CARE Market Development Update

CARE National Conference
May 1, 2019
CARE Market Development Update

Verdex Technologies
Non-Woven Institute
General Market Update

CARE National Conference
May 1, 2019
Verdex Technologies
Verdex developed proprietary Nozzle Technology to produce fibers in a single step into Non-Woven webs.

Suited for Contaminated Polymers Because Tech. does not depend on small orifice holes to make fibers.

Suited for degraded Polymers such as P.C. PET fibers with low fiber strength which ordinarily would not be able to be spun.

Nozzle creates Aerodynamic Entanglement during web formation.
Development Update

Details.

CARE Grant allowed resources for nozzle commercialization

Nozzle development Complete and Testing Web Testing under way.

Verdex has finished work to define Orifice size and array for spinning Recycled PET Stream.

Several Versions of contaminated PET have been delivered and trialed.

Ash contamination in the 3% to 5% range is acceptable. PP contamination can be as high as 10%.

Multi-Orifice Nozzle Array is being built with Grant funds for Commercial Development.
Nozzle Details.

Array of Entangled fibers Spinning from new Verdex Orifice
Next Steps

Newly Designed Nozzles
Next Steps

Verdex Expects to be spinning Recycled PET carpet fibers in May 2019 with Proprietary Scale-Up Spin Nozzle.

Three Non-Woven Markets have been Identified

1. **Acoustics** - Verdex Non-woven Fibers Sandwiched between 2 layers of Virgin Spunbond. Samples made and tested more efficient than incumbent Products for Automotive uses.

2. **High Efficiency Air Filtration**. PET Nano Fibers Deposited on a Pleatable Spunbond Substrate. Samples made and Testing in Progress.

3. **Cable & Wire Wrap**. PET fibers with Super Absorbent Polymer Particles on a Spunbond Substrate. Samples to be made.
Verdex PET Nanofiber to be Added to the Inside of Acoustical Blanket
Market End Use

Acoustic Market

Spunbond layer

Verdex PET recycle
Non-woven fiber layer
Acoustical Absorption of Verdex vs. Incumbents
Verdex Improvements
Low Frequency Sound Absorption
CARE Market Development Update

Non-Woven Institute (NWI)
Non-Woven Development

CARE Annual Conference
May 1, 2019
Objectives of Development

- Long Term Project
- Study all Potential P.C PET Candidates for Non-Wovens
- 3 Phases of Study
  - Characterization
  - Fiber Formation Trials
  - Applications Market Development
• A Dozen Streams from the Marketplace were Considered
  • Minimally processed >>>> Cleanest.

• How did each stream Perform in its Fiber making Ability
  • Could any, or all, make non-woven Fabrics
  • Which Manufacturing methods could be used
  • Which process parameters to use: Temp., press, flow rates, etc.
  • Hundreds of permutations and Combinations
PC. PET Characterization

- Eventually 3 versions were chosen
Recycled Streams Dirty >>>>> Clean

<table>
<thead>
<tr>
<th>Materials Considered</th>
<th>Impurity Levels</th>
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<tbody>
<tr>
<td>Rec PET grade 1</td>
<td>~15% ash</td>
</tr>
<tr>
<td>Rec PET grade 2</td>
<td>~6% ash</td>
</tr>
<tr>
<td>Rec PET grade 3</td>
<td>2% ash</td>
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<tr>
<td>F61 (virgin)</td>
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## Key to Success: Fiber Strength

<table>
<thead>
<tr>
<th>Recycled Carpet Stream</th>
<th>Intrinsic Viscosity</th>
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</thead>
<tbody>
<tr>
<td>Rec PET Grade 1</td>
<td>0.41 (38% low)</td>
</tr>
<tr>
<td>Rec PET grade 2</td>
<td>0.49 (26% low)</td>
</tr>
<tr>
<td>Rec PET grade 3</td>
<td>0.54 (18% low)</td>
</tr>
<tr>
<td>Virgin Indorama PET</td>
<td>0.66</td>
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</table>
Fiber Strength Variations

Within Each Recycled Stream Type: Great Variations

- IV Changes from one sample to next – Why?
  - Varying degrees of Degradation from Age
  - Samples could be 2 years old; or Decades Old
  - PET made 20 yrs. Ago is not same as today
  - Unseen or unknown Contamination
Non-Woven Fiber Formation Methods

Bi-Component Filament Extrusion

- Multi-functionality of 2 polymers simultaneously
- Can process low viscosity and poor melt strength polymers
- Applications: Medical & Hygiene products, Filtration, Industrial Wipes, Automotive, Carpets, Geotextiles, etc.

Melt-Blowing

- Can process low viscosity and low melt strength polymers
- Economical way to produce finer fibers
- Diverse range of raw materials
- Applications: Medical & Hygiene products, Filtration, Construction, Packaging, etc.

