in theory gives access to the entire protein complement and the entire metagenome of microbial communities, both metaproteomics and metagenomics are largely non-targeting. Thus, neither metaproteomics nor metagenomics will by themselves answer the question of which enzymes, or genes coding for enzymes, out of thousands of possible in microbial communities that are the most valuable and relevant for practical applications.

For identification of novel enzymes for enzyme based industrial biotechnology it is however specific enzymes with desired activities and properties that need to be targeted and identified. In order to be able to exploit the great unearthing potential of microbial communities by metaproteomics and metagenomics, while at the same time be able to separate for and pin-pointing only targeted enzymes we have developed a metaproteogenomic approach based on microbial communities in constructed environments. By this approach it is possible to control the regulation of targeted enzymes and provide samples for metaproteomics and metagenomics that allow for direct identification of the targeted enzymes, including the correct corresponding gene. This is further accomplished with an unprecedented accuracy and hit-rate, which will be exemplified by the identification of novel extracellular proteases.

Debjit Ray, Sandia National Labs
Genomic Prediction & Comparative Analysis Of Pathogenicity Of The New "Super Bug": Clostridium Difficile
Horizontal gene transfer and recombination leads to the emergence of bacterial antibiotic resistance, pathogenic and other traits. Genetic changes range from acquisition of a large plasmid to insertion of transposon into a regulatory gene. HGT events can be identified by comparing a large number of fully sequenced genomes across a species or genus, and find potential sources of new genes. Comparative phylogenomics requires that accurately sequenced, complete and annotated genomes. Due to dramatic advances in "short read" sequencing technology, the raw sequence coverage needed for sequencing a bacterial genome now can be obtained in a couple of days for a few dollars sequencing costs, starting with only a few nanograms of genomic DNA. Assembling closed genomes requires additional mate-pair reads or "long read" sequencing data to accompany short-read paired-end data. We are analyzing the performance for genome assembly of data from the Illumina NextSeq. Bioinformatics improvements are also needed to make rapid, routine production of complete genomes a reality. Modern assemblers such as SPAdes 3.6.0 are capable in a few hours of converting mixes of reads from different library preps into high-quality assemblies with only a few gaps. Remaining breaks in scaffolds are generally due to repeats are addressed by our software for gap closure, that avoid custom PCR or targeted sequencing. Our goal is to improve the understanding of emergence of pathogenesis using sequencing, comparative genomics, and machine learning analysis of ~1000 pathogen genomes. Machine learning algorithms will be used to digest the diverse features (change in virulence genes, recombination, horizontal gene transfer, patient diagnostics). It can be useful for comparing differences in virulence along or across the tree.. This would open new avenues in the prediction of un-characterized bugs and organisms and their evolution and pathogen emergence.

Session 3: Monday, April 18 2:30pm- 4:00pm
Developing Next Generation Renewable Chemicals

Moderator: Kevin Jarrell, Modular Genetics
Direct Production of Acyl Amino Acid Surfactants by Fermentation for use in Personal Care Products
Modular Genetics, Inc. (Modular) has developed engineered microorganisms that convert carbohydrate (for example cellulosic sugar) into acyl amino acid surfactants. Acyl amino acid surfactants, such as acyl glutamate and acyl glycinate, have properties that make them ideal for use in personal care formulations. The surfactants are mild, non-tearing, hypoallergenic and noncomedogenic. Modular has demonstrated the ability to produce acyl glutamate and acyl glycinate surfatants directly by fermentation. Testing by

customers has shown that the surfactants have the performance and purity required for use in commercial formulations. The fermentation-derived surfactants are attractive from the perspective of sustainability since no oil of any sort is used to produce the surfactants. In addition, no synthetic chemistry is used, and the surfactants are purified using "green" processes that consume little energy and use only water as a solvent. Significantly, this green route to surfactant production produces surfactants with high specificity, and produces pure surfactants, which are free of contaminating protein. The surfactants are generated with an unprecedented level of quality assurance with regard to the length of the fatty acid chain of the surfactant, providing a significant competitive advantage relative to production of surfactants from petroleum or seed oils. The ability to directly control fatty acid chain length is a significant value driver given that precise control of fatty acid chain length is the key to stability and performance of personal care formulations that contain surfactants.

Fabien Cabirol, Loreal

Tim Davies, Green Biologics Ltd
Clostridial Pathways: Developing Next Generation Renewable Chemicals with Synthetic Biology
Green Biologics' CTO (Dr. Tim Davies) will present our recent breakthrough on the use of synthetic biology tools to manipulate pathways in clostridial organisms to allow on purpose production of a variety of chemistries from clostridia. We believe clostridia are uniquely robust organisms capable of withstanding a wide range of environments, which makes clostridia an attractive platform for renewable chemicals. Recent advances in synthetic biology have opened up new opportunities to develop clostridia, including manipulation of existing pathways as well as development of entirely new pathways.

Green Biologics is a UK-based renewable chemicals company focused on producing n-butanol and acetone utilizing our advanced clostridial fermentation process (AFP). Several of our patents have recently been published based on a new technology platform we call CLEAVE(tm). A proprietary CRISPR/Cas based method for modifying clostridium genomes, CLEAVE is breakthrough technology that allows rapid and targeted changes in the clostridium genome without leaving behind antibiotic resistance markers or genome scars. This opens up a broad range of opportunities for Green Biologics in food and nutrition, pharma, and fine chemicals as well as others base chemicals.

Michael Goldfeld, Advanced Biocatalytics Corp.
Yeast derived ingredients in cleaning materials from industrial to skin care
The company developed innovative technology based on the discovery of synergistic enhancement and broadening the functionality of surfactants by their association with certain low-molecular weight proteins derived from living yeast. Application range from waste water treatment to industrial cleaning, to agriculture, to consumer products, animal and human skin care and beyond.

Aaron Kelley, Amyris
µPharm™: Combinatorial Biosynthesis to Unlock the Potential of Natural Product Drug Discovery
The µPharm™ platform puts combinatorial chemistry and high-throughput screening capabilities into a single cell, providing access to a wide range of natural and natural-like terpenoid products for the first time. The terpenoids are a particularly rich and bioactive class of compounds. Approximately 50,000 unique terpenoids are catalogued in the Dictionary of Natural Products, and a preliminary in silico analysis indicates that >10,000 of these compounds are drug-like and predicted to interact with nuclear receptor, GPCR, kinase and microbial targets (Similarity Ensemble Approach analysis). However, difficulties in obtaining chemical matter has left the terpenoids vastly under-sampled for drug development. Amyris's HI-RYSE™ technology enables rapid integration of biosynthetic pathways encoding terpenoid production into Saccharomyces cerevisiae, unlocking not only natural compounds, but also, by combinatorial re-assortment of the relevant genes, entirely new, "natural-like" compounds. To reduce the complexity of the libraries, a key option of the µPharm™ platform is the ability to integrate an in vivo "Tier 1" assay to identify clones producing compounds that interact with a target expressed in the cell (e.g. a nuclear receptor, GPCR, etc). Libraries of cells producing diverse compounds can be screened as colonies (on solid media) or in shake plate formats (liquid media). Subsequent investment is thus focused on a much smaller set of compounds known to interact with the target. Amyris is the world leader in the production of terpenoids by fermentation at industrial scale, and compounds of interest can rapidly be scaled for its

partners and customers and purified for combinatorial or medicinal chemistry efforts, clinical trials and manufacturing.

Session 4: Tuesday, April 19 2:30pm-4:00pm
Genomics Research: Design Build Deploy

Moderator: Blake Simmons, Joint BioEnergy Institute (JBEI), Lawrence Berkeley National Laboratory
Multi-institute, integrated cross-disciplinary and big-team science to create economically compelling renewable fuels and chemicals: the JBEI example
Today, carbon-rich fossil fuels, primarily oil, coal and natural gas, provide 85% of the energy consumed in the United States. Fossil fuel use increases CO2 emissions, increasing the concentration of greenhouse gases and raising the risk of global warming. The high energy content of liquid hydrocarbon fuels makes them the preferred energy source for all modes of transportation. In the US alone, transportation consumes around 13.8 million barrels of oil per day and generates over 0.5 gigatons of carbon per year. This has spurred intense research into alternative, non-fossil energy sources. The DOE-funded Joint BioEnergy Institute (JBEI) is a partnership between seven leading research institutions (Lawrence Berkeley Lab, Sandia Labs, Lawrence Livermore Lab, Pacific Northwest National Lab, UC-Berkeley, UC-Davis, and the Carnegie Institute for Science) that is focused on the production of infrastructure compatible biofuels derived from non-food lignocellulosic biomass. Biomass is a renewable resource that is potentially carbon-neutral. Plant-derived biomass contains cellulose, which is more difficult to convert to sugars. The development of cost-effective and energy-efficient processes to transform cellulose and hemicellulose in biomass into fuels is hampered by significant roadblocks, including the lack of specifically developed energy crops, the difficulty in separating biomass components, low activity of enzymes used to hydrolyze polysaccharides, and the inhibitory effect of fuels and processing byproducts on the organisms responsible for producing fuels from monomeric sugars. This presentation will highlight the research efforts underway within the four divisions at JBEI to overcome these obstacles, with a particular focus on the development of integrated solutions that can produce renewable fuels and chemicals.

Neil Parry, Unilever

Darren Platt, Amyris
Design Build Deploy
Many biotechnology companies are employing automation in their strain development programs, providing them with faster time to market for new molecules. At the forefront of this trend is Amyris, which over the past 10 years, has built the world's most advanced strain engineering and fermentation platform. Amyris's advancements have enabled the company to bring several molecules to commercial fermentation scale; with the most recent advancing from concept to manufacturing phase within a year.

As biotechnology companies grow, so will the number and complexity of molecules they develop. Pressure to deliver a successful molecule on time and within budget will mount and put added strain on a company's ability to deliver. Continued investment in automation and integration to increase speed and decrease costs will be required to remain relevant.

As a leader in this space, Amyris has already achieved a pipeline with critical mass with 17 molecules in the development pipeline, an additional several hundred as part of an exploratory DARPA program, and a diversity library approach for the pharma and agricultural sectors. The company has successfully managed this growing portfolio through its investment in in-silico tools and using its proprietary HI-RYSE™ technology to speed up time to market.

Looking into the future, Amyris ultimately intends this to culminate in a closed loop automated strain improvement cycle, incorporating machine learning algorithms. Investments in advanced robotics, miniaturization, computational tools, predictive cost models, strain construction techniques, and assay capabilities, are all reducing the cost and time needed to introduce new products. In this talk, we will detail how we have applied these tools to rapidly develop our most recent manufacturing molecule, and

how automation is allowing us to apply the same methods to hundreds of additional molecules changing Design-Build-Test-Learn into Design-Build-Deploy.

Priti Pharkya, Genomatica
Rapid bioengineering for high-value specialty chemicals by leveraging pathways designed for intermediate chemicals
New bioengineering capabilities allow the industry to tackle new customer problems and open new markets. This presentation will show how biology can address small molecules (including specialty chemicals) better than traditional chemistry – especially when leveraging pathways designed for intermediate chemicals. Topics include creating 'offshoots' of well-honed, highly-optimized pathway assets; rapid development and optimization of new pathways; application of advanced computation; the role of a metagenomics platform in improving enzyme effectiveness; how rapid scale-up/scale-down disciplines can reduce the time to reach the 'less-demanding' performance targets needed for highly-competitive economics; and how process modeling and technology transfer disciplines can simplify commercial production options. We'll estimate how these techniques, collectively, can shrink timelines and development costs.

