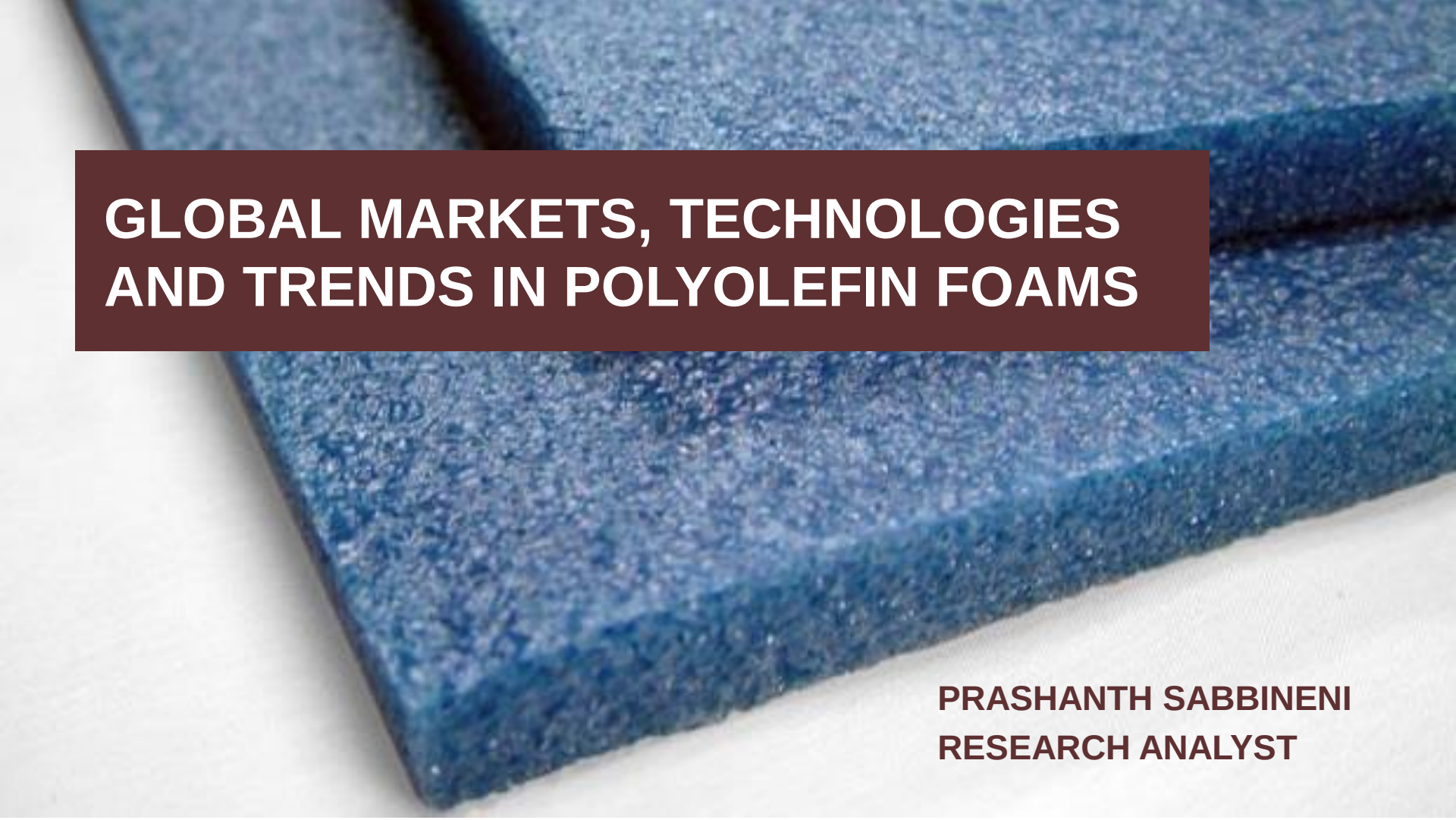

GLOBAL MARKETS, TECHNOLOGIES AND TRENDS IN POLYOLEFIN FOAMS

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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

