GLOBAL MARKETS, TECHNOLOGIES AND TRENDS IN POLYOLEFIN FOAMS

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Presentation Outline

- Introduction
- Why Couldn’t Polyolefin Foams Make it Big?
- Current Opportunities for Polyolefin Foams
- Outlook for Polyolefin Foams
- Concluding Remarks
INTRODUCTION
Introduction

- Foams are the substitute for natural cushioning materials. Polymeric foams in general provide: (1) cushioning, (2) insulation, (3) safety and packaging advantages

- The most common plastic foams include: (1) Polyurethane foams, (2) Polystyrene foams, (3) PVC-Poly Urea foams, (4) Phenolic Foams and (5) Polyolefin Foams

- Polyolefin foams are based on: (1) Polyethylene and (2) Polypropylene
  - PE foams are similar to flexible polyurethane foams (foamed through foaming agents to form closed cells)
  - PP foams are extruded/expanded similar to polystyrene foams and are based on increased melt strength of regular polypropylene

- Polyurethane foams are produced by reacting a polyol with an isocyanate using a blowing agent and are thermoset – cannot be recycled. Generally, polyols with TDI (Toluene di isocyanate) produce flexible foams while polyols with MDI produce rigid foams

- Extruded polystyrene foam is produced by extruding molten polystyrene containing a blowing agent. Expanded polystyrene beads are produced by expanding pellets with impregnation using a blowing agent
Foam Classification

- **Rigid Foams**
  - Building & transport insulation
  - Appliance insulation (e.g. refrigerators & freezers)
  - Buoyancy and in-fill

- **Flexible Foams**
  - Cushioning
  - Packaging
  - Automotive safety
  - Footwear and others
Types of Plastic Foams

Polyurethane Foams, 48%

Major Applications:
- Automotive
- Others

Polystyrene Foams, 37%

Major Applications:
- Insulation
- Cushioning
- Bedding
- Packaging

Polyolefin Foams, 6%

Major Applications:
- Packaging
- Automotive
- Medical
- Sports & Recreational

Other Plastic Foams, 9%

Major Applications:
- Packaging
- Building & Construction
- Insulation

Others

Major Applications:
- Automotive
- Insulation
- Cushioning
- Bedding
- Packaging
Polyolefin foams are the fastest growing plastic foams globally, expected to grow at 4.9% between 2014-2020.
WHY COULDN’T POLYOLEFIN FOAMS MAKE IT BIG?
Melt strength is defined as the resistance to extensional flow above the melting point of the polymer. High melt strength is a function of molecular weight and long chain branching.

Two regions where melt strength is of great importance are (1) at very high shear rates such as in extrusion applications, and (2) shear rates approaching zero such as in thermoforming and blow molding applications.

The different commercial techniques employed by manufacturers to produce HMS PP include:

- Increasing average molecular weight
- Broadening molecular weight distribution
- Creation of long chain branched structures

Improvements in melt strength and melt drawability are achieved by the introduction or creation of long chain branches, where the entanglement of the branched polymer chain gives rise to improved strength and drawability of the melt.
Polyolefins’ lack of satisfactory melt strength properties have historically prevented them from effective use in foam applications.

Polyolefin foams are attempting to increase market share across all the applications of other foams.

Polypropylene – essentially has the major disadvantage of low melt strength:
- The inherent melt strength characteristics of polypropylene tend to limit its usage in foaming, as well as in thermoforming, extrusion coating, and blow molding applications.

PE flexible foams – use the blowing agent with or without cross linking to provide additional strength - are mainly applicable for light duty cushioning, protective packaging and limited insulation (sound and roof insulation) applications.

There have been several technologies developed by polyolefin resin producers to increase the melt strength of PP -
1. LyondellBasell post reactor radiation method,
2. Borealis’ Daploy® - after-treatment of conventional polypropylene granules by a combination of peroxides,
3. JPP’s Chisso in-reactor method,
4. Dow Chemical’s Inspire™ (now part of Braskem),
5. Several compounders have attempted to increase the melt strength by using additives and re-design of equipment.
Approaches to HMS PP

- Post Reactor Process → Grafting, Peroxide
- In – Reactor Process → High MW, Broad MWD
- Compounding/Modifiers → Stiffness, Crystallinity
- Equipment Modification → Web Support

Source: Chemical Market Resources Inc.
Approaches to HMS PP (contd.)