Vinayak Kapatral, Igenbio Inc.
ERGO 2.0 a Genomics Platform for Synthetic Biology and Expression Analytics: Statin production design.
ERGO 2.0 provides a systems biology informatics toolkit centered on comparative genomics to capture, query, and visualize sequenced genomes. Using Igenbio's proprietary algorithms, and the most comprehensive genomic database integrated with the largest collection of microbial metabolic and non-metabolic pathways, ERGO™ assigns functions to genes, integrates genes into pathways, and identifies previously unknown or mischaracterized genes, cryptic pathways, and gene products. ERGO 2.0's hand-curated content combined with new computer-aided design (CAD) tools help scientists in the biotechnology, agriculture, and pharmaceutical industries design, debug, and compile biological code leading to new bio-based products faster.

Using ERGO 2.0, we present the design and development of statin production in a heterologous host.

Session 5: Wednesday, April 20 8:30am-10:00am
Carbon Capture Instigated by Synthetic Biology

Michael Krel, EnobraQ
What It Takes To Make A CO2 Fermenting Yeast
Enobraq is a start up founded in 2015 based on scientific work done by Philippe Soucaille's and Denis Pompon's teams through the Toulouse White Biotech cluster. The goal of the company is to implement two complex metabolic pathways in a yeast: one involving a CO2 capture mechanism and one involving an energy source in order, once combined to develop a yeast able to grow only on CO2 as a carbon source. Several proofs of concept have already been developed and will be discussed during the presentation. Recent improvements, development plan and near/medium term milestones and achievements will also be discussed

Bruce Dannenberg, Phytonix Corporation
Utilizing Synthetic Biology to Address Global Challenges: Climate Change and Sustainable Chemistry
Phytonix and its organism development partners are using synthetic biology, genomics and metabolomics to develop efficient photosynthetic microbial cell factories for the direct and sustainable production of n-butanol – a valuable industrial chemical intermediate and potential "drop-in" gasoline replacement fuel – from solar energy, utilizing carbon dioxide as the sole, direct feedstock.

The provision of an affordable, available and sustainable carbon source has been one of the greatest barriers to the production of economically viable renewable chemicals. Phytonix's photobiological/photosynthetic process uses carbon dioxide as the sole feedstock and along with solar energy and water produces the desired chemical with oxygen as the co-product. This is a significantly carbon-negative and sustainable process.

This 2016 BIO presentation will provide an overview of how Phytonix is employing synthetic biology to address the global challenges of climate change and the production of cost competitive, sustainable chemicals and fuels. Phytonix's breakthrough technology for the production of customized cyanobacterial microbial chemical factories for applications across a broad range of climates will be discussed, as well as it collaborative, "capital-light" business model and the economic and environmental opportunities that new advances in industrial biotechnology, enabled by synthetic biology, provide in terms of a rapid transition to a new bio-economy and ultimately to a CO2-based economy for the production of consumer products, chemicals and fuels.

Ping Yang, Synbio Technologies
DNA Storage ——A novel synthetic biology solution to digital information storageDNA storage for digital information is a recently emerged cutting-edge technology. It is based on a "nature law" that cytosine (C), guanine (G), thymine (T), adenine (A) and their combination precisely inherit biological information among organisms. Different combinations of A, T, C, G represent different genetic information. DNA storage uses the synthetic DNA as a new storage media to record and long-term store digital information that include texts, pictures, audios and videos etc.. DNA storage is a better media for information storage because of its unique features such as: high storage capacity, long storage time, reproducibility and fully environmental friend. As the foundation of the broad applications, it is critical to develop a new generation of synthetic technology for DNA storage that should be faster and cheaper. This kind of technology paves a solid foundation for the breakthrough of synthetic biology and future applications. Synbio Technologies' Syno®3.0 platform is a new generation DNA synthesis platform. It reduces the cost by 100-1000 folds in comparison with the current technology. In addition, Synbio Technologies has generated a patent pending technology that can translate the digital information into a four-letter codon based DNA sequences. In a combination to these novel technologies, we can provide a new way to "Moore's Law" regarding to the bottleneck of IT information storage. The biology solution to the digital information storage has been proved a novel, more green and more cost effective approach to human society.

Michele Rubino, Synthetic Genomics

Session 6: Wednesday, April 20 10:30am- 12:00pm
Synthetic Biology Tools Enables Predictable Bioengineering

Ian Fotheringham, Ingenza Ltd
Development of SynBio Tools to Enable Predictable Bioengineering for Industrial Applications
In this talk I will describe the application of Ingenza's proprietary synthetic biology tools to more predictably engineer biological production systems with specific reference to commercially relevant examples in specialty chemicals and biobased materials. These tools include protein engineering to address poor response during the control of gene expression, the development of synthetic landing pads to optimize the genomic operating environment around delivered genes, the use of genome editing and RNA trafficking systems to control gene expression, the application of transciptomics and metabolomics to enhance cell system performance, the development of synthetic gene expression regulatory elements to better control gene expression and the deployment of our proprietary inABLE combinatorial genetics platform for large scale gene/pathway assembly and optimization. Together these tools have been used to rapidly clone, express, select and optimize target activities for many separate enzymatic reactions, from thousands of independent genes derived from metagenomic and phylogenetic discovery approaches. Obvious synergy exists between this approach and versatile, solid phase screening and selection methods using growth-based, cross-feeding or colorimetric methods to identify engineered cells of interest. This is illustrated through the rapid identification of critical pathway enzymes, optimal gene coding sequences and enzyme variants from inABLE®-derived high quality variant libraries for industrial applications in bio-based polymers, chemicals and personal care products with our commercial customers. We will also describe the success of modelling approaches to gene design that enhance the predictability of heterologous gene expression in diverse hosts. In developing this suite of technologies we aims to bring increasing predictability and overcome persistent limitations associated with today's iterative and empirical processes for microbial strain improvement.

Jay Konieczka, enEvolv, Inc
Harnessing and accelerating evolution to discover and produce biobased chemicals
Companies are increasingly using engineered microorganisms to produce bio-based chemicals. Due to the complexity of biological systems, engineering strains is difficult and expensive. In addition to understanding of the relevant pathway(s), the right combination of genomic changes must be identified to produce the desired outcome. This requires building and screening numerous designs.

Evolution is effective in creating complex life forms to solve various problems. Advanced technologies have been developed to harness and accelerate evolution -- to efficiently build and screen billions of combinatorial variants – directly in vivo and in a single culture. This approach substantially improves the economics and effectiveness of strain engineering.

Yasmin Mirza, Praj Industires Ltd.
Bacteriocins- A new way to health
The rampant use of antibiotics in human as well as animal health care has led to the obvious and much discussed problem of antibiotic resistance. Agencies like 'World Health Organization' have stressed upon the need to develop alternatives to prevalent antibiotics in order to be ready for superbugs like MRSA and VRSA. Bacteriocins have emerged as an upcoming area of research and can be developed as an arsenal to fight multi drug resistant pathogens. This appears to be due to multiple modes of action of Bacteriocins against bacteria. Bacteriocins are ribosomally synthesized, extracellularly released bioactive peptide or peptide complexes which have a bactericidal or bacteriostatic effect on other species. Lactic acid bacteria (LAB) are source of Nisin, a bacteriocin approved by FDA for food preservation. New Bacteriocins are increasingly being discovered from a diverse range of genera.

At Praj Industries Ltd., a diversity of GRAS bacterial cultures have been screened against both gram positive and gram negative pathogens collected from regional poultry and dairy farms. Bacteriocins have been identified that are effective against gram negative pathogenic E. coli and Salmonella and also for fungal spores found in stored animal feed. Certain Bacteriocins are effective against pathogens that are multi-drug resistant. The fermentation technology has been optimized for higher yields and has been successfully scaled up.

In India, use of antibiotics is substantial both in Dairy and poultry farms. Praj endeavors to attain a mighty goal of replacing this antibiotic usage with Bacteriocins, which are safe and natural. Praj has developed several products based on Bacteriocins, like- LIQBAC & NOMAST and probiotics, like- PIB-PRO and PIB Super. Field trials have been conducted to test the efficacy.

Praj Industries Ltd. intends to research upon other applications of Bacteriocins and probiotics in human health as well.

Track 6: Specialty Chemicals, Food & Nutritional Ingredients

Session 1: Monday, April 18 8:30 am – 10:00 am

Moderator: James La Marta, DSM
David Mason, Novozymes
Vincent Sewalt, DuPont Industrial BioSciences
Diane Shanahan, BASF Enzymes LLC

The Safety of Enzymes
Enzymes have developed into an essential, biotechnological tool in both the laboratory and manufacturing sectors for a variety of materials and processes that positively impact the lives of millions of people around the world, every day. The safety of these critical catalysts is often taken for granted by the users and the public in general. A panel of Enzyme Technical Association members will provide insight into why enzymes have acquired such a positive characteristic and highlight aspects of current regulatory oversight that underpin this common understanding.

To set the stage, a review of the safe utilization of enzymes over the last fifty plus years from the laboratory to the production floor for food, dietary supplements, pharmaceuticals, textiles, detergents, biofuels, and specialty chemicals will be provided.

The speakers will address such topics as the Generally Recognized As Safe program of FDA, worker safety, the Global Harmonized System of hazard communication & labeling, and the Environmental Protection Agency's oversight of non-food enzyme manufacture and use.

Panel members will highlight manufacturing via microorganisms with a safe strain lineage, use of a well-known safety rubric, assessment of potential allergenicity, and other toxicological attributes. Exposure considerations for manufacturing, handling, and end uses such as detergents and textile processing will also be discussed.

Alice Chen, Keller and Heckman LLP
Safety First - Guidelines for the Development of Safety Data for Microbial Food and Feed Ingredients
Microorganisms have the ability to create a wide range of human food, animal feed ingredients, dietary supplements, and cosmetics. In our presentation, we focus on data considerations and dietary exposure assessments to establish safety and support regulatory determinations such as generally recognized as safe notifications (GRASN), self-GRAS determinations, New Dietary Ingredient Notifications (NDIN), EU Novel Food applications, and Association of American Feed Control Officials (AAFCO) submissions. Genetically modified and unmodified examples such as food enzymes, nutritional oils from algae, whole cell biomass, spent biomass co-products, probiotics, protein extracts, and yeast in distillers grain will be highlighted.

Session 2: Monday, April 18 10:30am-12:00pm
Microbial Cell Factories: A New Era of Biobased Flavors and Fragrances
Modern biotechnology enables the design of tailored microbial cell factories for the production of a huge range of chemicals. Flavors and fragrances (F&F) represent a highly attractive market:

F&F market prices rank above bulk chemicals or fuels; biobased production enables the industry to shift processes from fossil to renewable resources; biotech F&F make the industry less dependent on exploiting plant raw materials from distant countries; biotech F&F usually afford the industry the preferred label 'natural'; enzymes often outperform chemistry if structurally more complex and enantiopure molecules are aimed at.

However, there are also specific requirements and constraints in the F&F industry: there are many F&F of interest, which are used in relatively small amounts only; many desired natural aromas are multi-compound compositions with plant essential oils as the benchmark; regulatory aspects and public acceptance set boundaries to labeling issues and the use of GMO.

With this panel a representative cross section of the value chain from precompetitive research institution to biotech companies to big F&F industry has been framed. The speakers will present their different viewpoints and discuss recent developments and perspectives in this highly attractive field of industrial biotechnology.

Moderator: Jens Schrader, Dechema Research Institute
Biotech flavors and fragrances using unconventional microbes
Biotechnological production of flavor and fragrance compounds needs both engineered microbial cells and specifically designed bioprocesses to overcome key challenges, such as product toxicity and low yields. For this, biological and technical solutions are developed and combined at our institute to provide proof of novel biotechnological production strategies on lab scale. We focus on engineering unconventional microorganisms, such as solvent-tolerant or C1 source dependent bacteria, and on the integration of techniques for in situ product recovery.