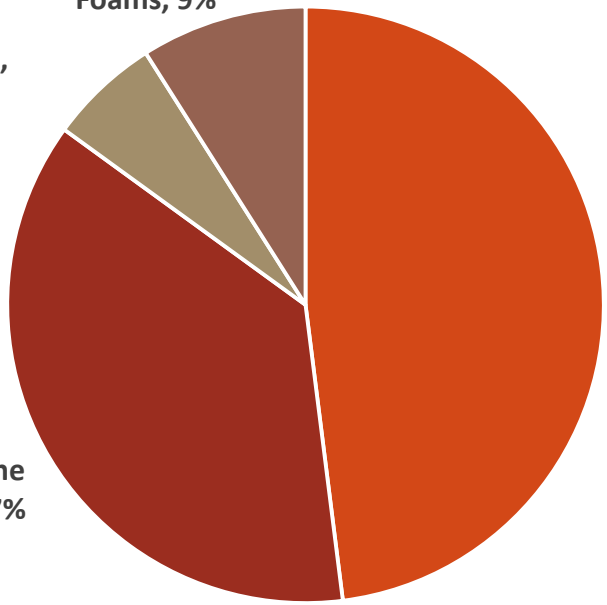
Foam Classification

- 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

Major Applications:
Automotive
Others

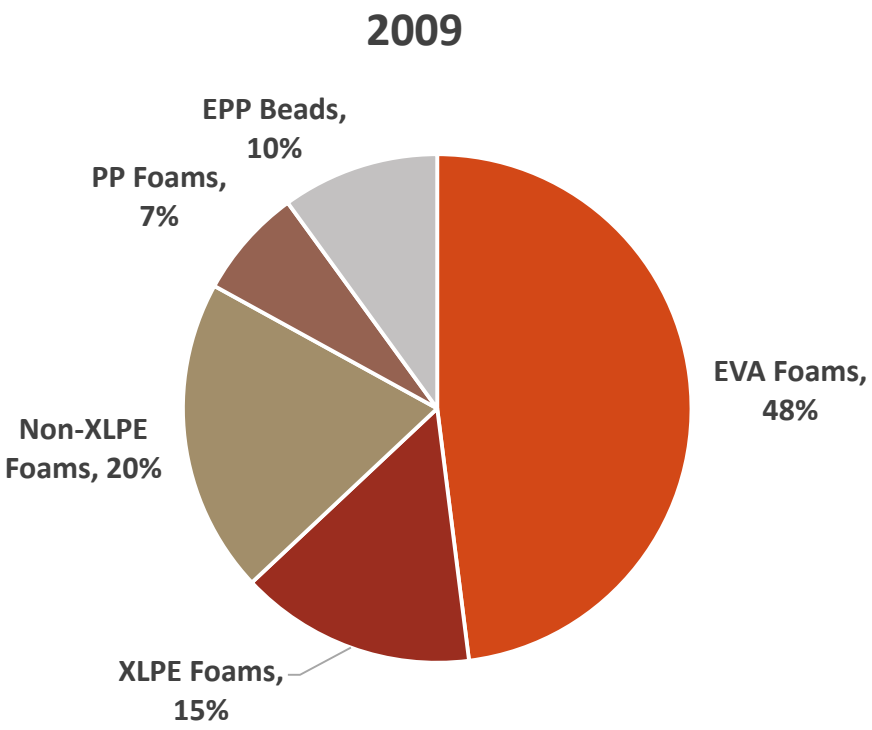
Major Applications:
Packaging
Automotive
Medical
Sports & Recreational

