Material Sector
Business Briefing
Performance Polymers SBU

September 8, 2016
Asahi Kasei Corp.
1. Overview of Performance Polymers SBU
2. Synthetic rubber business
3. Engineering plastics business
Overview of Performance Polymers SBU
Outline of medium-term strategy

1. Expansion of profitable businesses on a global scale
   - Europe: Strengthening business relations with European automotive manufacturers
   - North America/Mexico: Expanding compounding business
   - China: Driving growth through competitive materials
   - ASEAN: Expanding market share in Japanese automotive sector

2. Expansion focused on S-SBR for high-performance and fuel-efficient tires

3. Expansion focused on engineering plastics for automotive applications

Sales growth plan (FY2013 = 1.0)
## Main products

<table>
<thead>
<tr>
<th>Business</th>
<th>Main products</th>
<th>Main applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Synthetic Rubber</td>
<td>S-SBR (solution-polymerized styrene-butadiene rubber)</td>
<td>High-performance and fuel-efficient tires</td>
</tr>
<tr>
<td></td>
<td>Hydrogenated styrene-butadiene thermoplastic elastomer (SEBS and SBBS)</td>
<td>Medical fluid bags, sanitary products</td>
</tr>
<tr>
<td>Engineering Plastics</td>
<td>Leona polyamide 66 (PA66)</td>
<td>Automotive parts, electrical/electronic parts</td>
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<td>Tenac polyacetal (POM)</td>
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<td>Xyron modified polyphenylene ether (mPPE)</td>
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<td>Thermylene reinforced polypropylene (PP) compound</td>
<td>Automotive parts, furniture</td>
</tr>
</tbody>
</table>
Global bases (production, sales, and R&D sites)

- **Germany** (Asahi Kasei Europe GmbH)
- **Alabama** (new plant)
- **Vietnam** (new subsidiary)
- **Singapore** (mPPE, S-SBR plants)
- **Mexico** (new subsidiary)
- **Michigan**

Legend:
- Red circle: Compound plant, polymerization plant
- Yellow diamond: Technical center, R&D center
- Gray square: Sales & marketing office

- **Tochigi**
  - Asahi Kasei Color Tech Co., Ltd.
- **Mizushima**
  - (POM plant)
- **Oita**
  - Japan Elastomer Co., Ltd.
- **Nobeoka**
  - (PA66 plant)
- **Kawasaki**
  - Technical center
    - (engineering plastic, synthetic rubber)
  - (synthetic rubber plant)
- **Chiba**
  - R&D (engineering plastic)

* New plant/subsidiary in FY15-16
Synthetic rubber business
Synthetic rubber & elastomer products

Contributing to life and living around the world with our broad lineup of products based on butadiene and styrene

Key technologies
- Functionalization
- High molecular weight
- Hydrogenation
- Functionalization

Polybutadiene rubber
- Asadene and Asaprene (BR)
- Introduce styrene

Solution-polymerized styrene-butadiene rubber
- Tufdene and Asaprene (S-SBR)
- Block copolymers

Styrene-butadiene thermoplastic elastomer
- Tufperene and Asaprene T (SBS)
- Increase styrene content

Transparent styrenic resin
- Asaflex

Solution-polymerized SBR for silica-compound tires
- Tufdene and Asaprene (S-SBR)

Hydrogenated styrene-butadiene thermoplastic elastomer
- Tuftec and S.O.E. (SEBS, SBBS)
S-SBR

Solution-polymerized styrene-butadiene rubber

• There are two types of SBR, E-SBR and S-SBR. Both are used for vehicle tire tread.
• Featuring high design flexibility, S-SBR enables various performance criteria for tires to be met. S-SBR is especially suited to high-performance and fuel-efficient tires.