Sunil Chandran, Amyris
Creating novel flavor and fragrance compounds through high throughput platforms for strain optimization and screening

Amyris is an integrated renewable products company dedicated to providing sustainable, high-performance alternatives to plant and petroleum-sourced chemicals, consumer goods, and fuels. Our industrial synthetic biology platform converts plant sugars into a variety of molecules that can be used in a wide range of products, including pharmaceuticals, cosmetics, flavors and fragrances (F&F), polymers, industrial lubricants, and renewable fuels. This presentation will cover details of the automated platforms that enabled Amyris scientists to rapidly iterate through multiple cycles of the strain engineering process, as well as the engineering of metabolic pathways to convert naïve yeast strains into commercial scale production hosts for various F&F molecules. We will discuss some of the challenges faced in the transition from lab scale to commercial scale production. Finally, we will present our vision for how the industry can leverage these platforms to reduce the cost and time to market for a variety of molecules.

Jason Whaley, Manus Biosynthesis Inc
Beyond Price: Creating Value in Specialty Chemicals
As an industry, industrial biotechnology has shifted its focus from fuels to specialty chemicals. Low selling prices, extremely long and expensive R&D cycles, and high capex requirements have driven companies away from fuels, and toward niches where they can more easily compete on price. However, in industries like food, nutrition, cosmetics and other fine chemicals, the lowest price does not always win. We must understand other drivers of value. Customers want to see what's in it for them - consistency, availability, performance and price - and also what's in it for society - safety and sustainability. Unfortunately, the specific drivers that matter in each vertical - and even for each product - are different and not readily apparent to new entrants. To complicate matters further, we must explain the benefits of our technology without confusing consumers - the customers of our customers. Using examples, we will cover different ways that industrial biotechnology companies can build an advantage over incumbent sources. We'll then discuss specific strategies companies can use to discover which drivers matter in their markets in order to design product strategies that win.

Neil Goldsmith, Evolva SA

Lisa Navarro, Givaudan

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Session 3: Monday, April 18 2:30pm- 4:00pm
New Renewable Food & Flavor Ingredients

Moderator: Josh Silverman, Calysta, Inc.
Innovative Animal Feed through Proprietary Methane Fermentation Platform
By 2050, 9.6 billion people will demand 60% more protein than is currently available. Further, arable land

and water are finite resources and while crop yields continue to increase, new sources of protein will be required to meet this growing demand.

The recent rise in domestic production of methane has driven the cost of natural gas to record lows. Calysta has developed the world's only commercially validated gas fermentation platform using specialized microorganisms (methanotrophs) which efficiently convert methane to high quality protein with properties similar to fish meal.

Methane is a highly sustainable feedstock, with a greenhouse gas impact approximately 34x worse than CO2. Methane does not compete with the human food chain and Calysta's process has minimal impacts on land and water usage. Renewable methane is also available through proven technologies such as anaerobic digestion and waste treatment.

Calysta is further building on the methanotroph platform to produce a wide range of chemicals, materials, and fuels from methane. This platform technology allows the production of biobased chemicals made from sustainable methane rather than sugar (a feedstock which does directly compete with the human food chain). Calysta's technology provides for a dramatic reduction in feedstock cost for a wide range of current biobased products, while providing a path towards a more sustainable and environmentally friendly bioeconomy.

Edi Eliezer, Conagen, Inc.
Commercialization of New Renewable Food and Flavor Ingredients: Fast track Scale-up from R&D to Large Scale Production in a Global platform
Current biotechnologies allow a paradigm shift in sustainable and cost-effective production of natural food ingredients by synthetic biology, advanced fermentation and bioconversion technologies.

With a vision of complete vertical integration from discovery to commercialization, Conagen started a very ambitious program to perform process development, scale-up and commercialization of high-value renewable specialty biochemicals for the food and flavors industry. This program involved development of facility design concepts with fermentation and DSP for both a semi-commercial demonstration and a full scale commercial plant in the US and Asia.

The key success factors for the right selection of technology platforms & facility engineering concepts were based on very early 'integration' at various levels. It was crucial to have very early engagement of R&D, Engineering and Business stakeholders of a growing biotech company.

Selection of a variety of products based on Conagen's and its clients' needs with diverse technology platforms presented challenges in the design of a facility with its own constraints in space, time and budgets. The presentation will discuss how these challenges in the technology, facility and business spaces were addressed within a very tight project schedule.

Emmanuel Petiot, Deinove
Leveraging biotechnology to produce innovative natural ingredients
DEINOVE is a biotech company that develops breakthrough production processes based on a yet to be fully exploited bacterial genus: the Deinococcus. Deinococcus bacterium, being 3.5 billion-year-old, is one of the oldest life forms on earth and features an extraordinary biodiversity. Taking advantage of the unique genetic properties and robustness of the Deinococcus, DEINOVE optimizes metabolic capabilities of these bacteria to produce bio-based molecules from renewable feedstocks.

The company is segmented into several projects.

Its program focused on second-generation biofuels is called DEINOL. Similarly, DEINOCHEM is focused on renewable chemicals and isoprenoids in particular. Isoprenoids are the largest family of natural substances in the world and are subjects of many industrial interests as they are key components in numerous applications : carotenoids (beta-carotene, lycopene…) are key components in cosmetics, animal feed formulations, food additives… ; pinene, linalool, geraniol, are often found in flavors, fragrances, personal care and household products. Deinococcus bacteria are ideal for these types of developments due to their natural expression of some of those compounds, such as carotenoids. The intrinsic expression of carotenoids in Deinococcus demonstrates both that the pathway for isoprenoid biosynthesis is already

present and active and that they are an ideal host for the industrial production of such compounds. Limited genetic engineering operations – adding terminal enzymes, optimizing limiting enzymes… - may lead to the production of many isoprenoids of interest.

DEINOVE is the sole company exploiting these bacteria for industrial processes, it holds more than 170 worldwide patent applications.

Benjamin Gonzalez, Metabolic Explorer
Industrial biotechnology competitiveness in a low price oil barrel environment: The L-Methionine Case
Well aware of environmental challenges and climate change-related impacts, METabolic EXplorer brings its contribution to changing the way the industry produces consumer goods. Developing innovative and sustainable industrial processes based on the well-known process of fermentation, the company fulfills the prerequisites of industrial biotechnology: breakthrough innovations in metabolic engineering; capacity to build alliances, bio products performance in their applications vs. synthetic products; costs competitiveness even with an oil barrel price at its lowest since the last 10 years…

The example of a cutting-edge technology with a high-potential market; an amino acid notably used in feed for chickens and piglets: L-Methionine.

Karl Seck, Mercurius Biorefining
Biomass derived FFAs
An efficient synthetic approach to furan fatty acids starting from the biomass-derived platform chemical 5-(chloromethyl)furfural (CMF) is described. The route involves seven steps and has a 60% overall yield. Furan fatty acids are dietary antioxidants that occur naturally in fish and are proposed to have anti-atherosclerotic properties.

The modern concept of the biorefinery is characterized by the production of fuels, commodity chemicals, and value-added pro- ducts from non-petroleum based carbon sources (Clark and Des- warte, 2015). This is a strong movement in the physical and bio- logical sciences which is established around the proposition that the unabated use of all current fossil fuel reserves would have serious, potentially irreversible environmental consequences (McGlade and Ekins, 2015). The synthesis of value-added products (e.g. agrochemicals, healthcare products) from biomass feedstocks is a key strategy within this movement to leverage business models organized principally around low-margin, high-volume commodities such as biofuels and polymers. Previously, we have described the synthesis of the natural herbicide δ-aminolevulinic acid 2 (Mascal and Dutta, 2011a), the anti-ulcer drug ranitidine (Zantac) 3 (Mascal and Dutta, 2011b), and the furan-based pyre- throid insecticide prothrin 4 (Chang et al., 2014) from the re-newable platform molecule 5-(chloromethyl)furfural (CMF) 1, which can be derived in a single step from sugars, cellulose, or raw biomass in isolated yields as high as 80% (Mascal and Nikitin, 2008, 2009). In a continuing effort to expand the derivative markets of CMF 1, we now report an efficient synthetic approach to naturally occurring furan fatty acids (FFAs).

Session 4: Tuesday, April 19 2:30pm-4:00pm
The Development of New Enzymes with Unique Properties

Moderator: Edmund Talideh, Biocatalysts Ltd
Advances in Novel Enzyme Discovery, Development & Manufacture
These are exciting times for enzymes if you are working with a partner who understands and can exploit all they have for offer. Previously novel enzymes were the preserve of the multi-nationals due to the high development costs involved. High risk of failure meant that there were no guarantees of a sample, let alone a viable long term product. Fast forward just two short decades and the landscape has changed enormously. Costs have been driven down greatly by the ability to design enzymes using metagenomics, directed evolution and enabling technologies within the synthetic biology space. The result? Much higher success rates, lower costs and less risk involved in commissioning novel enzyme development. The upside of this is opening up previously unavailable markets to many mid-sized companies who see the potential to differentiate one of their products (or achieve a specific biochemical step in a process) using a novel enzyme. Biocatalysts is bringing on new strains to ensure that there is as a good a chance as possible of

getting a high protein expression yield. Our goal is to take the process for our customers right through from small samples all the way to commercial launch and long term manufacture.

Novel enzyme development often produces many unexpected technical challenges. Enzyme quirks and inconsistencies make them a constant challenge but using our 30 years of experience in developing and manufacturing enzymes, there is very little that we haven't seen or experienced, and therefore learnt from. It is our practical approach to novel enzyme identification, development and production that sets us apart from our competitors.

In the presentation Biocatalysts will give insight into the latest methods for cost effective enzyme development, the path of a typical project and the timelines and success rates.

Felipe Sarmiento, Swissaustral
New enzymes development: SME's perspectives in an increasingly consolidated landscape
Swissaustral is a worldwide specialist in Extreme Biotechnology with over 15 years of experience in the discovery, development and production of reliable and stable enzymes: High-performance enzymes™ from extremophilic microorganisms. Our enzymes catalyze reactions optimally under extreme conditions of pH, temperature, salinity, radiation and others, for industrial applications and scientific research. We have implemented an "Extremophilic Bioprospection and Development Platform" to feed our enzyme pipeline, which is based on proprietary know-how and key partners collaborations.
As a SME, one of our biggest challenges is to growth in the global industrial enzyme market, which has become increasingly competitive due to massive consolidation in the past years. Much as in the Pharma industry, the industrial enzyme market is characterized by long and investment intensive product development cycles favoring big players like Novozymes, Dupont and DSM, which together represent more than 75% of the market.

At Swissaustral we have defined target niches within the industrial enzymes market and established a network of partners that have allow us to speed-up our time to market. These elements define our pathway for growth. As part of our continuous efforts in enzyme innovation we have several products in the market, all of which present extreme properties that give them a competitive advantage. Our products include: catalase, violacein, glutamate dehydrogenase and others under development as xylanases, lipases, nitrilase, laccase and alcohol dehydrogenase.

Michael Raab, Agrivida Inc.
Grainzyme®: A Paradigm Shift In Novel Animal Nutrition Feed Additives
Agrivida, Inc., is launching engineered corn grain that expresses a variety of feed enzymes used in animal nutrition. Agrivida's GraINzyme® products express high levels of specifically engineered enzymes for use in animal nutrition. The first two products are a grain-expressed phytase and a grain-expressed carbohydrase, which both improve weight gain and feed conversion in monogastric animals. These enzymes have been engineered for improved activity and deliver high levels of thermal stability to enable direct use of the grain in feed pelleting processes. These products are produced on a relatively small number of confined acres and used in animal diets at inclusion rates ranging between 50g and 1500g per ton of formulated feed. Because of the low costs of production, essentially the cost of producing and segregating the specialty grain, GraINzyme® products can provide higher dosing levels at competitive prices, which may enable greater inclusion rates of lower value feed inputs to help improve animal production costs. The ability to dose enzymes at higher levels may also provide an opportunity to expand enzyme use to ruminants, where enzyme products have been challenged by high costs to provide a dose that ensures consistent nutritional improvements. As a platform for animal nutrition feed additives, plant biotechnology offers a low cost, integrated mechanism for delivering highly differentiated and functionalized feed ingredients for animal nutrition and health.