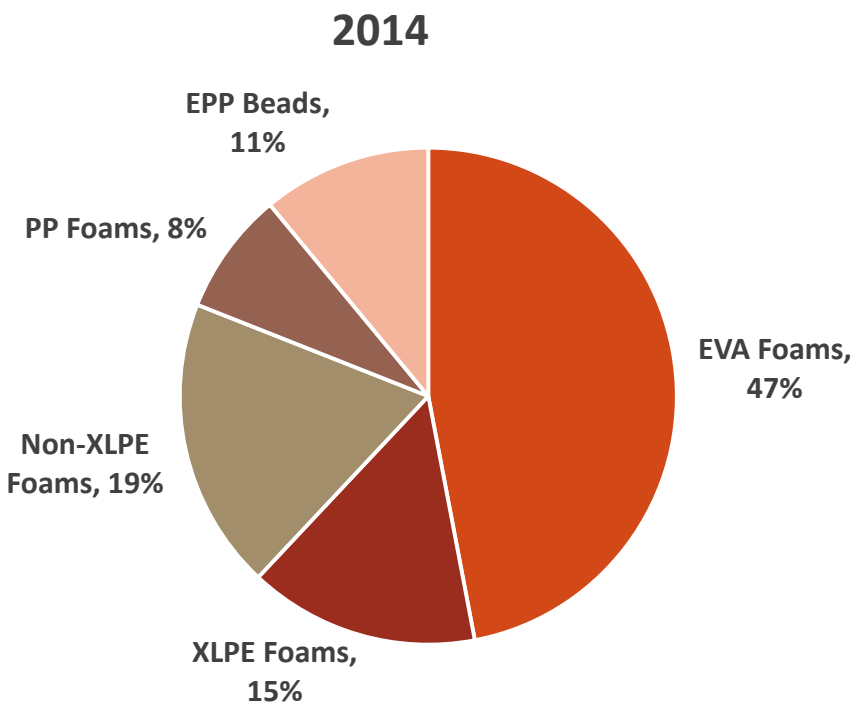


Major Applications:
Insulation
Cushioning
Bedding
Packaging

Major Applications:
Packaging
Building & Construction
Insulation

Estimated Polyolefin Foams Demand 2009-2014





AAGR POLYOLEFIN FOAMS DEMAND 2009-2014 = 4.5%

- 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?