Homo-component Fiber Extrusion

- Cost-effective & simple
- High-speed of production
- Staple fiber & continuous filament production, with drawing process (increases tensile strength)
- Applications: Apparel, clothing and shoe industry, Medical products, Protective wear, etc.
Non-Woven Web Formation Trials

- Filament Spinning – Dozens of Variations - Not Viable
  - 100% & variety of Blends
- Biax Melt Blown System – Dozens of Variations - Not Viable
  - 100% & variety of Blends
- Bicomponent Spinning
  - Next Work Scheduled week of May 5, 2019
Technical Path Forward Q2 2019

- Bicomponent Spinning
  - Has best chance of Success
- Trials Scheduled w/o May 5, 2019
Why Bi-Component Spinning

This process is much more forgiving. The recycled PET pellets will be used as the **CORE**, where lower IV, low melt strength and contamination levels are less critical. Virgin PET with high Strength will be used in the **SHEETH** engulfing the Core with high strength material.
**Development Summaries to Date**

**Completed**
- TGA – Thermographic
- DSC Scanning Calorimeter
- MVR – Melt Flow
- Web formation trials on Spunbond line
- Web formation trials on the Biax line

**Partially completed**
- Solution Viscometry (for IV)
- FTIR (compositional analysis)
- GPC (MW analysis)
- Fiber spinning trials on the Hills Homo-component line - Cancelled
- Fiber Spinning trials on Bi-component line – To Come
**Initial Market Interest In NWI Technology: INDA Non-Woven Show**

<table>
<thead>
<tr>
<th>Company Name</th>
<th>Contact Person</th>
<th>Region</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nagreeka Exports Ltd.</td>
<td>Aditya Patwari</td>
<td>Mumbai, India</td>
<td>Interested in recycled polymers – PET (mostly bottle)</td>
</tr>
<tr>
<td>Foss Performance Materials</td>
<td>Bill Cummings</td>
<td>Hampton, NH, USA</td>
<td>Interested in recycling process</td>
</tr>
<tr>
<td>Auria Solution</td>
<td>Ernie Wilson</td>
<td>Albemarle, NC, USA</td>
<td>Recycling and sustainability, use in nonwovens</td>
</tr>
<tr>
<td>Blachford Acoustics Group</td>
<td>Alex Rak</td>
<td>Cambridge, ON, Canada</td>
<td>Interested in recycling of PET</td>
</tr>
<tr>
<td>Brunson Recycling</td>
<td>Megan Sharp</td>
<td>Matthews, NC, USA</td>
<td>Interested in recycling of PET bottles and carpet, nonwoven product development</td>
</tr>
</tbody>
</table>
Full Market Development

- To Begin toward End of Technical Work after all specifications have been developed.
- Slated to begin Q4 2019.
All Fibers Recycling Update

General National Development
Fiberon

- Minnesota Plant in Startup mode
- Plant has been Retooled for new PET Products.
- Equipment changes have delayed production.
- Expect Volume of PET recycling in 2019
- High Volume Expected when in full Operation
Aquafil

- Phoenix Plant has begun Operations. Phase I Operational
- Beginning Phase II.
- California Plant in Initial Phase of Implementation.
- Process Converts Nylon 6 PC Carpet into Virgin Like Nylon
Safe Path Products

- California Operation: Very Innovative Products
- Sidewalk Repair Kits: Thousands of kits needed
- Instant Spill Absorber: In final stages. Outperforms competitive products.
- PC4 is main Carpet Ingredient
- Cable Channels: New Development: PU + PC4
Visions Environmental

- California Operation: CARE Double Green Product.
- Colored aggregates Product: for Landscaping
- Using PC4 and Recycled paints as an ingredients
- Large opportunity in Asphalt Road Patches: Testing.
- 2 new product Groups
  - Road Bed Fill
  - Flowable Fill
Circular Polymers

- California Operation
- Expanding Rapidly: Additional Technology to reduce contaminants
- Developing large PET End Uses
- Processing Both Nylon 6 and Nylon 66
- Supplier of Processed PC4 to various companies for new products
**Arropol**

- CARE Grant Recipient
- Georgia Operation: Division of Star Chemicals
- Conversion of P.C. PET Carpet into Polyols
- Final Product: Polyurethane foams (Rigid & Flexible).
- In Startup mode and expansion
- Input product must be very clean: 97% range.
SwissTrax

- California Operation.
- Rubber Flooring manufacturer: Events Flooring
- Incorporating Granulated PET/PP in Swisstrax Ramp Edges.
- Testing via Grant is under way.
- Developing PC4 into Tierra Verde Products
- Rubber Technology licensed to manufacturers
Swisstrax
Ramp
Edges
Rubber
Flooring
TierraVerde
Family of Products
Interface

- Starting Tile Recycling Operation on West Coast
- Reclaimed PCV Backing will be used in new Tile products
- Will Reclaim Face fiber as well.
Miura Board

- Houston Texas Operation
- Producing several Product Categories
  - Boards for Variety of Applications
  - Testing in progress - Prosthetics
  - Testing in progress - Flooring in Trailers
- One important component is PET Carpet fiber.
  - PET does not melt in process: Gives boards Strength
- High PC4 Content not critical
SaN Pallets

- Past CARE Grant recipient
- Pallets Parts from Carpet PET and PP components
- Equipment Arriving for production.
Brotex

- Shearing **Nylon 6 Carpet Face fibers**
- Output sold to Engineered Plastics
- Output is Pelletized on internal Extruder.
- One of the last remaining shearing operations in U.S.
PET Chemical Recycling: A new Life

Brand Owners are taking more and more interest in Recycling plastics amid the publicity of Ocean plastics, etc.

- **Loop Industries**: Proprietary Low Temp system.
  - Major Contracts with PET Brand Owners. Evian, Indorama, etc.

- **Arropol**: Internally Designed System:
  - PET >>> Polyols >>> Polyurethanes

- **Eastman Chemicals**: New Chemical Recycling initiatives
  - Methanolysis & Other systems under consideration
Thank You

- Questions