Marc Struhalla, c-Lecta GmbH
Efficient enzymatic production processes for carbohydrate ingredients
Special carbohydrate ingredients have proven extraordinarily beneficial not only but above all in the food industry. Prominent examples of ingredients being used to improve human health and nutrition are galactoligosaccharides (GOS) and even more complex structures like human milk oligosaccharides (HMO). In infant nutrition such specialty carbohydrates can provide several benefits to the infant like prebiotic

effects and immunological support. Market volumes and prospects are accordingly high, but exploitation in many cases is hampered by inefficient production processes so far. A remedy are enzymes whose role for the production of such carbohydrate ingredients is becoming increasingly important, especially since chemical routes involve hazardous reaction conditions that are less acceptable for the production of food. Even more important, enzymes are featuring a regio-selectivity that is mandatory for the synthesis of complex carbohydrates and which is simply not accessible with chemical catalysts. Consequently, enzymes turn out to be the ultimate key for the implementation of efficient large-scale manufacturing. c-LEcta, as a leading technology company in the field of enzyme development and production, will present how specific engineering objectives have been addressed to provide breakthroughs in the enzymatic production of carbohydrate ingredients.

Frank Hellmers, Evonik Creavis GmbH
Robust Heterogenous Biocatalyst For Continuous Processes
Although biocatalytic processes are widespread today and increasingly competitive with classical chemical production routes, high enzyme costs often prevent their industrial use. This is particularly problematic with commodity products where high volume processes are needed, thereby requiring an enormous biocatalytic productivity and concomitant stability.

A common approach to meet this challenge is to reuse the biocatalyst through techniques such as immobilization. A wide variety of methods currently exist to obtain a robust immobilized biocatalyst, however they are often very process specific and frequently suffer from scale-up limitations. The immobilization of whole cells in a biopolymer matrix for utilization in continuous fixed-bed reactors is a common approach. Unfortunately, a biopolymer immobilization matrix has economic and ecological disadvantages, as it is not storable in a dried state and mechanical forces can easily destroy the matrix. To enhance the stability of the heterogeneous biocatalyst cross-linking agents are employed, leading to hazardous waste streams. To overcome these disadvantages and to meet today´s industrial requirements a new immobilization platform was developed. Already established and cost-effective formulation technologies comprising of only a few process steps are used to produce the heterogeneous biocatalyst. By choosing an inorganic carrier material and an aqueous binder dispersion, it was possible to produce granules containing the biocatalyst with defined properties while avoiding any hazardous substances.

Through an intense characterization, it was possible to demonstrate that the novel immobilization method leads to incompressible and stable granules, owning an activity and shelf life comparable to references. Furthermore, it was shown that the granules have not only a high operative stability, but in contrary to many references are storable at dry conditions.

Session 5: Wednesday, April 20 8:30am-10:00am
How to Cut Cost in Fermentation and Biocatalysis

Manfred Kircher, CLIB2021
Ruth Maas, Authodisplay Biotech
Jeff Lievense, Genomatica
Shawn Jones, White Dog Labs
Luca Zullo, CLIB2021

Cost efficiency is key to expand the industrial application of bio-based processes beyond today's 10% niche in the chemical industry. This is not only true when turning new technologies into industrial reality, it is a never ending challenge for processing and bio-catalyst performance. Especially in early developments options for improvement are easy to identify but the more optimized the process is the more initially hidden options open room for cost-reduction.

Efforts to improve cost-efficiency often concentrate on space-time yield (g/l*h) by evolving the bio-catalyst's specific activity. Beside this essential performance indicator the bio-catalysts life-time and recycability directly affect processing cost. The longer it can be employed with no loss in space-time yield the less bio-catalyst is needed, thus reducing its cost share.

Another key performance indicator is product yield. In most fermentation processes it is based on sugar or other carbohydrates. In any case strain improvement focuses on minimizing side-products and

streamlining the metabolic pathways to the desired product. Respiration losses are seen as unavoidable and are therefore no subject of strain development. Also here new develpments give room for tremendous cost-cutting improvements concerning bio-catalysts and processes.

In state-of-the-art processing biomass treatment and transforming the resulting carbon source are strictly separated steps. Integrating both will not only optimize the carbon yield but also reduce investment and running cost significantly.

This panel will discuss industrially relevant cost-factors in whole-cell as well as enzymatic biocatalysis and present strategies to reduce processing cost by innovative approaches.

Session 6: Wednesday, April 20 10:30am- 12:00pm

Moderator: Harry Baumes, USDA

Bert Herring, BioFiber Solutions International (BFSI)
Paper Products to Commercialization in the Bioeconomy
One challenge bio-based entrepreneurs and businesses face in bringing bioproducts to commercialization is connecting the right players of the supply chain together. BioFiber Solutions International (BFSI) has organized a panel consisting of a manufacturer, a wholesaler, a distributor, and an end user to provide perspectives from each major player in supply chain. We will share our experience and lessons learned about connecting the office product supply chain together to bring biobased products to commercialization. Each panel representative will speak about their respective role in the supply chain and what they believe is essential for placing a new biobased product into a consumer's hand. We hope our panel's example will provide parallel insight into the operations and channels necessary for bringing other biobased products to market by entrepreneurs, small business, and large business. Our objective is to educate these organizations so that they leave BIO World Congress with a stronger understanding and confidence of the forces that influence a product's success getting into market, while equally encouraging a stronger movement in the development of and education regarding biobased products.

Paul Martorella, Office Depot

Gurminder Minhas, Performance Biofilaments

Marie Wheat, USDA
The Successful Commercialization of Biobased Products: Through the Lens of the USDA BioPreferred Program
There has been advancement and increased sophistication across the biobased products industry over time, which can be viewed through the lens of the USDA BioPreferred program created in 2002. Advances across the industry, both in the U.S. and internationally, in the use of feedstocks, conversion technologies, sound investments, supply-chain adoption, etc. have resulted in biobased products that perform better and are more cost competitive. This presentation will discuss how a wide range of biobased products and supporting technologies continue to penetrate diverse industrial markets and grow the biobased sector.

The BioPreferred Program has evolved with the industry, now including more innovative products, intermediates, and currently considering the designation for federal purchase of complex products. In this presentation, we will discuss the progression of the biobased industry focusing on policy drivers, economic impacts, market push and pull, and factors influencing success in commercializing biobased products. We will also discuss the federal regulation to designate intermediate ingredients and feedstocks as a market driver for new and innovative biobased products.

Track 7: Renewable Chemicals and Biobased Materials

Session 1: Monday, April 18 8:30am- 10:00am
Building Aromaticity in Renewable Chemicals

Moderator: Philipp Walter, Succinity

Michael Saltzberg, DuPont Industrial Biosciences
A Breakthrough Process to Manufacture Furan Dicarboxylic Methyl Ester (FDME) From Fructose
DuPont and ADM have collaborated to develop a new process to produce furan dicarboxylic methyl ester (FDME) from fructose that is substantially more efficient than previously described processes. FDME is the methyl ester form of furan dicarboxylic acid (FDCA). It is structurally analogous to dimethyl terephthalate (DMT)/terepthalic acid (TPA) and can be used for many similar applications, e.g. synthesis of polyesters. FDME can be used to make a number of exciting polymers and chemicals which will have unique functionality in large part due to the presence of the aromatic furan ring rather than the benzene ring found in the TPA molecule. The manufacturing process developed by ADM and DuPont will be described, focusing on the advantages of integrating the dehydration and oxidation steps and the in utilizing the ester form to simplify and improve the purification process. Some comments will be made on the unique properties of the polyester made form FDME and 1,3 propanediol (Bio-PDO™) called PTF, which will be one of the first commercial applications of the FDME monomer.
Len Rand, xF Technologies

XF Technologies has developed a thermo-chemically efficient process for converting C-6 sugars into a suite of aromatic compounds generally known as furoates (furan esters). Since pronouncing the word "furoate" is challenging, we named our line of molecules "408's". 408's have a broad performance profile that includes solvents, plasticizers and personal care products. In addition to their solvency power, some 408's obviate the need for conventional preservatives and can reduce the human and environmental sensitivity of the overall product. Certain 408's also provide effective non-petrochemical alternatives to solubilizing fragrance compounds in the personal care and household cleaning markets.

XF Technologies has a novel process for converting C-6 sugars into these types of industry enhancing molecules as well as an active 5 MT pilot facility in Albuquerque, NM. TSCA approval is currently in process while we continue to find new markets that can take advantage of of our technology. The 408 brand is proving helpful to existing industries as well as expanding the available markets and uses of immerging bioplastic technologies. Finally, the 408 process yields a valuable co-product that can reduce the cost of ownership and increase the efficiency for the increasingly important water treatment industry.

Joop Groen, TNO
The Next Step In Functionalised Biobased Aromatics
Biorizon is a Shared Research Center with an initial focus on technology development for the production of functionalized biobased aromatics for performance materials, chemicals & coatings. Biorizon is anticipating the expected growing shortage of aromatics from the petrochemical industry and the widely shared ambition to green the chemical industry.

Biorizon was initiated by VITO, TNO and the Green Chemistry Campus.

In the last years Biorizon has made great progress both on the feedstock- as well as on the application side together with different consortia of companies and knowledge organisations combining intelligence, facilities and experience. This way of value chain integration has resulted in very targeted business cases.

On the feedstock side in the Biorizon project "Waste to Aromatics - W2A" various municipal solid waste streams were evaluated for their potential to produce bio aromatics. The 3 most promising streams were combined with 2 conversion technologies and this resulted in multiple promising pathways to produce furanic intermediates. Next to techno economic feasibility also availability and market size are taken into account.

On the application side a number of projects are focusing on the conversion of furanics into functionalized aromatics, specifically for polymers, coatings and specialty lubricants. 5 leading companies have set the priorities for the target molecules and evaluate samples in their products.

In the presentation more information on the target molecules, pathways and applications will be shared.

Now the principles are well proven the focus is on scale up and proof of concept. Various continuous flow skid units are being prepared for construction for this purpose.
The work in Biorizon on feedstock, conversion processes as well as applications is increasing in size and impact. Organizations that wish to become part of this are invited to join.

David Sudolsky, Anellotech, Inc.
Meeting Sustainability Demands through Bio-Based Chemicals from Non-food Biomass
Increasing demand has been placed on consumer product brands and chemical producers to improve their sustainability profiles. The chemical industry has no viable option for 100 percent bio-based aromatics benzene, toluene and xylenes [BTX] before due to the lack of a cost-effective process.

Anellotech's pioneering thermochemical catalytic biomass conversion (Bio-TCATTM) technology economically produces BTX from non-food biomass. Through this innovative process, Anellotech is accelerating the development of bio-based polyester plastic (polyethylene terephthalate or "PET"). Bio-TCAT's bio-paraxylene paired with the other core component of PET, monoethylene glycol (MEG) — already commercially available from bio-based resources —will allow the economical production of 100 percent bio-based beverage bottles. Other bio-based derivatives of BTX are also enabled, such as nylon, SBR, polyurethane, polycarbonate and linear alkyl benzene.

Anellotech's process is targeted to be cost-competitive compared to traditional petro-based processes, and cost-advantaged to fermentation-based routes, there will be a strong economic incentive for companies globally to license and build facilities based on Anellotech's technology.

To ensure success in its technology development and licensing efforts, Anellotech has assembled a world-class R&D team by complementing its internal team with strategic partner relationships ((Johnson Matthey, leading global catalyst and IFPEN/Axens, process development, design and licensing) to ensure its proprietary process technology is successfully developed, scaled-up and presented for licensing to the global market. Anellotech has partners in the BTX supply chain for development funding and with potential to build the first commercial Bio-TCAT unit.