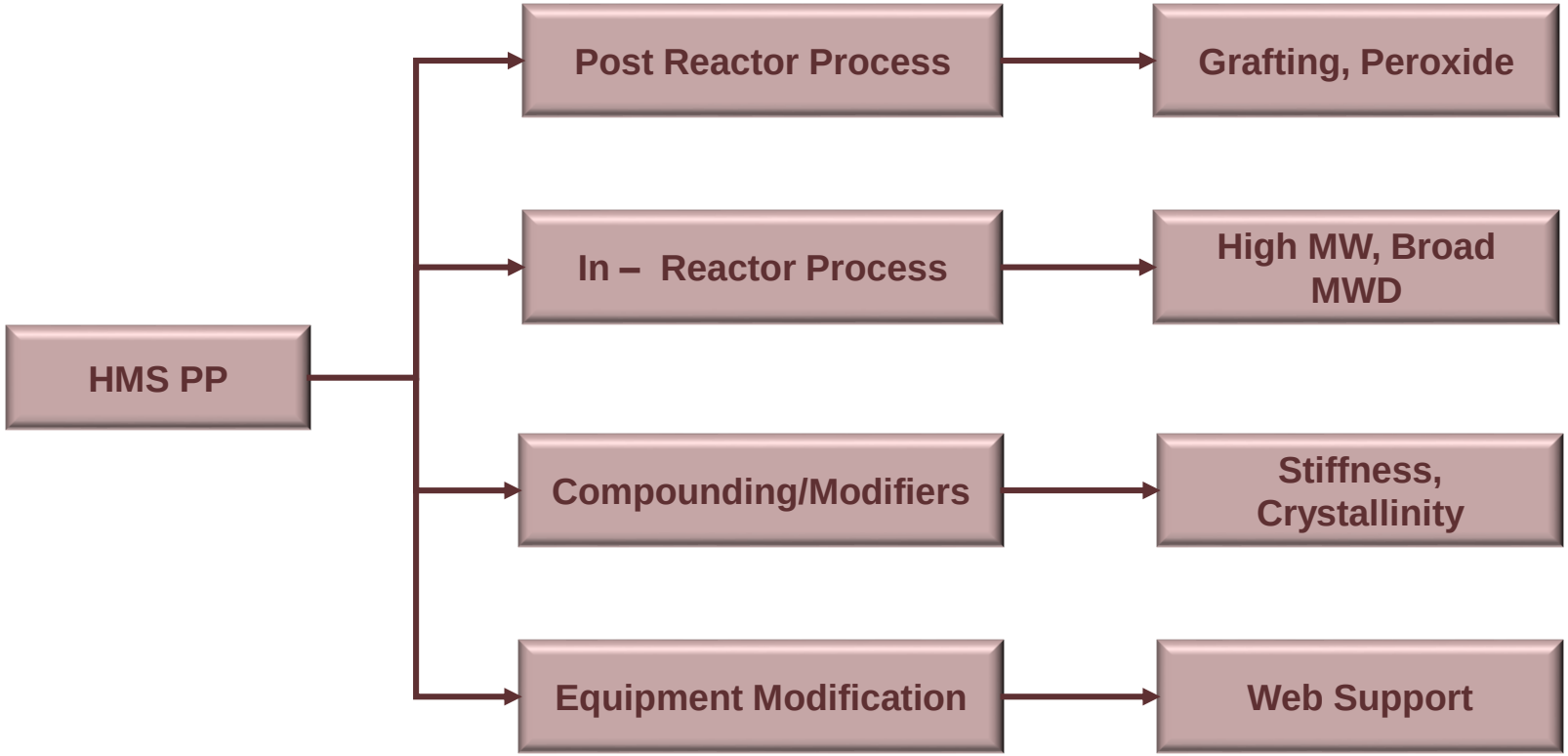
Melt Strength

- 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

Melt Strength of Polyolefins

- 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



Source: Chemical Market Resources Inc.

Approaches to HMS PP (contd.)

Post-reactor based HMS PP

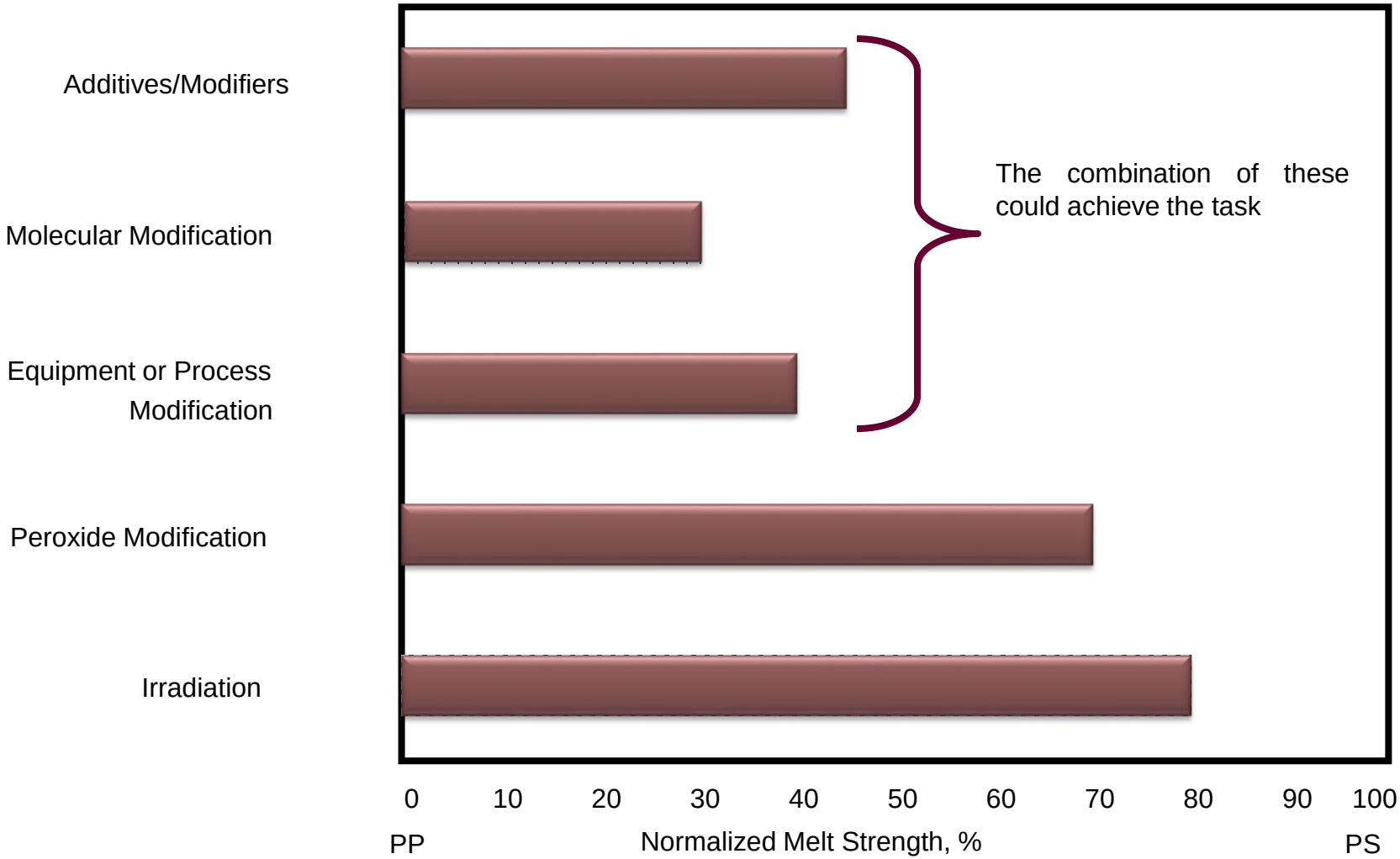
- Borealis developed Daploy® method, which is a post-reactor treatment of polypropylene with and multifunctional co-agents or monomers at a temperature well below the melting point of polypropylene

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.)



