Advantages to Use Polyisobutylene in Metalworking Fluids

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Applications Engineer

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Petrochemical Industry

“Competitive Integration Braskem”

**EXTRACTION**
Basic feedstocks

1\textsuperscript{st} **GENERATION**
Basic Petrochemicals

- NAPHTHA
- GAS
- ETHANOL
- SALT

2\textsuperscript{nd} **GENERATION**
Thermoplastics Resins

- ETHYLENE
- PROPYLENE
- CHLORINE/ SODA

3\textsuperscript{rd} **GENERATION**
Plastics Processors

- PE
- PP
- PVC

AROMATICS
FUELS
SOLVENTS
SPECIALTY CHEM

Braskem
Braskem operates in more than 70 countries worldwide, establishing itself as an important global player in the thermoplastics resins and chemicals market.

7,657 MEMBERS

CLIENTS In more than: 70 COUNTRIES

GROSS Revenue: R$55 BI (US$ 15.9 BI)

NET Revenue: R$47 BI (US$ 13.7 BI)

EBTDA: R$11 BI (US$ 3.3 BI)

EXPORTS / INTL UNITS 49%

INDUSTRIAL Units: 36

INVESTMENT Innovation & technology R$3 BI (US$ 0.9 BI)

Source: Braskem Annual Report 2016
Results for 2016 not yet audited
*Only Exports from Brazil
PRODUCTS

Basic Chemicals
OLEFINS
AROMATICS
FUELS

Specialty Chemicals
SOLVENTS
SPECIALTIES

Polymers
PE
PP
Green PE
EVA
SODA
PVC
PIB

A highly versatile product, present in several applications such as lubricants, stretch film, adhesives, sealants, among others, providing important technical properties.
Braskem’s PIB is nontoxic, meet the requirements for applications in cosmetics and food and it has NSF certification.
PIB
POLYISOBUTYLENE

Molecular Weight (Mn) from 300 to 4,200 g/mol
- Kinematic Viscosity:
  @ 37.8°C: 15 - 190,000+ cSt
  @ 100°C: 6 - 13,000 cSt

Classified as a synthetic Oil – Group V (API)

Simple molecule – polymerization of isobutene under a catalyst system, in a continuous process

One double bond per molecule – controlled reactivity
PIB - POLYISOBUTYLENE

\[ \text{CH}_3 \quad \text{H}_2\text{C}=\text{C} \quad \text{CH}_3 + \quad \text{H}_2\text{C}=\text{C} \quad \text{CH}_3 \]

\[ \text{catalyst} \]

\[ \text{CH}_3 \quad \text{CH}_3 \quad \text{CH} = \text{C} \quad \text{CH}_3 \]

\[ \text{CH}_3 \quad \text{C} \quad \text{CH}_2 \quad \text{C} \quad \text{CH}_3 \quad \text{CH}_3 \]

\[ \text{CH}_3 \quad \text{C} \quad \text{CH} = \text{C} \quad \text{CH}_3 \quad \text{CH}_3 \]

\[ \text{CH}_3 \quad \text{C} \quad \text{CH} = \text{C} \quad \text{CH}_3 \quad \text{CH}_3 \]

\[ n \]
PIB
POLYISOBUTYLENE

LIQUID
CHEMICALLY STABLE
OXIDATION RESISTANCE TO LIGHT AND TEMPERATURE
CLEAR
GREAT DIELECTRIC PROPERTIES
BRIGHT
PIB - POLYISOBUTYLENE

Main Applications
Global Demand ~ 900 kty

- Adhesives, Sealants: 9%
- Fuel Additive: 13%
- 2-Stroke Engines: 13%
- Industrial Lubes: 16%
- Lube Additives: 49%

Other Applications
PIB - POLYISOBUTYLENE

<table>
<thead>
<tr>
<th>PIB</th>
<th>Avg Molecular Weight (g/mol)</th>
<th>KV @ 40°C (cSt)</th>
</tr>
</thead>
<tbody>
<tr>
<td>240</td>
<td>4,200</td>
<td>*</td>
</tr>
<tr>
<td>128</td>
<td>2,700</td>
<td>190,000</td>
</tr>
<tr>
<td>122</td>
<td>2,500</td>
<td>120,000</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>PIB</th>
<th>Avg Molecular Weight (g/mol)</th>
<th>KV @ 40°C (cSt)</th>
</tr>
</thead>
<tbody>
<tr>
<td>32</td>
<td>1,300</td>
<td>22,000</td>
</tr>
<tr>
<td>28</td>
<td>1,050</td>
<td>10,000</td>
</tr>
<tr>
<td>24</td>
<td>940</td>
<td>7,000</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>PIB</th>
<th>Avg Molecular Weight (g/mol)</th>
<th>KV @ 40°C (cSt)</th>
</tr>
</thead>
<tbody>
<tr>
<td>16</td>
<td>640</td>
<td>760</td>
</tr>
<tr>
<td>10</td>
<td>500</td>
<td>380</td>
</tr>
<tr>
<td>8</td>
<td>440</td>
<td>105</td>
</tr>
<tr>
<td>6</td>
<td>330</td>
<td>32</td>
</tr>
<tr>
<td>4</td>
<td>300</td>
<td>15</td>
</tr>
</tbody>
</table>
Main Metalworking Processes