Anellotech, together with its strategic R&D and funding partners, targets commercialization of its technology in 2019.

Session 2: Monday, April 18 10:30am-12:00pm
Navigating the Valley: Scaling Up in a Low Oil Cost Environment

Moderator: Sean Sutcliffe, Green Biologics Ltd
Greg Smith, Croda

Cameron Hibbert, Genomatica
The new forces driving commercialization of biobased products
Our industry has made great progress to enable commercial production of an increasing number of biobased products. This presentation looks at some new approaches driving more rapid adoption and deployment of these products, beyond what any individual technology supplier can provide. These approaches often act to stitch together and/or solidify a complete product value chain, and can include assured access to feedstocks; back-integration by major chemical users; leveraging the financial resources of a large firm's balance sheet to complete a project, in return for long-term purchase commitments; financial hedging and risk management expertise; and application-knowledgeable distributors. The presentation will examine multiple examples of these new commercialization structures and discuss how different parts of the industry can benefit from these trends.

Thomas Boussie, Rennovia, Inc.
Scalable Bio-Based Chemicals Production using "Conventional" Catalysis
Rennovia is developing scalable, chemical-catalytic conversion processes for the production of high-value chemical products from renewable raw materials. Production processes employ standard industrial chemical manufacturing equipment coupled with Rennovia's proprietary catalyst technologies. Current large-volume product targets include adipic acid (AA) and hexamethylenediamine (HMD), a combined $10.2 B global market opportunity. Rennovia's renewable AA technology has been piloted for three years and is currently being scaled up with development partner Johnson Matthey Process Technologies. Bio-

based HMD is currently in pilot phase at Rennovia, moving to scale-up in 2016. Both processes are operating close to target commercial metrics and have projected production costs significantly advantaged over current petrochemical processes.

Session 3: Monday, April 18 2:30pm- 4:00pm
Advancements in Sugar Molecule Production

Moderator: Colin South, Proterro

Theodora Retsina, American Process, Inc.
AVAP® process: the innovative platform for nanocellulose production and bio chemicals
A viable lignocellulosic Biorefinery should be able to extract the highest value from the principal biomass components (cellulose, hemicelluloses and lignin) by converting a variety of feedstocks to a range of products at high yields. Efficient recovery of chemicals and low operating costs are also required for economic feasibility. These criteria are fully met by AVAP® technology patented by American Process Inc. (API). The technology utilizes hot sulfur dioxide-ethanol-water (SEW) solutions to fractionate various lignocellulosics into cellulose, hemicellulose sugars, acetic acid, organosolv lignin and lignosulfonates.

The cellulose stream can be enzymatically hydrolyzed to produce high quality C6 sugars. The sugars have been tested by a variety of end users with several fermentation processes to bio chemical products. Since the AVAP process operates at low temperatures, low pH and occurs quickly, the hemicelluloses and dissolved glucose (from cellulose) fraction is not degraded and is made almost entirely available for conversion into ethanol or butanol coproduct. Lignin is removed from the process and burned, making AVAP a net energy (power) exporter.

Alternatively, the cellulose stream can be used to produce nanocellulose. Nanocellulose is a versatile material with a vast array of commercial applications including composites and foams for automotive, aerospace, and building construction, viscosity modifiers for cosmetics and oil drilling fluids, and high performance fillers for paper, packaging, paints, bioplastics, and cement. API is the world's first company to produce and sale six different varieties of nanocellulose products with tailored morphologies and surface properties to satisfy the needs of different end users. The products are produced at API's fully-integrated Thomaston Biorefinery demonstration plant along with lignocellulosic sugars, fuels and chemicals co-products. The plant has a capacity of up to 0.5 tons per day (dry basis) nanocellulose.

Arno van de Ven, Stora Enso
Commercializing Biomaterials Through Stora Enso's Innovative Biorefinery Concept
Traditionally a pulp and paper business, Stora Enso has access to non-food-competing, non-GMO, renewable feedstock, which puts the company in a strong position to diversify into biomaterials. In 2012, Stora Enso created a Biomaterials division to begin providing renewable materials solutions and the company now offers a new biorefinery concept. With a sustainable fractionation process, valuable raw materials from different biomasses can create a range of fossil-free products in industries such as food, packaging and home and personal care. After acquiring a proprietary extraction and separation technology, Stora Enso developed a 3-platform process: C5 sugars, lignin and C6 sugars. A high-purity xylose sugar stream, lignin and glucose can all be extracted, yielding high-purity sugars which can be varied. The cellulose fraction can be hydrolysed into glucose or used in its polymeric form and directly converted into chemicals or materials.

Lignin from this process has different characteristics to kraft lignin, which can be recovered from pulping operations, opening up new application opportunities in the automotive and construction industries, among others. By-products and new chemical, mechanical and enzymatic processes will also help unlock the value of high-purity cellulose contained in lignocellulosic feedstock. Products which were previously used in renewable energy production should be considered to be of a higher value as new markets open up. An efficient, flexible route for producing biomaterials has been created, addressing cost and purity issues and allowing both virgin biomaterials and biomass waste to be used. The small biorefinery concept can also be applied to pulp mills – Stora Enso's Sunila mill produces 370k tonnes/year of pulp and now also isolates lignin, removing it from the waste stream. As technology improves, the biomaterials industry will grow and demand from brand owners will increase. A new biorefinery concept is key for this shift.

Fred Moesler, Renmatix
Island to Inland: What's Driving Bio-Collaboration?
Industrial manufacturers & consumer goods companies alike are opening the door for increasing adoption and integration of biobased chemical products. Looking to meet that demand, upstream & downstream players are evolving their operations & forming partnerships to collaborate in the production or processing of biobased intermediaries. The bridge connecting such pioneers is a low-cost, large volume supply of biobased building blocks – enabling expansion of the bioeconomy. Efficient production & use of cellulosic sugars involves multiple parties with complementary capabilities. This cooperative alignment calls for interdependent collaboration to deliver realistic alternatives to augment conventional petrochemicals. Access to conversion technology that results in an affordable cellulosic sugar stream, enables upstream players to advance along the value chain, & helps long developing downstream technologies to be realized in market, & produce meaningful volumes of renewable materials.

Session 4: Tuesday, April 19 2:30pm-4:00pm
Production of Renewable Chemicals from Waste

James Iademarco, Strategic Avalanche LLC Consulting

Gisle Johansen, Borragaard AS
Advanced Biomaterials And Biochemicals From Wood And Agricultural Waste
Recent development within the biofuel industry has shown that it is challenging to build a sound business case for advanced biofuels as a standalone operation, even with economic incentives from the local authorities. As one of the world's leading biorefinery operators, Borregaard is currently producing specialty cellulose, lignin chemicals, vanilla flavour and ethanol from various species of wood. The strategy has been particularly successful for lignin, which is considered a troublesome by-product in many other contexts and at best has a value as a fuel for co-generation plants. The result is an operation that is economically sound with a very favourable carbon footprint. Borregaard's new biorefinery demonstration plant was commissioned early 2013 and turns woody biomass or agricultural waste into biochemicals or bioethanol and lignin chemicals. In parallel, Borregaard has developed an industrial process, Exilva, for the production of nanofibrillar cellulose, and will to commission a commercial plant late 2016. The presentation will focus on experiences from the biorefinery demonstration plant, value added products from lignin and cellulosic sugars and industrialization of nanofibrillar cellulose.

Philip Goodier, Plaxica
Profitable Conversion of By-Products from the Pulp Industry into Low Cost Industrial Chemicals
Nearly all processes to convert biomass to chemicals rely upon the conversion of cellulose to fermentable sugar. The cost of these processes is dominated the energy and / or enzyme required to hydrolyse the strong cellulose molecule to clean fermentable sugar, and the cost of the biomass processing unit. This in turn leads to economic challenges, especially in today's low oil price environment.

Plaxica is taking a radically different approach in 3 areas:

(1) We focus on the hemicellulose content of biomass. This is easier to extract and hydrolyse than cellulose, leading to a large reduction in operating costs.

(2) We use a low cost chemical process to convert sugars to lactic acid – with a particular focus on the C5/C6 sugar streams from the hydrolysis of hemicellulose. Our process is tolerant of the impurities present in biomass.

(3) We use low value hemicellulose-rich waste streams - such as those produced by the Dissolving Pulp Industry - as feedstock. These are available in large quantities at existing industrial sites and are currently incinerated. As the biomass to hemicellulose plant already exists, investment costs are reduced.

Plaxica takes the hemicellulose waste stream and, configured as a true biorefinery, converts the stream and its associated impurities into valuable products – lactic acid, esters of acetic acid and lignin.

Lactic acid is a valuable C3 platform chemical. Its conversion to polylactic acid green polymers is well known – our process transforms the cost and performance of PLA. Plaxica's lactic acid can also be used to produce green propylene glycol at a lower cost than the existing petrochemical route.

In parallel with the production of lactic acid, the naturally occurring wood acids are converted into acetic esters which have high value applications in the coatings industry. High quality lignin is also isolated.

The low cost feedstock and high carbon yield of the process allows it to deliver attractive investment returns.

Timothy Cesarek, Enerkem, Inc.
Renewable chemicals from waste to close the loop of the circular economy
"We are proud that municipalities around the world are looking at the City of Edmonton and the Enerkem facility to see how they too can divert waste from landfill while producing clean fuels and chemicals through this innovative technology." – Mayor Don Iveson, City of Edmonton, Alberta

The world's very first full-scale biorefinery to use non-recyclable municipal solid waste (MSW) as a feedstock recently reached a pivotal milestone when it initiated biomethanol production at the commercial scale – a game-changing success which had never been accomplished before anywhere in the world.

This facility, called Enerkem Alberta Biofuels, will soon begin delivering commercial quantities of renewable methanol, a tangible step towards closing the loop of the circular economy.

In 2009, Enerkem and the City of Edmonton signed a 25-year agreement. The agreement followed a highly competitive global technology review and qualification process in which the City evaluated more than 100 waste diversion technologies.

Under the agreement, the City of Edmonton agreed to provide Enerkem with 100,000 dry, prepared and sorted metric tons of non-recyclable MSW for a 25-year period while Enerkem committed to take the feedstock as well as build and operate a waste-to-biofuels facility in Edmonton.

This is the first collaboration between a waste-to-biofuels producer and a metropolitan center to address waste disposal challenges. This facility is becoming a model for other municipalities, urban and rural, on how to sustainably manage their waste and increase waste diversion rates.

The company has developed the first technology capable of breaking down chemically and structurally heterogeneous waste materials and convert them into a pure, stable and homogeneous syngas. This syngas is then converted into renewable fuels and chemicals which can help reduce carbon dioxide emissions, aid in extended producer responsibility and meet the growing world demand for renewable chemicals.

Lisa Dyson, Kiverdi, Inc.
Using CO2 & CO to make Specialty Oils and Oleochemicals
Kiverdi is commercializing replacements for specialty oils and oleochemicals derived from CO2 and / or CO using its proprietary Carbon Engineering Platform. Kiverdi's technology converts gasified biomass and waste sources into a diverse range of high value, renewable products, serving important markets such as sustainable intermediates for surfactants, polymers, and lubricants.

Kiverdi's technology competes on cost and performance. Instead of building larger plants to drive economies of scale, Kiverdi's solution fills a "scale gap" to optimize supply chain costs using local, low capital plants. The combination of low-cost, flexible feedstock and high-yield CO2 / CO bioprocessing enables Kiverdi to produce Carbon Engineered Products with lower capital and materials costs, driving higher margins. Kiverdi can customize molecules specific to its customers' process and business needs, improving performance and achieving sustainability goals.