Source: Chemical Market Resources Inc.

Historical Developments in HMS PP

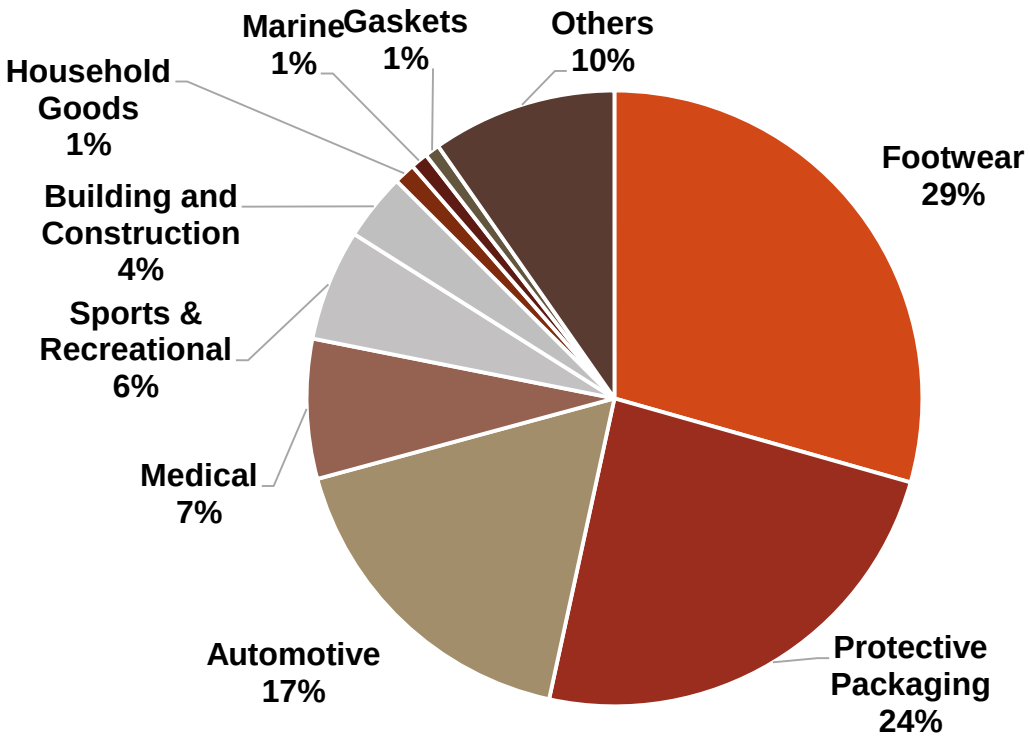
- Almost every supplier of polypropylene resins at some time has done some research work on developing high melt strength polypropylene resins (HMS PP).
- Historically, most companies have tried to manufacture HMS PP via post reactor modification
- Basell was able to introduce long chain branches by 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

- Slabstock Foam
- Molded Foam
- Integral Skin and Others

Application	Can PO Foams Compete?
Bedding	Not Currently
Furniture Cushioning	Not Currently
Seats in Public Transport	Not Currently
Textile Backing (Sportswear)	Yes
Carpet Linings	Yes
Packaging	Yes

Application	Can PO Foams Compete?
Furniture Seating	Not Currently
Automotive Seat Lining, Headrests, etc	Yes
Sound Barriers	Yes
Composite in-fill	Not Currently

Application	Can PO Foams Compete?
Steering Wheels	Yes
Automotive Bumpers	Yes
Flotation	Yes
Shoe Soles	Yes