<table>
<thead>
<tr>
<th></th>
<th>S-SBR (solution polymerized)</th>
<th>E-SBR (emulsion polymerized)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Polymer design flexibility</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>Manufacturers</td>
<td>Few</td>
<td>Many</td>
</tr>
<tr>
<td>Applications</td>
<td>High-performance and fuel-efficient tires</td>
<td>General-purpose tires</td>
</tr>
</tbody>
</table>
Tire structure

Tread compound technology revolution: from carbon black to silica filler

<table>
<thead>
<tr>
<th>Performance criteria</th>
<th>Polymers used</th>
</tr>
</thead>
<tbody>
<tr>
<td>✤ Fuel efficiency</td>
<td>SBR (main polymer)</td>
</tr>
<tr>
<td>✤ Wet grip</td>
<td>Natural rubber (NR)</td>
</tr>
<tr>
<td>✤ Wear resistance</td>
<td>High-cis BR</td>
</tr>
<tr>
<td>✤ Handling stability</td>
<td></td>
</tr>
</tbody>
</table>

Dramatic improvement in fuel efficiency by compounding tread with silica. Achieving all performance criteria is highly dependent on the properties of SBR.

Key technology is SBR structural design

Dramatic increase in both fuel efficiency and wet grip performance
Trends impacting S-SBR demand

Demand for higher tire performance (both fuel efficiency and wet grip)

Needs for lighter vehicles
Improving fuel efficiency of conventional fuel cars
Extending driving range of hybrid/electric cars
↓ Lighter weight tire
↓ Thinner and longer-life tread
↓ Needs for better wear resistance

Tire labeling regulations

<table>
<thead>
<tr>
<th>Region</th>
<th>Evaluation criteria</th>
<th>Launch</th>
</tr>
</thead>
<tbody>
<tr>
<td>Japan</td>
<td>1. Rolling resistance 2. Wet grip</td>
<td>January 2010 (voluntary)</td>
</tr>
<tr>
<td>Korea</td>
<td>1. Rolling resistance 2. Wet grip</td>
<td>Voluntary from November 2011, mandatory from December 2012</td>
</tr>
<tr>
<td>Brazil</td>
<td>1. Rolling resistance 2. Wet grip 3. Noise</td>
<td>Under study</td>
</tr>
<tr>
<td>USA</td>
<td>1. Rolling resistance 2. Wet grip 3. Wear resistance</td>
<td>Under study</td>
</tr>
</tbody>
</table>

Global sales forecast of tires for passenger cars and light trucks
(Asahi Kasei estimate based on a market research report)
Growth of S-SBR market for tire

Global demand forecast for SBR for tires (excluding in-house production by tire manufacturers)

- S-SBR demand growth exceeding that of E-SBR
- Asahi Kasei’s global S-SBR sales growth far above overall market growth
S-SBR business growth strategy

1. Technological development

Continuous R&D to further heighten our original technology to create products that meet customers’ needs and support their development of higher-performance tires

2. Proactive supply capacity expansion

Proactive expansion of our production capacity to ensure a stable supply to our customers as demand continues to grow
# Technology for fuel-efficient tires

<table>
<thead>
<tr>
<th>Cause of energy loss</th>
<th>Approach to reducing energy loss</th>
<th>Polymer design features</th>
</tr>
</thead>
<tbody>
<tr>
<td>Filler-to-filler interaction (friction between filler particles)</td>
<td>Finer dispersion of filler</td>
<td>- Higher molecular weight (higher shear force)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Functionalization (functional group introduced)</td>
</tr>
<tr>
<td></td>
<td>Reduced filler content</td>
<td>- Higher molecular weight (loss of strength suppressed)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Branched structure (processability improved)</td>
</tr>
<tr>
<td>Motion of polymer chain ends (energy lost as heat)</td>
<td>Reduced number of free polymer chain ends</td>
<td>- Higher molecular weight</td>
</tr>
<tr>
<td></td>
<td>Fix free polymer chain ends</td>
<td>- Narrow molecular-weight distribution</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Functionalization (functional group introduced)</td>
</tr>
<tr>
<td>Filler-to-polymer interaction (friction between filler and polymer)</td>
<td>Chemical bond between filler and polymer</td>
<td>- Functionalization (functional group introduced)</td>
</tr>
</tbody>
</table>

### Effect of functional groups

- Regular SBR with silica filler
  - Polymer
  - Silica
  - Energy loss due to motion of free polymer chain ends

- Functionalized SBR with silica
  - Functionalized SBR
  - Regular SBR
  - Silica dispersion (TEM images)
  - Interaction
  - Fixed polymer chain ends and better dispersion of silica particles
Technical advantages of Asahi Kasei’s S-SBR

- S-SBR production technologies are continuous process and batch process. Asahi Kasei focuses on continuous process, which is employed by fewer manufacturers.