Post-reactor based HMS PP
- Borealis developed Daploy® method, which is a post-reactor treatment of polypropylene with and multifunctional co-agents or monomers at a temperature well below the melting point of polypropylene.

In-reactor based HMS PP
- Japan Polypropylene (Chisso) developed a process to manufacture high melt strength PP resins in the reactor. JPP markets in-reactor HMS PP resins under the Newstren and Newfoamer.

Other methods to enhance melt strength include equipment or process modifications, blending conventional PP with melt strength enhancing modifiers.
Approaches to HMS PP (contd.)

The combination of these could achieve the task.

Source: Chemical Market Resources Inc.
Historical Developments in HMS PP

- Almost every supplier of polypropylene resins at some time has done some research work on developing high melt strength polypropylene resins (HMS PP).
- Historically, most companies have tried to manufacture HMS PP via post reactor modification.
- Basell was able to introduce long chain branches by irradiation of a conventional polypropylene resin below its melting point in an inert environment.
  - Until 2008, LyondellBasell produced HMS PP at their Quebec, Canada facility.
- Borealis’ Daploy method involves an after-treatment of conventional polypropylene granules by a combination of peroxides and multifunctional co-agents or monomers at a temperature well below the melting point of polypropylene.
- JPP (Chisso) developed an in-reactor process and markets HMS PP resins under the Newstren (thermoforming and blow molding applications) and Newfoamer (foaming applications) trade name.
Current Status of HMS PP

- There are multiple PP producers that offer high melt strength polypropylene – Borealis, JPP, Braskem, and Reliance
- Borealis (Daploy®) and JPP (Newfoamer) are the only two companies that offer HMS PP grades for foaming
- The major markets for Borealis’ Daploy® high melt strength polypropylene resins include: (1) extruded foams, (2) thermoforming, (3) extrusion coating, and (4) packaging
- The major market for Newfoamer is foams, Newstren high melt strength polypropylene resins are used in (1) thermoforming, (2) blowmolding
- Braskem produces Inspire™ HMS PP for blown film extrusion, sheet extrusion, thermoforming, blow molding and cast film
  - Inspire™ series product used to belong to Dow Chemical, but spun off to Braskem after Braskem acquired Dow’s PP plants in USA and Germany
- Reliance produces Repol HMS PP. Reliance filed a patent on its HMS-PP preparation process in 2011, which is a post reaction route
CURRENT AND POTENTIAL OPPORTUNITIES FOR POLYOLEFIN FOAMS
Current Opportunities for Polyolefin Foams

AAGR POLYOLEFIN FOAMS DEMAND 2014-2020 = 4.9%
### Flexible PU Foams vs. PO Foams

#### Flexible Polyurethane Foam

<table>
<thead>
<tr>
<th>Application</th>
<th>Can PO Foams Compete?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bedding</td>
<td>Not Currently</td>
</tr>
<tr>
<td>Furniture Cushioning</td>
<td>Not Currently</td>
</tr>
<tr>
<td>Seats in Public Transport</td>
<td>Not Currently</td>
</tr>
<tr>
<td>Textile Backing (Sportswear)</td>
<td>Yes</td>
</tr>
<tr>
<td>Carpet Linings</td>
<td>Yes</td>
</tr>
<tr>
<td>Packaging</td>
<td>Yes</td>
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#### Slabstock Foam

<table>
<thead>
<tr>
<th>Application</th>
<th>Can PO Foams Compete?</th>
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<tbody>
<tr>
<td>Furniture Seating</td>
<td>Not Currently</td>
</tr>
<tr>
<td>Automotive Seat Lining, Headrests, etc</td>
<td>Yes</td>
</tr>
<tr>
<td>Sound Barriers</td>
<td>Yes</td>
</tr>
<tr>
<td>Composite in-fill</td>
<td>Not Currently</td>
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#### Molded Foam

<table>
<thead>
<tr>
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<th>Can PO Foams Compete?</th>
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<tbody>
<tr>
<td>Furniture Seating</td>
<td>Not Currently</td>
</tr>
<tr>
<td>Automotive Seat Lining, Headrests, etc</td>
<td>Yes</td>
</tr>
<tr>
<td>Sound Barriers</td>
<td>Yes</td>
</tr>
<tr>
<td>Composite in-fill</td>
<td>Not Currently</td>
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#### Integral Skin and Others