Rigid PU Foams vs. PO Foams

Rigid Polyurethane Foam

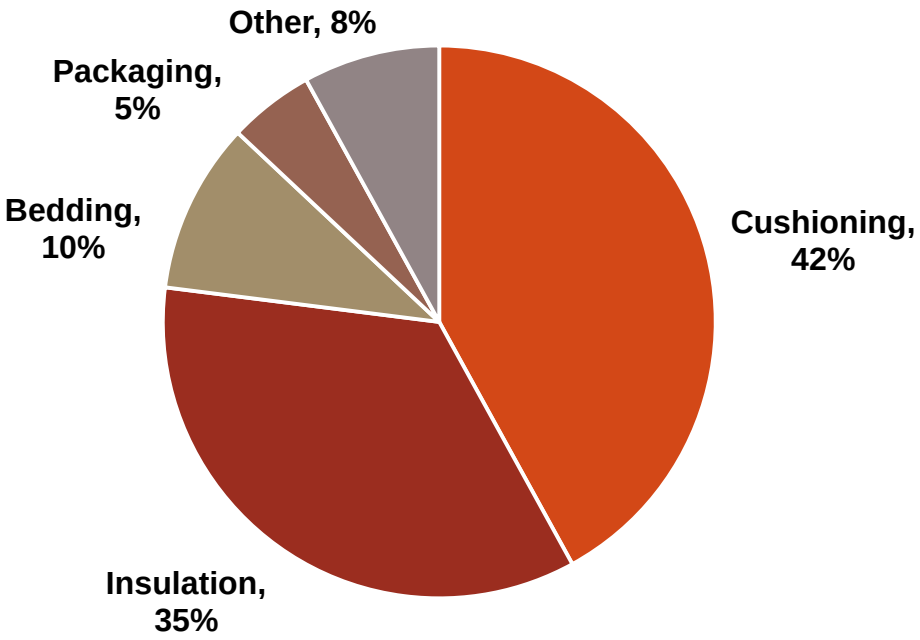
- Appliance Foam
- Construction Foam
- Transporation Foam

Application	Can PO Foams Compete?
Domestic and Commercial Insulation	Not Currently
A/C Units	Yes
Water Heaters	Not Currently
Cool Boxes	Yes
Flasks	Not Currently

Application	Can PO Foams Compete?
Building Insulation	May Be
Pipe-in-pipe	Yes
Cold Store Panels	Not Currently
Food Processing Enclosures	Not Currently
Spray Systems	Not Currently

Application	Can PO Foams Compete?
Sandwich Panels for Trucks	Yes
Reefer Boxes	Yes
Flotation	Yes

Global Market Size of Polyurethane Foams



- Current global market size of polyurethane foams is 6 times higher than that of polyolefin foams

PS Foams vs. PO Foams

Polystyrene Foam

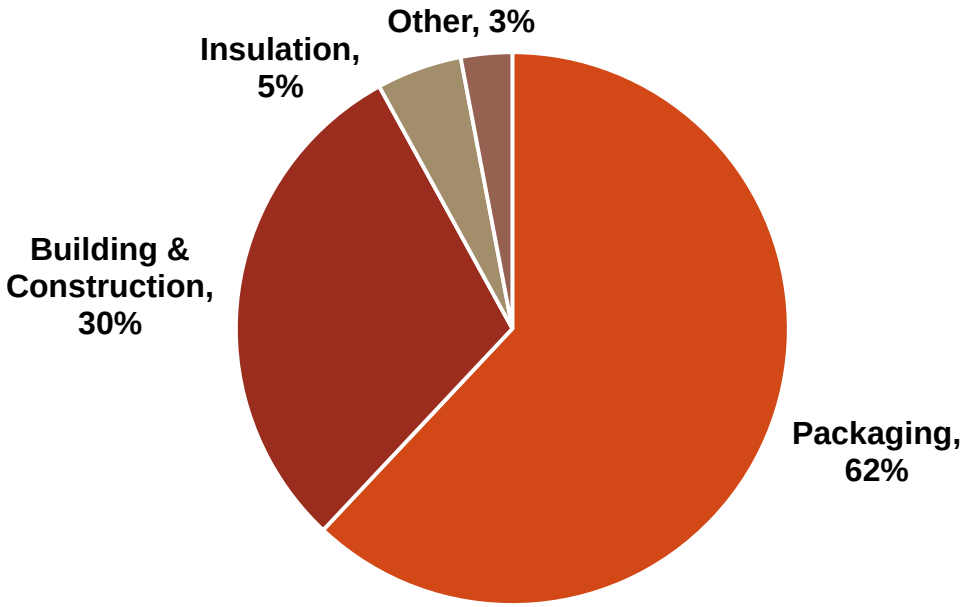
Extruded PS Foam

Application	Can PO Foams Compete?
Food Packaging	Not Currently
Laminated Sheet	Yes
Roof Insulation Boards	Yes
Floor Underlay	Yes
Other Small Insulation	Yes