- Our continuous-process S-SBR, with high molecular weight, contributes to enhanced wet grip, wear resistance, and handling stability. Together with functionalization technology and polymer design technology, we offer high-value specialty products that contribute to overall tire performance.

Asahi Kasei’s continuous process technology for S-SBR

Fuel efficiency (low rolling resistance)

- Continuous process
- Target

Wet grip

- Batch process

Wear resistance

Handling stability

Utilizing polymer design, high molecular weight, and functionalization technologies to improve the four major performance criteria of tires.

Comparison between continuous process and batch process in four major performance criteria

- 4th Gen. launched in 2012
- 3rd Gen. launched in 2015
Proactive expansion of supply capacity

- Proactively expanding capacity to meet rapid market growth
- Studying expansion of existing facilities and construction of new facilities overseas

### Further expansion

**World’s No. 1 S-SBR supplier**

<table>
<thead>
<tr>
<th>Year</th>
<th>Japan</th>
<th>Overseas</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012</td>
<td>140,000* Kawasaki and Oita</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2013</td>
<td>+50,000 Singapore Line 1</td>
<td>190,000</td>
<td></td>
</tr>
<tr>
<td>2015</td>
<td>+50,000 Singapore Line 2</td>
<td>240,000</td>
<td></td>
</tr>
<tr>
<td>by 2020</td>
<td>Expansion New line or facility</td>
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* Flexible capacity including BR

Unit: tons / year
Engineering plastics business
About our engineering plastics business

Superior grade lineup
Matching customer needs

Value added to products by Asahi Kasei technology

Customers’ value increased

Value added to products by Asahi Kasei technology

Needs in automotive applications
- Lighter weight and reduced number of parts
- Greater safety and comfort
- Longer-term reliability

Polymer technology
Alloy technology
Compound technology
Grade development technology
Application development technology
CAE technology

What is compounding?
- A process in which a polymer material is given various additional performance properties.
- A polymer is melted and mixed in an extruder with other polymer, glass fiber, flame retardant, and other additives to produce a compound.
Engineering plastics business growth strategy

Basic principle

Expanding business by leveraging our superior grade lineup and application development technology with our global compounding infrastructure

Strategic focus on automotive applications

- Demand for engineering plastics expanding with needs for greater fuel efficiency (vehicle weight reduction) prompting greater substitution of metal
- Establishment of Asahi Kasei Europe GmbH for further expansion of business in Europe
- Meeting customers’ needs through our capability of developing superior grades by polymerization, alloy, and compound technologies, and capability of developing new applications
- Employing CAE (computer-aided engineering) for product proposals in the design of automotive parts
- Utilizing our global network to swiftly meet customers’ needs

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Engineering plastics sales growth plan

Engineering plastics sales (fiscal 2013 = 1)

Automotive applications portion of sales volume

Sales by region

- Japan
- China
- ASEAN
- US, Europe

Overseas sales are forecasted to expand

FY 2015

FY 2018
Strengths by material (1)

Our engineering plastics improve performance, quality, and reliability of automotive parts
• Leona: Maintains good heat resistance and strength even in harsh conditions of engine compartment
• Tenac: Contributes to comfortable and pleasant car interiors with low VOC emission

Leona polyamide (PA) 66
❖ Broad lineup of grades with good balance of heat resistance, strength, and rigidity
❖ Rich track record in substitution of metal

Tenac polyacetal (POM)
❖ Superior grades with low VOC (volatile organic compound) emission
❖ Formaldehyde emission reduced by 90%

Know-how for applications development and substitution of metal
Alloy and compound technology to develop superior grades
Grades with heat resistance, strength, and rigidity

