Sustainable Bio-based Polyamide Fibers

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SUMMARY

• Early industry efforts focused on PA-6 depolymerization and PET bottle recovery.

• A preferable path is to use competitive bio-manufactured intermediates without impacting the global food supply.

• Universal Fibers, working with Evonik and Verdezyne, are developing bio-polyamides that prove this.
What is a Sustainable Fiber?

1. Is it recyclable?
   - Back into fiber or into something else where it contributes performance / properties [not fill].

2. How favorable is its LCA [Life Cycle Assessment]?
   - In comparison to petro-based 1st use polymer fiber.

3. Is it economically competitive?
   - Does it fit within customer value proposition.
Polyamide Fiber Recycling – Early Days

- **Solution dyed** [melt pigmented] fibers expand opportunities – in the short term.

- **Evergreen Recycling** – a JV between Allied signal and DSM forms at the end of 1997 for PA-6 depolymerization into caprolactam.

- **Post consumer carpet separation** – shredding, screening, shaving, decontamination.
Fast Forward to the Present

• Commercial carpet specifiers want sustainability, but without a $ penalty.
• Performance apparel brands striving for dominance and differentiation.
• PA-6 depolymerization still in the red.
• PA-66 depolymerization unlikely to ever be commercialized.
• Commodity fibers default to PET.
What This Tells Us

• The future for polyamide fibers will be where their performance properties are valued.

• One polyamide molecule can be, to some degree, substituted for another in making fiber.

• The race is on for biosynthesis between lactams and salts.
Why Bio?

• Life Cycle Assessment [LCA]
  – Embodied energy requirements
  – Sidestream wastes

• Economics
  – Plant size economies of scale are lower than for petrochemical counterparts
  – Potential for current sidestreams as feedstocks.
Universal Fibers’ Journey – Chapter 1

• Used post industrial wastes for over 25 years

• Began including post consumer polyamide content in 2007.

• At a key customer’s request, began developing a PA-6,10 melt colored carpet fiber in 2007.

• Started its investigation into the feasibility of bio-adipic acid late in 2010.
Premiere Fibers’ Journey – Chapter 2

• If recycled content jumps to 100% in PET, then when, in comparison, does bio-based polyamide become relevant and competitive?

• What 100% bio-based polyamides are available today?

• What 100% bio-based polyamides offer comparable toughness properties to PA-66?

• What “give and take” will performance apparel Brands allow?
The Journey Continues – Chapter 3

- Dec 2012 – Verdezyne enters into strategic relationship with Universal and Premiere for bio-adipic acid into polyamide fibers.
- The search continues for bio-based diamine.
  - Will it be from BDO based on succinic acid? [Evonik & BioAmber]
  - Will it be from BD based on BDO? [Genomatica]
  - Will it be from novel catalysis? [Rennovia]
  - Will it be Pentamethylene Diamine? [Cathay IB]
Observations

• Globally, plastics account for 6.7% [net] of oil consumption.

• In an impatient world, everything takes longer than we’d like.

• From the cutting edge of discovery, it takes years and lots of $$ to commercialize.

• Our experience favors the collaborative model.
Predictions

• In a world of increasing population and diminishing resources, sustainability is key.

• Amidst an increasing rate of change, organisms adapt more quickly than bricks, mortar, pipes and kettles.

• Bio content will continue to be seen as equally desirable as post consumer recycling. One as a beginning, the other as an end.
Conclusions

• It took Universal Fibers 20 years to make the jump from post industrial to post consumer.

• It will make a similar jump to commercial scale bio-polyamide in less than ½ that time.

• It gratefully acknowledges collaborative support:
  – Verdezyne and Evonik are 2 prime examples