Expanded PS Foam

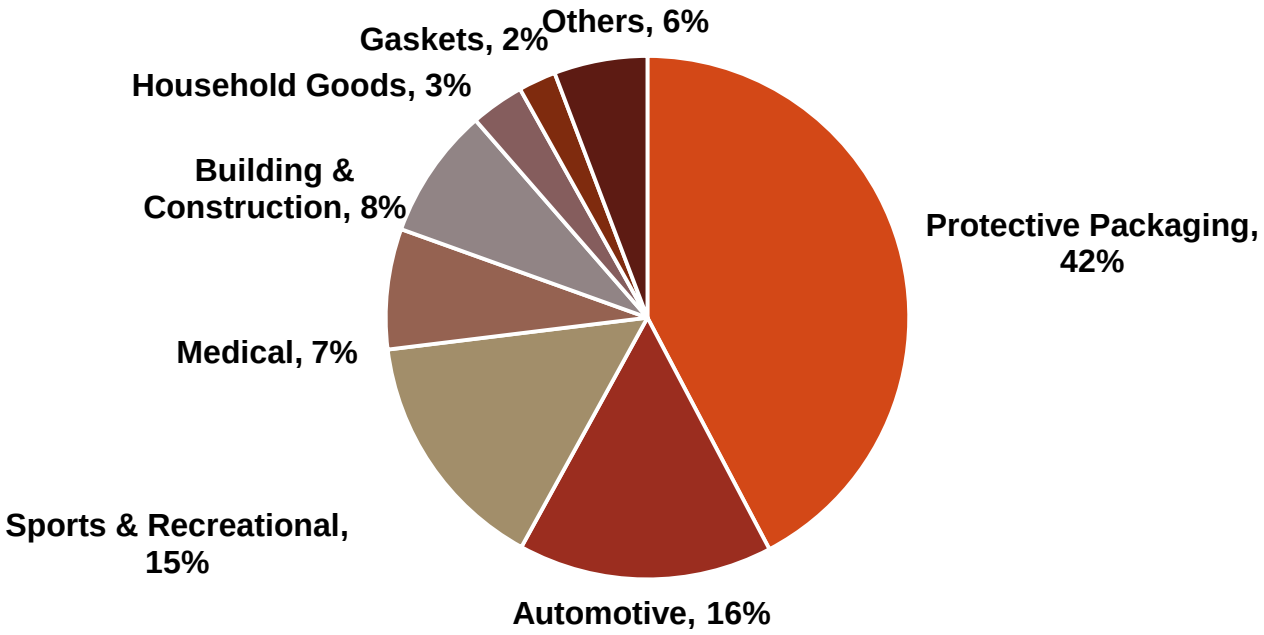
Application	Can PO Foams Compete?
Food Packaging	Not Currently
Building & Construction	Yes

Global Market Size of Polystyrene Foams



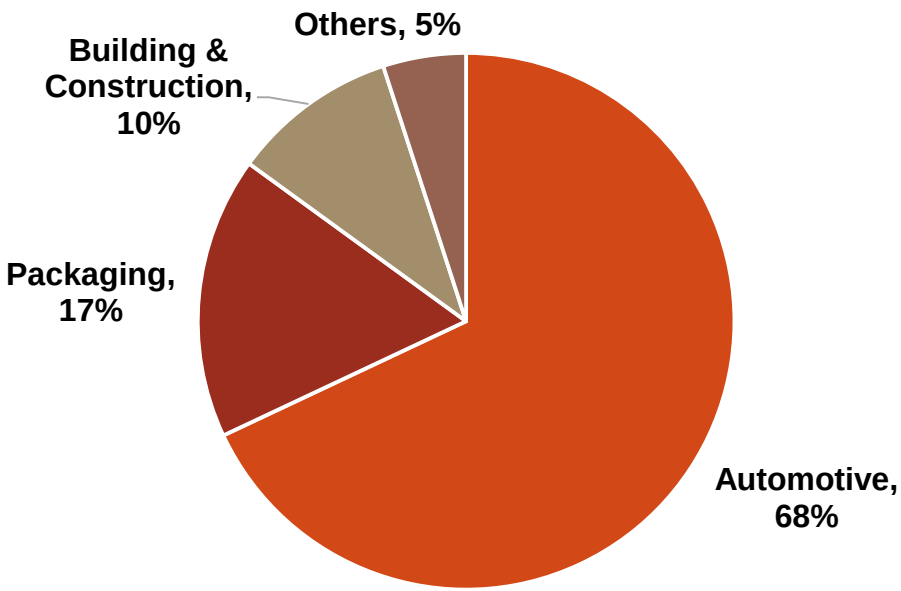
- Current global market size of polystyrene foams is 4 times higher than that of polyolefin foams