Head cover 
Engine mount 
Door mirror bracket

Inside handle 
Seatbelt buckle

Polymer technology

PA66 
PA610 
PA612 
66/I

Mold temperature 220°C

<table>
<thead>
<tr>
<th>Grade</th>
<th>HC series</th>
<th>Low formaldehyde</th>
<th>Normal grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>Z4513</td>
<td>3</td>
<td>1.6</td>
<td>2.3</td>
</tr>
<tr>
<td>Z4563</td>
<td>3</td>
<td>1.6</td>
<td>2.3</td>
</tr>
<tr>
<td>ZH760</td>
<td>3</td>
<td>3</td>
<td>22</td>
</tr>
<tr>
<td>ZH450</td>
<td>0.6</td>
<td>0.6</td>
<td>0.6</td>
</tr>
<tr>
<td>Z4520</td>
<td>1.4</td>
<td>1.4</td>
<td>1.4</td>
</tr>
<tr>
<td>Z3510</td>
<td>2.3</td>
<td>2.3</td>
<td>2.3</td>
</tr>
</tbody>
</table>

VDA275 Formaldehyde emission (mg/kg)
Strengths by material (2)

Our engineering plastics improve performance, quality, and reliability of automotive parts
- Xyron: Good balance of heat resistance, chemical resistance, and dimensional stability
- Thermylene: Light weight, easy to mold, good strength and durability

Xyron modified polyphenylene ether (mPPE)
- Improved heat resistance, chemical resistance, and dimensional stability by alloying with PA and PP in addition to polystyrene (PS)
- Differentiation with original alloy technology

Thermylene polypropylene (PP) compound
- Improved strength added by compounding with glass fiber (GF) and minerals, while leveraging PP’s low cost and easy moldability
- Growing as a substitute of high performance plastics

Truck fender  
PA/PPE
Lithium-ion battery holder  
PPE/PS
Fan shroud  
PA + GF → PP + GF
Interior console  
PP + long GF → PP + short GF

Car battery case  
PP/PPE
Relay block  
PA/PPE
Door module  
PP + long GF → PP + short GF
Mirror bracket  
PA + GF → PP + GF
Strengths in computer-aided engineering (CAE)

Oil pan for car engine

Succeeded in 60% weight reduction compared to metal with outstanding stiffness, impact resistance, and vibration resistance.

Using CAE technology to make design proposals that meet customers’ needs to reduce vehicle weight for better fuel consumption.

Customers’ needs:
- Substitute metal parts with plastic
- Integrate two or more parts into one
- Predict how new parts can be molded
- Reduce costs

Hundreds of successful cases including cylinder head covers and brake brackets.

Meet customers’ requirements with our engineering plastics

Asahi Kasei Plastics Vietnam Co., Ltd. (CAE center) began operation in June 2016.
# Roadmap for expanding business bases

## Expanding our global network of bases for swift response to customers’ needs

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<tr>
<td>Europe</td>
<td>□ Asahi Kasei Europe GmbH (European headquarters, Apr. 2016)</td>
<td>□ Local compounding in Europe</td>
<td>□ Expand sales offices in China</td>
</tr>
<tr>
<td>China</td>
<td>Shanghai technical center (2013)</td>
<td>□ Technical center in Guangzhou</td>
<td>□ Increase compounding capacity in Suzhou</td>
</tr>
<tr>
<td></td>
<td>□ Sales offices in Wuhan and Ningbo (2013)</td>
<td>□ Technical center in Thailand</td>
<td>□ Increase compounding capacity in Thailand</td>
</tr>
<tr>
<td></td>
<td>□ Local compounding in India</td>
<td>□ Local compounding in India</td>
<td>□ Technical center in Thailand</td>
</tr>
</tbody>
</table>
Name: Asahi Kasei Plastics Mexico S.A. de C.V.
Address: Querétaro, Mexico
Established: June 2015
President: Iichiro Kitsuda
Ownership: 100% owned by Asahi Kasei Corp. through North American subsidiaries
Operation: Sales and technical support of performance plastic compounds, mainly polyamide and polypropylene
Start-up: September 2015
Second compounding plant in the US

Company: Asahi Kasei Plastics North America, Inc.
Location: Athens, Alabama
Capacity: 30,000 tons/year
Products: Performance plastic compounds, mainly polyamide and polypropylene
Start-up: February 2016

About Asahi Kasei Plastic North America (APNA)
Headquarters: Fowlerville, Michigan
Establishment: July 2000
President: John Moyer
Operation: Manufacture and sale of performance plastic compounds, mainly polyamide and polypropylene
Capacity: 105,000 tons/year (Fowlerville, MI)
30,000 tons/year (Athens, AL)