Session 5: Wednesday, April 20 8:30am-10:00am
High Value Renewable Chemicals from Vegetable Oils

Moderator: Doris De Guzman, Tecnon OrbiChem
Oleochemicals: A perspective from a matured renewable chemical sector
The oleochemical industry, the oldest renewable chemical market, has continuously evolved and adapted throughout centuries pre- and post-petrochemical eras. This presentation will cover a short overview of the different markets covering the lipids-based chemicals sector, their challenges in the ever-changing

chemical landscape, how this industry has co-existed with the petrochemical markets, and new companies and technologies entering this sector.

Products that will be talked about include basic oleochemicals: fatty acid, fatty alcohols and glycerine. Applications such as surfactants and lubricants will be covered. New uses for glycerine such as epichlorohydrin, methanol and glycols will be briefly discussed. Fats and oils feedstock such as palm oil, soybean oil, rapeseed oil as well as new generation of feedstock such as algae, waste oils, waste gases and other industrial oilseeds will be covered in this presentation.

Stefano Facco, Novamont SPA
New Renewable Building Blocks Derived From Renewable, Vegetable EU Resources
The transition from a traditional chemistry to the one based on bioeconomy opens the door to new markets and allows to broaden the range of already available products, built on a new economic, social and environmental strategies.

The development of integrated, local biorefineries, designed to mainly produce innovative products such as biochemicals and bioplastics, do offer a much higher added value compared to existing sites producing energy and biofuels.

In Italy major steps have already been taken, thanks to investments in research and the construction of new plants and demonstrators by some national industrial players. A practical example is represented by Matrìca, a 50:50 joint venture between Novamont and Versalis. The reconversion of a petrochemical site in Porto Torres (Sardinia) into an integrated biorefinery that, starting from selected oleaginous local crops, produces a range of chemical products based on Novamont's research and technology, is a first step in such a new industrial model.

Matrica's initial product family is based on azelaic, a dicarboxylic acid. This is an extremely interesting product from a chemical perspective, because it is one of the basic constituents of bioplastics and has a series of other possible applications (e.g. cosmetics and pharmaceutical sectors). Together with dicarboxylic acids, Matrica also produces a series of monocarboxylic acids. The flagship product of this set of acids is the pelargonic acid, a natural product which has a series of potential applications in the field of phytosanitary products, for example, but which will above all be used as a base in the production of biolubricants.

Matrìca is merely the first example of industrial development to have successfully been brought to such a positive result. More projects are meant to follow, based on various innovative technologies, such as the production of 1.4 BDO derived directly from sugar, through a fermentation process.

Zainal Azman Abu Kasim, Malaysian Biotechnology Corporation
The Emergence Of Advanced Oleochemical Industry And The Future Outlook Of Biobased Chemical In Malaysia
Recent developments in the petrochemical market have significantly changed the outlook for biobased chemicals especially the drop-in replacements chemicals. As a result, technology providers are looking for the most economically viable starting materials such as plant oil that could provide cost advantages while delivering a sustainable chemical product. Global oleochemicals market is expected to reach USD 30.03 billion by 2020, driven by rapid growth in various end-user traditional industries including personal care, food additives, surfactants, pharmaceuticals and the potential of new emerging biochemical market such as bio lubricants, flavors and fragrances. With current technological advancement, plant oil has also become a viably cheap source of feedstock for some commodity chemicals and a variety of novel chemicals. Palm oil is one of the most promising candidate for the feedstock as it is one of the 17 major oils and fats produced globally and it is also the most efficient oilseed crop in the world. The global supply of oils and fats estimated at 186.4 million tonnes of which palm oil contributes 32% of global output with world production at 53.7 million tonnes annually. With more than 20 million tonnes of CPO and other palm oil derivatives produced yearly, Malaysia is Asia's commercial hub for Advanced Oleochemical. The availability of palm related products such as CPO, CPKO, palm kernel and it's by products, make palm related products/ by products as a good candidate as feedstock for the biochemical industry. To date, several renowned global biochemical players have already chosen Malaysia as home for their first commercial production facility. BiotechCorp as the industry developer for Industrial Biotechnology in

Malaysia will highlight the potential of this in Malaysia and what it can offer to the biochemical industry players as well as the issues and challenges that need to rectify.

Erich Rosenberger, Nucelis
Challenges and Opportunities in Commercializing a Fermentation-Based Production Platform
Nucelis is successfully leveraging the versatility and flexibility of its proprietary technology and production platform to build a robust portfolio of high-value, functional, and sustainably-sourced ingredients. The first family of ingredient products currently being commercialized includes squalane for the personal care market, ergocalciferol and Vitamin D2 for the human nutrition and animal nutrition markets, and unique oil products also for the personal care market.

For the last three years, Nucelis has developed its technical process in parallel with our production strategy, and channels to market. We have faced challenges in strain development, fermentation, downstream processing, and market development. However, difficulties and challenges found in each of these steps have been overcome, leading to where we are now: on the brink of commercializing our first project.

We have chosen a "capital lite" approach to manufacturing, and the use of selected distributors as channel partners to bring our products to market. This strategy has provided us with enormous capital flexibility, resulting in numerous opportunities and advantages to alternate models that exist in industrial biotechnology.

This presentation will look at the path that Nucelis successfully navigated in taking a fermentation based chemical production project from ideation and early development, through the R&D process, and ultimately to successful commercialization. We will look at what went right, what went "not so right", and what lessons we learned along the way.

Thomas Beardslee, Verdezyne, Inc.
Progress Towards First Commercial: Verdezyne's Biobased DDDA
Verdezyne is constructing the world's first plant for the large-scale production of bio-based dodecanedioic acid in Malaysia. Dodecanedioic acid (DDDA) is a linear, twelve carbon α,ω-dicarboxylic acid that has multiple applications in the chemical industry. The largest application is in the polyamide market to produce nylon 6,12 that is used for engineered plastics requiring special properties such as high chemical, moisture, and abrasion resistance . Other market applications include coatings, corrosion inhibitors, adhesives, lubricants, and fragrances. Currently DDDA is produced using non-renewable fossil-based feedstocks such as butadiene or alkanes. Verdezyne has developed fermentation technology for the production of DDDA that uses renewable vegetable-based fatty acids. In this presentation we will give an update on the progress of commercializing our process for the production of BIOLON™ DDDA. Included in the update are challenges overcome in demonstrating fermentation at sufficient scale to de-risk commercialization, partnerships that enable commercialization, customer evaluation of product performance, and progress on the construction of our first commercial facility.

Session 6 Wednesday, April 20 10:30am- 12:00pm
Development of Mono and Diacid Renewable Chemicals

Moderator: Jim Barber, Barber Advisors

Peter Punt, DutchDNA Biotech
Itaconic acid – The next major renewable building block chemical
The relatively high cost of conventional and cellulosic sugars combined with low prices of building block chemicals pose critical strategic questions for firms that are developing novel biological solutions for renewable building block chemicals. We contend today there are only a few biochemical product candidates which could be techno-economically viable for bioconversion of carbohydrate feedstock and that most hydrocarbons do not meet the economic viability criterion. Renewable chemical product candidates with higher oxygen contents (for example organic acids such as lactic and succinic acids), which might not be drop-in chemicals, offer greater yield potential and hence greater likelihood for techno-economic viability, albeit with a greater market adoption risk.

We claim itaconic acid (IA) could be the next major commercial renewable building block chemical. A joint collaboration between Lesaffre (Fr) and DutchDNABiotech (NL) aims at developing a new IA production strain and fermentation technology to significantly reduce IA production cost, hence enabling its broader use as a building block chemical. We elaborate on our innovative approach and its key advantages.

Marcel Van Berkel, GFBiochemicals
Bringing Levulinic acid to the market
GFBiochemicals is the only company to produce levulinic acid at commercial scale directly from biomass. Levulinic acid is one of the most promising biobased platform chemicals, levulinic acid has far-reaching applications.

With the acquisition of Segetis in February 2016, GFBiochemicals has obtained an important position downstream the value chain.

This presentation will address the industrial applications of levulinic acid and levulinic ketals, as well as the chemical's consumer product uses. Market sectors include plastics, flavors & fragrances, coatings & resins, packaging and personal care.

As in-house application development is expanding, greater functionality for levulinic acid, ketals and other derivatives will continue to evolve. With GFBiochemicals' own IP portfolio and a commercial-scale plant, biobased levulinic acid can enable truly sustainable products.

Alexandre Zanghellini, Arzeda
Bio-based Levulinic Acid and Derivatives for Advanced Materials Applications
Arzeda is an industrial synthetic biology company focused on the production of sustainable specialty and fine chemicals. Arzeda has engineered de novo a cell factory able to ferment sugars to Levulinic Acid (LA) derivatives as well as other C5 building blocks, compounds that are not known to be naturally produced by living organisms. The advantages of a fermentation route are numerous: a fermentation strain can convert both C5 and C6 sugars to LA, dramatically increasing the theoretical yield from biomass while producing few or no by-products compared to chemical and thermochemical alternative routes. Levulinic Acid was selected as a TOP25 sustainable chemical building block by a recent Department of Energy (DOE) report because of its large number of valuable derivatives: all are accessible with Arzeda's technology, either chemically or with additional enzymatic steps branching out from our core metabolic pathway.

In this session, we will discuss Arzeda's product portfolio of LA derivatives, including potential applications as high-performance additives for performance polymers, solvents for coatings and biopesticides.

Track 8: Technical Presentations

Session 1: Monday, April 18 8:30am- 10:00am
Global Biobased Economy Trends: Renewable Chemicals & Biofuels

Moderator: Josko Bobanovic, Sofinnova Partners
Building better, faster, cheaper start-ups in the global bioeconomy
We explore how investors work with start-up companies to build viable businesses in the long run, evaluate what often goes wrong and how those mistakes can be avoided. A careful look on investment trends in the coming years and ways for investors to see returns more rapidly is discussed. We discuss the need for project financing in the sector and ways for companies to reduce their capital expenses. Finally, we talk about importance of attracting entrepreneurs to the sector and helping them repeat their successes.

Michael Carus, Nova Institute
Turnover and employment in the European Bioeconomy
The presentation will show for the first time detailed information on turnover and employment in the European bioeconomy by sectors (NACE Divisions) and Member States of the European Union. The main data source for all of the sectors of the bioeconomy is the European database Eurostat containing comprehensive data on the economy of the Member States.

For those sectors that can be fully attributed to the bioeconomy, the data on turnover and employment was directly obtained from the respective Eurostat datasets. These sectors comprise primary biomass production (agriculture, forestry and fishery) as well as the sectors food, beverages, tobacco, paper and paper products.

The sectors textiles and textile products, forest-based industry, chemicals and plastics as well as pharmaceuticals only partly contain fully or partly bio-based products. Therefore, the bio-based shares of each product in these sectors were estimated and only these estimated shares are accounted for.

The methodology has been proven to work well and due to the reliance on Eurostat, annual updates of the results are possible. The Bio-based Industries Consortium (BIC), organizing research funds together with the European Commission in an order of nearly 4 billion Euro is using the economic data from nova-Institute to evaluate the bioeconomy in Europe.

Including agriculture and food products, the European bioeconomy shows a turnover of 2.1 trillion Euro and 18.3 million employees. The EU bio-based economy (bioeconomy without agriculture, forestry, fishery and food products) contributes a turnover of 600 billion Euro and jobs for 3.2 million employees.

Turnover and employment in the different bio-based sectors as well as the estimated bio-based shares in the Chemical Industry are further broken down by Member States. Additionally, the analysis comprises a comparison of absolute employment between different sectors of the bio-based economy (such as chemicals, plastics, biofuels and bioenergy) as well as a comparison of their employment relative to their feedstock demand.