Current Opportunities for Polyethylene Foams



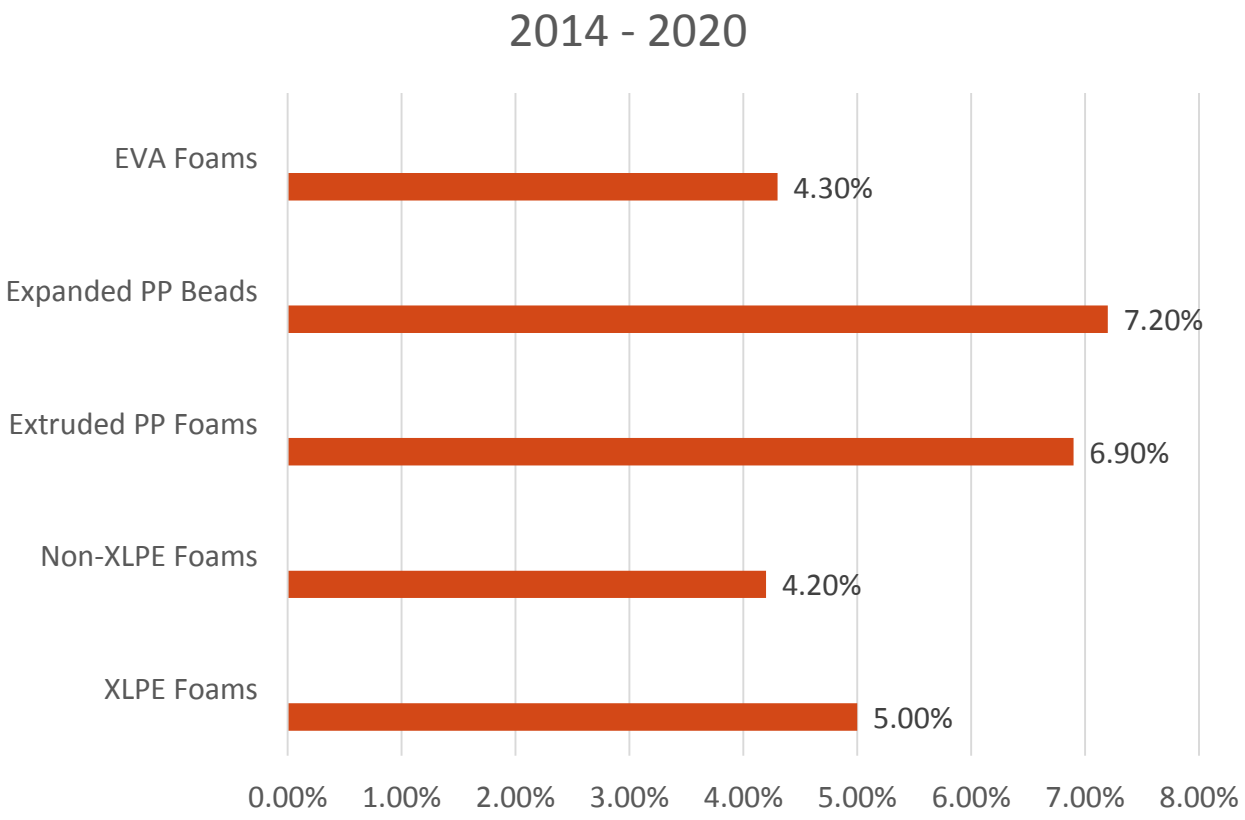
- Polyethylene foams currently have a market share of over 33% in the polyolefin foams market
- Major applications of polyethylene foams include protective packaging, automotive, sports & recreational, medical, building & construction, and others
- Polyethylene foams are forecast to grow at 4.6% per 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

Outlook for Polyolefin Foams



- The overall growth of polyolefin foams is about 4.9% per year between 2014 - 2020

Outlook for Polyolefin Foams (contd.)

- 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