<table>
<thead>
<tr>
<th>Application</th>
<th>Can PO Foams Compete?</th>
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<tbody>
<tr>
<td>Steering Wheels</td>
<td>Yes</td>
</tr>
<tr>
<td>Automotive Bumpers</td>
<td>Yes</td>
</tr>
<tr>
<td>Flotation</td>
<td>Yes</td>
</tr>
<tr>
<td>Shoe Soles</td>
<td>Yes</td>
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Rigid PU Foams vs. PO Foams

**Appliance Foam**

<table>
<thead>
<tr>
<th>Application</th>
<th>Can PO Foams Compete?</th>
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</thead>
<tbody>
<tr>
<td>Domestic and Commercial Insulation</td>
<td>Not Currently</td>
</tr>
<tr>
<td>A/C Units</td>
<td>Yes</td>
</tr>
<tr>
<td>Water Heaters</td>
<td>Not Currently</td>
</tr>
<tr>
<td>Cool Boxes</td>
<td>Yes</td>
</tr>
<tr>
<td>Flasks</td>
<td>Not Currently</td>
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</tbody>
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**Construction Foam**

<table>
<thead>
<tr>
<th>Application</th>
<th>Can PO Foams Compete?</th>
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</thead>
<tbody>
<tr>
<td>Building Insulation</td>
<td>May Be</td>
</tr>
<tr>
<td>Pipe-in-pipe</td>
<td>Yes</td>
</tr>
<tr>
<td>Cold Store Panels</td>
<td>Not Currently</td>
</tr>
<tr>
<td>Food Processing Enclosures</td>
<td>Not Currently</td>
</tr>
<tr>
<td>Spray Systems</td>
<td>NotCurrently</td>
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**Transportation Foam**

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<tr>
<th>Application</th>
<th>Can PO Foams Compete?</th>
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<tbody>
<tr>
<td>Sandwich Panels for Trucks</td>
<td>Yes</td>
</tr>
<tr>
<td>Reefer Boxes</td>
<td>Yes</td>
</tr>
<tr>
<td>Flotation</td>
<td>Yes</td>
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</table>
Current global market size of polyurethane foams is 6 times higher than that of polyolefin foams.
### PS Foams vs. PO Foams

#### Polystyrene Foam

- **Extruded PS Foam**
  - **Application**: Food Packaging, Laminated Sheet, Roof Insulation Boards, Floor Underlay, Other Small Insulation
  - **Can PO Foams Compete?**: Not Currently, Yes, Yes, Yes, Yes

- **Expanded PS Foam**
  - **Application**: Food Packaging, Building & Construction
  - **Can PO Foams Compete?**: Not Currently, Yes
Current global market size of polystyrene foams is 4 times higher than that of polyolefin foams
Polyethylene foams currently have a market share of over 33% in the polyolefin foams market.

Major applications of polyethylene foams include protective packaging, automotive, sports & recreational, medical, building & construction, and others.

Polyethylene foams are forecast to grow at 4.6% per year between 2014-2020.
Current Opportunities for Polypropylene Foams

- Extruded polypropylene foams currently have a market share of 8% in the polyolefin foams market.
- Major applications of extruded polypropylene foams include automotive, packaging, and building & construction.
- Extruded polypropylene foams are forecast to grow at 6.9% per year between 2014-2020.
The overall growth of polyolefin foams is about 4.9% per year between 2014 - 2020.
Polyolefin foams are the fastest growing foams with growth driven mainly by protective packaging, automotive, sports & recreational and other applications.

Large volume foam markets are dominated by polyurethane and polystyrene foams. Current market share of polyolefin foams is relatively very small.

Though polyolefin foams are forecast to grow at a healthy rate, polyurethane and polystyrene foams will continue to dominate the market size.

Lack of melt strength characteristics prevented polyolefin foams from effective use in foam applications.

Improving melt strength characteristics of polypropylene represent an untapped potential for foams that theoretically can overcome some of the shortcomings of conventional polypropylene.

Overall, polyolefin foams market will be a stable industry with healthy growth rate and suppliers focusing on global markets.
Over Two Decades of Business Research Excellence