Green Pioneers initiate container trial in response to environmental challenges

The refrigerated container industry (reefer) is facing an environmental challenge resulting from the use of hydrochlorofluorocarbons (e.g., HCFC-141b) in the manufacturing process of insulation foam. HCFC-141b was a preferred blowing agent for decades in polyurethane foam insulation applications, but this material depletes the ozone layer and contributes to global warming. As a result, it was regulated under the Montreal Protocol and is being phased out. China, the production base of global reefer containers, decided to phase out HCFC-141b in the container industry by 2015. Therefore, the industry is looking for a solution that has no impact on the stratospheric ozone layer and a minimal Global Warming Potential (GWP) in compliance with Montreal and Kyoto Protocols as well as providing maximum energy efficiency.

Honeywell is the leader in the development of fluorocarbon technologies and is now leading the development of fourth generation fluorocarbon materials. In 2011, the company announced its fourth generation low-global-warming potential (LGWP) fluorocarbon blowing agent Solstice® Liquid Blowing Agent (LBA). The new blowing agent offers improved energy performance and superior environmental properties compared to existing blowing agents. Solstice LBA will be a preferred solution for the reefer container industry.

Solstice Liquid Blowing Agent
Solstice LBA, a fourth generation fluorocarbon blowing agent called a hydrofluoroolefin (HFO-1233zd) was announced by Honeywell in September 2011, and the material is commercially available.

Solstice LBA has a negligible impact on the ozone layer, and a significantly lower global warming potential (GWP) of 1. The molecule retains all other positive attributes of the HFCs: superior energy efficiency performance, very good processability to improve foam performance, non-flammability and non Volatile Organic Compound (VOC) unlike hydrocarbon blowing agents. These properties continue to differentiate fluorocarbon blowing agents as the best choice for high performance rigid foam applications where flammable blowing agents are unsafe, too costly to use or fail to provide desired energy efficiency and foam performance.

**Physical Properties**

<table>
<thead>
<tr>
<th>Solstice® LBA 245fa</th>
<th>141b</th>
<th>Cyclopentane</th>
</tr>
</thead>
<tbody>
<tr>
<td>Molecular Weight</td>
<td>130</td>
<td>134</td>
</tr>
<tr>
<td>Boiling Point</td>
<td>19°C (66°F)</td>
<td>15°C (59°F)</td>
</tr>
<tr>
<td>Flashpoint</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>LFL / UFL, (Vol % in air)</td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

**Environmental Properties**

<table>
<thead>
<tr>
<th>Solstice® LBA 245fa</th>
<th>141b</th>
<th>Cyclopentane</th>
</tr>
</thead>
<tbody>
<tr>
<td>Atmospheric Life¹</td>
<td>26 days</td>
<td>7.6 years</td>
</tr>
<tr>
<td>ODP²</td>
<td>−0</td>
<td>−0</td>
</tr>
<tr>
<td>GWP, 100yr</td>
<td>1</td>
<td>1030</td>
</tr>
<tr>
<td>VOC Exempt</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Toxicity / OEL</td>
<td>800ppm</td>
<td>300ppm</td>
</tr>
</tbody>
</table>

* Similarity in physical properties is only a portion of the overall mosaic of chemical properties and performance attributes that ultimately define the efficacy and overall suitability for use.

Reefer Container Evaluation

Trial Results: In September 2012, the first Solstice® LBA blown foam insulated reefer container was produced at Yangzhou Tonglee factory in close collaboration with the container owner Unit 45 and blowing agent supplier Honeywell. Insulated with polyurethane foam formulated with Solstice LBA, the reefer container offers both high energy efficiency and low environmental impact. Also Solstice LBA shows excellent properties in foam production process including high flowability, even density distribution, good adhesion and fewer voids. It is most impressive that the reefer container has outstanding insulation performance under standard Reversed Heat-Leakage (RHL) test which is even better than HCFC-141b.

Thermal conductivity of Polyurethane foam

Foams with Solstice LBA demonstrate the best thermal insulation value, especially at lower temperature, which is the typical reefer container working temperature.

Reversed Heat Leakage (ATP, U20)

Solstice Liquid Blowing Agent

- High Energy Performance
  - 6% lower heat-leakage than 141b (ATP, U20)
  - 10% lower heat-leakage than 365/227 (ATP, U20)
  - Could be even better at in-service operating temperature
  - Estimated electricity consumption less 5,000kwh per container during lifetime

- Best Environmental Balance
  - Minimal Global Warming Potential (GWP 1)
  - No impact on the stratospheric ozone layer
  - Safe: non-flammable and acceptable toxicology
  - Estimated CO₂ emission reduced by 43,000kg per container
  - Improved foaming process during reefer container production
  - Preferred substitute for 141b without sacrificing space or energy efficiency
  - Commercially available

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