Julia Allen, Lux Research
Capacity Growth And Megatrends Of The Bio-Based Material And Chemical Industry From 2005 To 2019
The Bio-based Materials and Chemicals (BBMC) industry is maturing, commercializing, and realigning to adjust to the latest market realities. The leading technologies are aligning the financing, corporate relationships, and research muscle necessary to scale in a era of lower priced crude, rising feedstock costs, and a push towards non-food biomass inputs. We examined over 300 production facilities throughout the world, that were planned, operating, or shuttered between 2005 and 2019 to determine the current trends of this ever evolving space. This presentation will analyze and quantify capacity change and capacity trends from 2005 to 2019.

Bernard Roell, RSC Bio Solutions
Beyond the Mandate: The Adoption Curve of Biobased Lubricants
As many industries have shifted their sustainability focus from WHAT they produce to examine HOW they produce, an increasing number of companies have embraced sustainability-driven products and processes in many operational areas – from land use to downstream products.

In the wake of growing environmental scrutiny and heightened regulatory requirements, marine operators and OEMs have embraced environmentally acceptable lubricants (EALs) as a safe and effective alternative to petroleum based products. Now, and even in the absence of a regulatory mandate, many land-based firms have begun to follow suit, citing not just these fluids' ability to have an immediate impact on overall sustainability, but their performance benefits and impact in reducing overall costs.

This presentation will provide the following information related to the increasing adoption of biobased lubricants:

- Market trends - Where are we on the adoption curve? What can we expect to see moving forward? For which types of operations are EALs most viable?
- A comparison to mineral oil counterparts in terms of function and performance
- An overview of the types of EALs and next-generation biobased renewable technologies, including definitions of environmentally preferable products and the strengths and limitations of each type

- Guidance on current products that meet key various industry needs and what's next in terms of product development. Session attendees will leave this presentation with an enhanced understanding of the following areas:

- Trends in the adoption of biobased lubricants

- The suitability of various types of environmentally acceptable lubricants based on application and varying levels of sustainable lubricants, from biobased to Ecolabel, and the requirements for each

- Performance characteristics of EALs and mineral oils

- Determining the overall impact of switching to EALs

- Next-generation biobased technologies and new product development

Mark Riedy, Kilpatrick Townsend & Stockton LLP
The Status Of Available US And International Debt And Equity Mechanisms For Renewable Chemicals And Bioenergy
Mr Riedy will discuss available debt, equity and non-dilutive funding sources and mechanisms for renewable chemicals and bioenergy technology companies and their US and international projects, including the use of credit enhanced debt with government loan guarantees and other enhancements; green bonds; protective insurance products; strategic investor equity; non-dilutive grants and tax equity; regulatory incentives; capital and institutional markets; green funds from states and banks; and new capital equity expansion mechanisms such as MLPs, REITs, High Yield Bond Funds, Yieldcos, Warehouse Entities and other hybrid structures.

Session 2: Monday, April 18 10:30am-12:00pm
Synthesis and Applications of Bioplastics

Paul Antoniadis, Solegear Bioplastic Technologies Inc.
Durable Consumer Products and Packaging Materials Made from Next Generation Bioplastics
Solegear Bioplastic Technologies Inc. is fundamentally changing the way plastics are made by using the principles of Green Chemistry to reduce CO2 emissions, remove Chemicals of High Concern and maximize the use of renewable, plant-based resources. Every year, 688 billion pounds of plastic are produced globally and only about 12% gets recycled. This means over ½ a trillion pounds of plastic is being discarded every year, piling up in landfills and eventually leaching hazardous chemicals into our water tables.

However, plastics are durable, versatile and reduce CO2 emissions significantly in shipping compared to glass. Solegear is focused on replacing the petroleum-based ingredients in plastic with the highest possible percentage of renewable materials. Solegear has developed proprietary, next-generation bioplastics that meet or exceed the performance characteristics of traditional plastics, can be produced using existing manufacturing equipment and are cost-effective.

Solegear has two main technology product lines – Polysole® and Traverse®. Polysole, formulated with the highest bio-content and no Chemicals of Concern, is suitable for rigid packaging and durable goods applications and can be recycled or composted in appropriate industrial facilities. Solegear recently introduced a line of office accessory products made with Polysole LV1250, which has earned a USDA BioPreferred® label with 85% bio-based content. Solegear's Traverse biocomposite materials are designed to meet more challenging performance requirements such as high heat resistance and flame retardancy. They are perfect candidates for international shipping conditions and can be used as drop-in replacements for PET, PVC and PS. Other types of Traverse are designed for extra-durable applications such as toys, housewares and pet products and can be an alternative to ABS and PA in existing manufacturing facilities. Traverse materials also excel at applications requiring high impact resistance.

Mateus Garcez Lopes, Braskem
Driving Innovation with Renewable Chemicals Platform
Braskem is the Americas' top thermoplastic resins producer. With 36 industrial plants spread across Brazil, United States and Germany, the company produces over 16 million tons of thermoplastic resins and other

petrochemicals per year. Braskem has a clear strategy for investing in R&D of renewable based chemical technologies as alternatives to complement its current portfolio. Braskem is the world's leading biopolymers producer with its 200,000 tons Green PE plant that produces polyethylene from sugarcane-based ethanol. Going forward into other markets, Braskem design a renewable rubber platform. The company has signed an agreement for the joint development of of butadiene with Genoamtica (2013) and isoprene with Amyris and Michelin (2014). Braskem wants to accelerate innovation through partnerships with R&D companies, which could aggregate advanced technologies to support its strategy. To support its partners, Braskem has invested in one of the most advanced laboratory in South America. A 7000 ft2 facility in Campinas (Brazil) with a multidisciplinary team in a variety of areas, including microbiology, chemical engineering, bioinformatics, fermentation and downstream processes. Braskem infrastructure to support partners also includes 7 pilot plants, a Polymer Science R&D center in Pittsburg (USA) and a Catalysis R&D Center in Triunfo (Brazil). The research programs seeks not only to find alternatives that are based on renewable feedstocks, but on developing routes that are also competitive in terms of production cost. Braskem reaffirms its commitment to invest in the research of producing chemicals from renewable feedstocks, effectively strengthening its leadership in biotechnology and renewable chemicals. Braskem vision is to be world leader in sustainable chemistry, innovating to better serve people.

Stan Dudek, Polymer Processing Technology
High Value, Low Cost Solutions in Aerobically Biodegradable Fumigant Mulch Films
In the agricultural film space, there exists a need for specialty films which effectively contain potentially hazardous pesticides, insecticides, and fumigant chemicals from atmospheric release. These short-life films are known as broadcast fumigation mulch films, and only multilayer multi-material films have historically met the vapor permeation requirements of the application. These films are concurrently less recyclable and more costly than traditional mulch films.

In conjunction with other strategic stakeholders, Genarex is in the midst of developing an effective biobased mulch film that simultaneously meets the fumigant barrier requirements and is an aerobically biodegradable film as defined by ASTM D6400 standards. In an effort to meet market demands for total system cost, the combination of multiple low-cost elements results in a relatively inexpensive film which qualifies for virtually impermeable film (VIF) and possibly even the totally impermeable film (TIF) classification. In addition to the impermeable classification, the biobased fumigant films addresses the performance and financial goals of the farmer while reducing the consumption of fossil fuels.

Session 3: Monday, April 18 2:30pm- 4:00pm
Renewable Chemical Platforms

Moderator: Susanne Kleff, MBI
Second Generation Succinic; A Technology Ready To Go!
Bio-based succinic acid is probably the best developed and commercially successful of the new generation of bio-based petrochemical replacement chemicals. However all the bio-succinic acid currently produced is all first generation (i.e. produced from non-cellulosic sugars).

Consumers, consumer brands, and chemical companies would prefer a lignocellulosic-derived bio-succinic acid.

MBI has developed a bio-succinic acid technology based around the production host Actinobacillus succinogenes. This organism has the dual benefits of being a natural succinic acid producer and simultaneously consuming a range of C5 and C6 sugars.

The ability of proprietary improved strains of A. succinogenes to produce succinic acid efficiently from different LCB has been demonstrated and the progress of this technology toward demonstration and commercial scale will be discussed.

Shawn Jones, White Dog Labs
Acetone production using acetogenic mixotrophy to maximize mass yields
A primary economic driver for biochemical/biofuel processes is feedstock cost, and therefore it is crucial to maximize conversion of the feedstock into a product of interest. However, biomass (particularly sugar) is less reduced than the majority of biochemical products of interest, particularly non-oxygenated fuels and

alcohols. Accordingly, fermentation processes must oxidize a portion of the biomass, thus releasing CO2 and decreasing the potential mass yield of the product of interest. Anaerobic Non-Photosynthetic (ANP) Mixotrophic fermentation is a fermentation process to help mitigate the mass loss of CO2 by using microorganisms that can consume both sugar and CO2 simultaneously into the product of interest.

As a first demonstration of this technology, our company is targeting acetone production, an important commodity chemical and a feedstock for poly(methyl methacrylate) (PMMA) production. Currently, there is no economically viable biological process for acetone production because with traditional fermentation, the theoretical maximum conversion of sugar into acetone is only 32wt%. With ANP Mixotrophy though, the theoretical maximum mass yield can be increased to 45wt%. Accordingly, our company has developed a production strain that can produced acetone at a mass yield of 43wt% from a diversity of sugar feedstocks, and we are currently moving towards 1000L, continuous fermentation demonstration-scale. While we are specifically targeting acetone as a first of its kind demonstration, this technology has the ability to produce a diversity of biochemical and biofuels at unprecedented mass yields that are 50 – 100% higher than previously accepted theoretical maximums.

Cesar Granda, Earth Energy Renewables, LLC
Short- and Medium-chain Fatty Acids as the Basis for A Renewable Chemical Platform in the 21st Century

Short- and medium-chain fatty acids, which are mono-carboxylic acids ranging from 2- to 8-carbon in length (i.e, acetic through caprylic acids) enjoy a rich chemistry, which allows them to become building blocks in the manufacture of many other highly valuable chemicals such as esters (e.g., ethyl butyrate), primary (e.g., n-butanol) and secondary alcohols (e.g., 3-hexanol), ketones (3-hexanone), diols (e.g., hexylene glycol), dienes (e.g., 2-Methyl-2,4-pentadiene), olefins (e.g., butylene), unsaturated carboxylic acids (e.g., acrylic acid) and unsaturated (e.g., fumaric acid) and saturated di-carboxylic acids (e.g., adipic acid). Such wide array of products presents a clear opportunity for a full-fledged renewable chemical platform with these fatty acids as intermediates. However, it is important that these acids be produced inexpensively and globally from many different types of renewables feedstocks. These acids are readily produced from renewable organic feedstocks in anaerobic digestion (AD) where methane production has been suppressed as in a cow stomach or in termite guts. Unlike pure culture fermentations, AD is an extremely robust and versatile process for bio-conversion of organic feedstocks. AD employs natural consortia of microorganisms that adapt very efficiently to most operating conditions and organic feedstocks and it requires no aseptic conditions, no GMOs, and no extraneous enzymes. As a result, AD is also the most inexpensive and globally replicable bio-conversion process in the market. Earth Energy Renewables (EER) is commercializing a technology that is able to process most organic feedstocks effectively by AD and then efficiently and inexpensively recovers the fatty acids in a very pure state. EER estimates that the highly pure fatty acids may be produced for <$500/ton at scales >14,000 ton fatty acids/yr capacity. Such simplicity, low costs and global replicability of the EER process provide a clear opportunity for these fatty acids to become the basis for a renewable chemical platform in this century.

Rishi Jain, Praj Matrix
Development Of A Process For The Production Of 2,3-Butanediol
2,3-butanediol is known to be a platform chemical with several industrial applications. One of the biggest potential applications is its conversion to 1,3-butadiene for rubber applications. In this study, we have shown that the fermentation of sugarcane molasses using Bacillus subtilis for the production of 2,3-butanediol can be an industrially viable solution.