Forming
low speed, high severity

Cutting
high speed, heat

Rolling
Laminação

Drawing
Trefilação

Stamping
Estampagem

Forging
Forjamento

Drilling
Furação

Grinding
Retificação

Turning
Torneamento

Milling
Fresamento
Metalworking Fluids

**MW Process**

**Main MWF**

**Composition**

**Characteristics**

### Forming
- **Straight Oils**
  - Mineral oils
  - Animal & Vegetable oils
  - Synthetic Oils
- **Emulsions**
  - Mineral Oils + Water
  - Synthetic Oils + Water
  - Synthetic Oils + Water + 20% Mineral oils

### Cutting
- **Chemical Solutions**
- **Semichemical Solutions**

**Characteristics**

- **PIB**
  - High lubricity
  - Corrosion protection
  - Easy maintenance
  - Poor cooling
- **PIB Emulsion**
  - Better cooling
  - Easier to clean
  - Versatile
  - Biological attack
  - Corrosion
  - Emulsify other lubes
  - Biological stability
  - Solution stability
  - Great cooling
  - Less oily residues
  - Contamination w/ other oils
  - Paint & seal compatibility
  - Better lubricity
  - Less corrosion
  - Less biological resistance

Braskem
Advantages of Synthetic Lubes in Straight Oils

- Clean Burning, non-staining
- Increase of Die Life
  - Data from sheet drawing – 5x higher die life
- Reduction in sheet and foil rolling forces – reduced thickness
- Better surface finish

PIB in Quenching Oils

Quenching Process Stages

PIB reduces the Vapor Blanket Phase, thus allowing for a more efficient quenching (surface-wetting property)
Stable PIB Emulsions can be reached with several emulsifiers.

Example of PIB Emulsions

<table>
<thead>
<tr>
<th>Component</th>
<th>Amount %</th>
</tr>
</thead>
<tbody>
<tr>
<td>PIB 8</td>
<td>-</td>
</tr>
<tr>
<td>PIB 24</td>
<td>45</td>
</tr>
<tr>
<td>Water</td>
<td>45</td>
</tr>
<tr>
<td>Non-ionic emulsifier</td>
<td>10</td>
</tr>
</tbody>
</table>
Advantages of PIB on MWF

**PIB on MWF**

- Mineral Oil Thickener
- Emulsifiable
- Non-corrosive
- Non-toxic
- Low Staining
- Clean Burning

<table>
<thead>
<tr>
<th>Grade</th>
<th>Viscosity Index</th>
</tr>
</thead>
<tbody>
<tr>
<td>PIB 10</td>
<td>111</td>
</tr>
<tr>
<td>PIB 24</td>
<td>130</td>
</tr>
<tr>
<td>PIB 32</td>
<td>182</td>
</tr>
<tr>
<td>PIB 122</td>
<td>256</td>
</tr>
<tr>
<td>PIB 128</td>
<td>287</td>
</tr>
<tr>
<td>PIB 240</td>
<td>326</td>
</tr>
</tbody>
</table>
## PIB Compared to Other Base Oils

### Comparison with non-additized base oils

<table>
<thead>
<tr>
<th>Property</th>
<th>PIB 8</th>
<th>PAG (50% Ethylene)</th>
<th>Mineral Oil (600N)</th>
<th>Mineral Oil (150N)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Viscosity (cSt, 40°C)</td>
<td>105</td>
<td>150</td>
<td>113</td>
<td>32</td>
</tr>
<tr>
<td>Flash Point (°C)</td>
<td>130</td>
<td>240</td>
<td>245</td>
<td>&gt; 200</td>
</tr>
<tr>
<td>Pour Point (°C)</td>
<td>-30</td>
<td>-48</td>
<td>-12</td>
<td>-</td>
</tr>
<tr>
<td>Density (g/cm³)</td>
<td>0,85</td>
<td>1,05</td>
<td>0,87</td>
<td>0,87</td>
</tr>
</tbody>
</table>

### Analyses:
- Oxidation Stability
- Carbon Residue
- Four Ball – Wear and EP
PIB Compared to Other Base Oils

Oxidation Stability

**ASTM D-2272**

*Description: T = 150°C, high O₂ pressure: 90psi – evaluation of pressure drop (25%)*

Mineral oils are better in water-free, non-catalysed systems (as in ASTM D943)
PIB and mineral oils have less than 0.1% carbon residue (0.1% is the equipment detection limit)
PIB Compared to Other Base Oils

Four Ball – Wear (40kg)

ASTM D-4172
Description: Rotation: 1200rpm for 60 minutes; room temperature

PIB slightly worse than PAG, but better than mineral oils
PIB Compared to Other Base Oils

Four Ball – Extreme Pressure

ASTM D-2783
Description: 1770rpm at 27±8°C for 10 seconds

<table>
<thead>
<tr>
<th>Test</th>
<th>PIB 8</th>
<th>PAG</th>
<th>Mineral Oil – Heavy Neutral</th>
<th>Mineral Oil – Light Neutral</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weld Point (kg)</td>
<td></td>
<td></td>
<td>126</td>
<td></td>
</tr>
</tbody>
</table>

All base oils show similar EP behavior
Conclusion
PIB in MWFs

Advantages brought by PIB Compared to PAG

Similar Oxidation Stability
Similar behavior in Wear and EP Tests
Lower carbon residue
Lower cost
Thank You!

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