PET-Recycling/Upcycling with the new LSP-Process (Liquid State Polycondensation)

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Thomas Pichler
PET-Recycling/Upcycling with the new LSP-Process (Liquid State Polycondensation)

- Next Generation Group in brief
- PET properties and forces describing material decomposition and reversible composition
- PET Reactor – basic functions
- Handling of various different input materials (bottle flakes, wovens, etc.)
- Results from test Runs
- Outlook on commercial availability
Competence for the Plastic Industry

Employees 2013: 226
Total Sales 2013: € 51,5 Mio.
Members

Next Generation Group

RECYCLING-SOLUTIONS
for industrial plastic converters and end-of-life plastics

> Headquarter Feldkirchen, AUSTRIA
> Customer Care Center for NAFTA/USA
> Customer Care Center for ASIA/CHINA

www.ngr.at

FILTRATION-SYSTEMS
for heavy contaminated end-of-life plastics

> Hanau, GERMANY

www.britas-recycling.de

PILOT PLANTS + LAB EQUIPMENT
for optimizing plastic materials and converting technologies

> Ebersberg, GERMANY

www.drcollin.de
Reducing the environmental pressures along the life cycle of products

**Product Design**
- Improving product-design concerning converting methods and material-properties with analytic-instruments focusing on recycling

**End-of-life**
- Improving the eco-efficiency of waste management with innovative recycling-solutions

**Production**
- Improving the eco-efficiency of production of goods by providing equipment for zero-scrap production

**Consumption**
- Reducing consumption levels and/or changing consumption patterns away from eco-intensive goods
LSP Technology

L S P

= Liquid State Polycondensation
PET properties and forces describing material decomposition and reversible composition

- Terephthalic acid
- Ethylene glycol
- Polyethylene terephthalate

Long polymer chain:
- high viscosity
- high molecular weight
- high IV-value
- high price

Cleaved by $\text{H}_2\text{O}$
PET properties and forces describing material decomposition and reversible composition

<table>
<thead>
<tr>
<th>Types</th>
<th>Intrinsic Viscosity (IV; dl/g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fiber, Textile</td>
<td>0.40 – 0.70 (0.62)</td>
</tr>
<tr>
<td>Film Grade</td>
<td>0.60 – 0.70 (BOPET)</td>
</tr>
<tr>
<td></td>
<td>0.70 – 1.00 (Thermoforming Sheets)</td>
</tr>
<tr>
<td>Bottle Grade</td>
<td>0.78 – 0.85 (Carbonated)</td>
</tr>
<tr>
<td></td>
<td>0.70 – 0.78 (Water flat)</td>
</tr>
</tbody>
</table>
PET properties and forces describing material decomposition and reversible composition

- AA-Value
  (Acetaldehyde) + others
  Less than 1,5 ppm

- Color value (L,a,b)

- Food Contact non objection letters (FDA, EFSA, etc.)
<table>
<thead>
<tr>
<th>Reason</th>
<th>Thermal decomposition</th>
<th>Thermal/oxidative decomposition</th>
<th>Hydrolytic decomposition</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Influence of too high temperature + too long exposure time</td>
<td>High Temperature+ Aerial oxygen</td>
<td>Moisture in the material</td>
</tr>
<tr>
<td>Comparison Decomposition-speed</td>
<td>1</td>
<td>10</td>
<td>10.000</td>
</tr>
</tbody>
</table>
**PET properties and forces describing material decomposition and reversible composition**

<table>
<thead>
<tr>
<th>State of PET</th>
<th>SSP (Solid State Polycondensation)</th>
<th>LSP (Liquid State Polycondensation)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solid / crystalline</td>
<td>Liquid (melt)</td>
<td></td>
</tr>
<tr>
<td>Environment</td>
<td>Vacuum or inert gas</td>
<td>vacuum</td>
</tr>
<tr>
<td>Typical Temperature</td>
<td>(200-240) °C</td>
<td>(270-280) °C</td>
</tr>
<tr>
<td>IV – Lift – Speed</td>
<td>(0.01 – 0.02) dl/g per hour</td>
<td>(0.01) dl/g per minute</td>
</tr>
</tbody>
</table>
PET-Reactor
Basic Functions

PET Upcycling unit for PET - fibers

Shredder-Feeder-Extruder-Combination

PET-Reactor

Strand-Pelletizer
Handling of various different Input-Materials

Input condition (clean in any case)

- fibers, wovens, non-wovens, sheets, films
- sheets, films, bottle flakes
- bottle flakes

Diagram:
- PET-Reactor
- Pelletizing
- Melt for direct converting
- Pellets
Results from test run

PET-fibre production waste
textured and uncut

<table>
<thead>
<tr>
<th>Material data</th>
<th>Parameter</th>
<th>Unity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture Average</td>
<td>3368</td>
<td>ppm</td>
</tr>
<tr>
<td>iV-Average</td>
<td>0.62</td>
<td>dl/g</td>
</tr>
<tr>
<td>Spin finish</td>
<td>~ 0.5</td>
<td>%</td>
</tr>
<tr>
<td>Output</td>
<td>350</td>
<td>kg/h</td>
</tr>
<tr>
<td>Result iV-Average</td>
<td>0.665</td>
<td>dl/g</td>
</tr>
</tbody>
</table>
LSP – Testresults PET Fiber

- Fibre
- after Extruder
- before Reaktor
- Pellets 60min. after Start
- Pellets 90min. after Start
- Pellets 120min. after Start
- Pellets 180min. after Start
- Pellets 240min. after Start
- Pellets 300min. after Start
- Pellets 360min. after Start

Test results:
- 0.630
- 0.570
- 0.563
- 0.641
- 0.663
- 0.658
- 0.655
- 0.660
- 0.666
- 0.665
New Laboratory facility
Production capacity of 400 kg/h (tests @ 250 kg/h)
FDA non-objection
Letter # 171
from Nov. 2013

under

http://www.fda.gov/food/ingredientspackaginglabeling/packagingfcs/recycledplastics/ucm376377.htm
Outlook on commercial availability

- Test program @ NGR
  - Preforms
  - Bottle flakes
  - Fibres / woven / non-wovens
  - Sheets
- Technical implementation
  - Up scaling
  - Results long term tests

- Test program in field
  - Long term performance
  - PET-properties
    - Colouring
    - Energy consumption monitoring
    - Operation parameters (controls)

Beta + Market Testing (Field tests)

Lab testing @ NGR

Technical Implementation

Commercialization
Post Consumer Fiber Trials

Input Material:

Output Material:
Summary

- LSP – Liquid State Polycondensation –
  shifts IV-increase and decontamination into the molten phase of PET (ideal for recycling-purposes)

- Lab tests and pilote plant show encouraging results

- Challenge tests have been very successful in terms of decontamination (FDA non objection-letter received in Nov.2013)

- Commercial availability to be expected early 2015
WE TAKE CARE OF YOUR PLASTIC WASTE