A metabolic engineering approach was taken to reduce acetoin, a by-product of the fermentation process. Two strategies were tested to modify Bacillus subtilis for increasing the yield of 2,3-butanediol. Cofactor engineering to improve the intracellular availability of NADH led to a significant decrease in acetoin and increase in 2,3-butanediol yields in sugarcane molasses fermentation. Over expression of the rate-limiting step also led to an increase in the 2,3-butanediol yield in sugarcane molasses fermentation.

For BDO extraction and purification, this work has explored the effect of addition of salt and the role of colloidal liquid aphrons (CLAs) in pre-dispersed solvent extraction (PDSE). Continuous countercurrent

liquid-liquid extraction experiments conducted for synthetic and fermented BDO solutions by adding 10 wt % K2HPO4 salt to the aqueous feed showed that addition of phosphate salt to the aqueous feed increased the BDO extraction efficiency by 81.8% for synthetic BDO solution and by 30 % for fermented BDO solution at 2.5 wt% BDO in feed. Meanwhile, for the first time, the use of centrifugal contactor (CCS) is established for the formation of stable CLAs. Compared to the traditional liquid-liquid extraction process, PDSE method provided 35% to 85% increase in mass transfer coefficient and about 30 % reduction in overall solvent loading. Overall, the purity of the BDO obtained from the process was 99.12 %, reflecting the potential benefits of the process that has been employed.

Allen Barbieri, Biosynthetic Technologies
As the first chemical company to receive USDA loan guarantee approval under the 9003 bio-refinery program, Biosynthetic Technologies (BT) is building a $200 million synthetic chemicals plant
With USDA 9003 biorefinery program loan approval, BT is in final engineering for a full scale commercial plant. Funded by shareholders that include BP, Monsanto, Sime Darby and Evonik, BT manufactures high-performance synthetic oils used as a key ingredient in motor oils and industrial lubricants. BT is actively working with over 100 major global lubricant manufacturers who will use BT's synthetic oils as an ingredient in the products they sell. With technology that was originally invented and patented by USDA scientists, BT now has over 40 issued patents and a clear lead in the biobased synthetic lubricants sector.

Session 4: Tuesday, April 19 2:30pm-4:00pm
The Value of Producing Renewable Specialty Chemicals

Moderator: John Shaw, Itaconix
Selling High Performance Renewable Polymers into an Evolving World of Trends, Labels and Laws
New specialty chemicals usually succeed by delivering new levels of competitive performance and cost advantages. Within consumer products, differentiation often depends on enabling customers to respond faster and better to market trends, product labeling and regulatory compliance. As use of Itaconix polymers grows in North America and Europe, Mr. Shaw will discuss how Itaconix is launching new products and evolving its marketing efforts to better meet emerging consumer preferences and regulatory demands.

Sanjay Chaturvedi, Praj Industries ltd
Bio chemicals : Bulk or specialty?
The Industrial biotechnology is seeing a shift form biofuels to bio chemicals. However choosing the right biochemical for development is still a challenge. Also, there is a big debate on what makes commercial sense for development, specialty or bulk chemical.

My talk will focus on pros and cons of choosing the bio chemicals with industrially relevant examples as well as Praj experiences.

Sagar Gadewar, Greenyug, LLC
Specialty Chemicals from Bio-ethanol: Capitalizing on the Biofuels Infrastructure
Greenyug develops and commercializes breakthrough technology to produce drop-in renewable specialty chemicals at significantly lower cost than identical petroleum-based products. Greenyug is leveraging $150 billion global biofuels industry investment using bolt-on strategy by co-locating at existing bio-ethanol facilities to significantly reduce capital needs. Greenyug is commercializing a highly profitable process to manufacture value added products from inexpensive, renewable, abundant bio-ethanol. We are targeting the specialty chemicals sector which is a category of relatively high valued, rapidly growing chemicals with diverse end product markets. All of our products are drop-in replacements and are not only renewable but also have a lower fixed and variable cost of production compared to the fossil-based current state of the art. Applications include paints, coatings, plasticizers, acrylates, pharmaceuticals, packaging, construction, automotive interiors and cosmetics. There is a growing demand for renewable and sustainable chemical products primarily driven by consumer interest in sustainability and climate change mitigation. At the same time, the market is not willing to pay a premium for "green" products. Our superior economics allows us to compete with conventional petroleum based products on market

economics alone and, therefore, our products do not require a "green" premium to succeed commercially. Greenyug is commercializing its technology at a large bio-ethanol facility in the US Midwest.

Session 5: Wednesday, April 20 8:30am-10:00am
Process Improvement and Scale-Up in Industrial Biotechnology

Daniel Bar, Chemistria
The Right Purification / Separation Process Cannot Be An Afterthought
In the production of industrial biochemicals or biofuels, separations can be difficult, costly, and inefficient. The difference between a good and a great separation process can mean the difference between a successful project and a failure. Separation technologies are many, and the selection and purchase of such components is anything but straight-forward. Having the right components in the right arrangement is critical to the technical and commercial viability of a new biorefinery. Working with the right purification partner from the start will increase the odds that the produced bio-molecule will meet customers' purity and composition requirements, and will ensure a robust, cost-effective, and high-yield production process.

Eurodia's CHEMISTRIA division is dedicated to the purification challenges of the bio-based chemical and biotechnology industries. With more than twenty-five years of experience in varied industries, including dairy, wine, sugars & sweeteners, specialty chemicals, biotechnology, and bio-based chemicals, Eurodia Industrie (and Ameridia, its North American subsidiary) is focused on the development of separation processes that are specifically tailored to each purification challenge. World leaders in the design of separation trains that include membrane technologies, chromatography, electrodialysis, ion exchange, and crystallization, the Eurodia process development team uses proprietary modeling and design techniques for the optimal mix, design, and implementation of process trains to provide reliable and cost effective separation / purification solutions.

Mathilde Gosselin, Materium

Arno Van De Kant, Bioprocess Pilot Plant
Scale up new biobased processes in an open access facility
Scale up is a key part of the process of bringing great idea's from lab to commercial scale. The Bioprocess pilot facility (BPF) in Delft, the Netherlands we are helping companies from all over the world to scale up their processes. Companies like DSM, Corbion, Verdezyne and many more are using the expertise and the facilities of the BPF to scale up their process and gather information for the commercial scale in an industrial environment. BPF is a service provider with very flexible facilities to help startup's and large enterprises to scale up their process. BPF has experience with many different chemicals, food and pharma ingredients.

Because of its high quality standards, the BPF can also be used to produce kg-quantities of material for pre-marketing and application tests at customers and/or preclinical trials (for Food or Pharma applications). The BPF has a long standing historical track record in bioprocess piloting with an experienced crew.

Situated at the Biotech Campus Delft, the Netherlands, the Bioprocess Pilot Facility B.V. (BPF) is a unique open access facility where companies and knowledge institutions can develop new sustainable production processes by converting bio-based residues into useful chemicals or fuels and production processes for Food and Pharma.

The facility has been specifically designed to enable the transition from laboratory to industrial scale. The facility has a modular setup. BPF allows users to construct complex operations by linking the separate process modules: Pretreatment, Hydrolysis, Fermentation and/or Downstream Processing.

About 33 people, mainly experienced process operators.

Investing about 37 Million Euro in expanding the facilities with pretreatment and food grade capabilities and also building a modern state-of-the-art control unit from which all the pilot plants can be controlled.

Based at the Biotech campus Delft all infrastructure and networks are available to perform chemical/biotechnology scaling processes

Kirsten Steinbusch, DAB B.V.
How To Increase Productivity Of Oil Product Fermentation While Scaling Up?
(Additional Authors: Fabienne Feskens-Snoeck, Rob Kerste, Arjan Heeres, Maria Cuellar Soares)
During the fermentative production of long chain hydrocarbons or extractive fermentations, product separation is often complicated by oil droplet stabilization and impaired coalescence, leading to emulsion formation. Delft University of Technology and Delft Advanced Biorenewables (DAB) have developed a technology to overcome emulsion problems without addition of costly chemicals, energy intensive operations or the use of expensive downstream equipment. The technology is based on gentle gas sparging, where the gas bubbles have two purposes: 1) formation of dispersion gradient in oil fraction and 2) break up the stable emulsion to form a continuous oil layer.

It was encountered that the gas phase, inherently present in the process, can be used to promote the separation. A proof of concept on fermentation broth in off-line columns operating at varying conditions of air flow and nozzle diameter, led to a maximal oil recovery (as clear oil) of 8% after 2 hours and 44% after 12h. By gravity settling no oil was recovered at all. The phenomena and working mechanism behind this effective technology are being investigated.

The method is attractive due to its potential low cost, ease of integration, and mild conditions facilitating cell reuse. The mode of operation for separation and fermentation have been investigated, to be able to integrate the technology into a fermentation. Accordingly these findings were translated into an integrated reactor system for product recovery during the microbial production of diesel and jet biofuels. This has led to the proof-of-concept of the technology on a 100 Litre and 1 m3 scale.

Doug DiLillo, Pall Corporation
Chemical Sterilization or Steam in Place - Considerations for BioTechnology Processes
Repeatable, reliable, and effective cleaning and / or sanitization is very important for successful Industrial Bio Technology Processing. Chemical Clean In Place (CIP) is commonly used for cleaning bio-reactors, fermenters and other equipment used in Industrial Biotech Manufacturing. CIP is used to remove in process residues, and control bio-burden. Complementing CIP, a Steam In Place (SIP) process is designed to kill harmful matter prior to beginning production and goes beyond the sanitization that can be achieved with only CIP.

Many Industrial BioTechnology processes require CIP and / or SIP to be performed as part of the manufacturing process between batches. The proposed presentation will detail the methods and equipment required to perform these operations to ensure the cleaning and / or sterilization of all product contact surfaces. The focus will be on the sanitization and sterilization methods for filters used in the process and how those methods relate to the technology in place, define limitations based on the technology in place, and will also highlight the latest equipment innovations.

Session 6: Wednesday, April 20 10:30am- 12:00pm

Moderator: Marilyn Bruno, Aequor, Inc
Cynthia Burzell, Aequor, Inc.
Ronald Cascone, Nexant, Inc
Tony Rook, Sherwin-Williams

Industrial Biofilm and Fouling Cause Operational Inefficiencies
Biofilm is everywhere. It is formed by bacteria to shield themselves from environmental stresses. It has been recorded on a titanium plate within 30 seconds after sterilization. Biofilm's top layers contain chemicals that neutralize the harshest antimicrobials. Bacteria below the biofilm dig into the surface, causing "microfouling" (corrosion, scale, contamination). Above the biofilm, contaminants, particles and other bacteria and organisms attach, often forming their own biofilms, such as molds, and fungi.

Barnacles, mussels and algae ("macrofouling") attach to biofilm on surfaces in contact with fresh or salt water, causing hydrodynamic drag and shear.

The panel will address the impacts of biofilm and fouling, including the loss of yields, and operational inefficiencies in the energy, transportation, and water sectors that cost time, manpower and money to remedy. For example, biofilm on renewable energy technologies (solar panels, wind turbines, algae ponds and bioreactors, tidal turbines), traditional energy plants (macrofouling in water intake pipes, biofilm on the surface of water in cooling towers, tills, etc.), and water treatment plants (clogged RO filters and membranes) means lower profitability and up to 50% increased fuel consumption (and emissions) to compensate for the drag and clogging.

Other industries impacted: heat exchangers, pulp and paper, food and beverage, agri/aquaculture, electronics, printing, aerospace, etc. Biofilm also carries disease, impacting the healthcare sector.

Speakers will give examples of the problem and evaluate the current and emerging remedies for biofilm and fouling that can rapidly improve yields, efficiencies, and profits in most industrial sectors:

--Physical scraping

--Heat/sterilization

--Biocides

--Slick surface materials and coatings

--Biomimetic, nano surfaces

--New technologies: toxic and non-toxic