Innovative new modifier for polypropylene processing

L-MODU™
Low Molecular weight and Low Modulus polyolefin

March 25th, 2021
Idemitsu Kosan Co., Ltd.
What is **L-MODU™**?

- **L-MODU™** is a propylene homopolymer developed by Idemitsu with an original metallocene catalyst technology.

- ‘**Low Modulus**, ‘**Low Melting Point**’ and ‘**Low Melt Viscosity**’ compared with Isotactic PP because of its low crystallinity and low molecular weight.
What is L-MODU™?

High Isotactic PP

Low Isotactic PP

Atactic PP

Stereo-regularity

High

Low

None

Property

Hard

Soft

Sticky
What is L-MODU™?

How to make “soft” polypropylene?

- Addition of rubbers
- Copolymerization with ethylene
- Stereo-regularity control

IDEIMITSU
Metalloocene Catalyst
What is L-MODU™?

Isotactic [mmmnn] ≈ 100

IPP
High Crystallinity & High Stiffness

Low isotactic

Mixture of various stereo-regularity

Conventional catalyst

IDEMITSU Metalloocene catalyst

Homogeneous stereo-regularity

Atactic [mmmnn] ≈ 6

APP
Amorphous
## What is L-MODU™?

### Properties of L-MODU™

<table>
<thead>
<tr>
<th>Property</th>
<th>Method</th>
<th>L-MODU™</th>
</tr>
</thead>
<tbody>
<tr>
<td>MFR (g/10 min) (230 °C, 2.16 kg)</td>
<td>ISO 1133 (JIS K 7210)</td>
<td>S400  S401</td>
</tr>
<tr>
<td>Molecular Weight (Mw)</td>
<td>GPC (Idemitsu method)</td>
<td>S410</td>
</tr>
<tr>
<td>Molten Viscosity (mPa·s) (190 °C)</td>
<td>Idemitsu method</td>
<td>S600</td>
</tr>
<tr>
<td>Density (kg/m³)</td>
<td>ISO 1183</td>
<td>S901</td>
</tr>
<tr>
<td>Melting Point (°C)</td>
<td>DSC (Idemitsu method)</td>
<td></td>
</tr>
<tr>
<td>Softening Point (°C) (Ring-and-ball)</td>
<td>ISO 4625</td>
<td></td>
</tr>
<tr>
<td>Tensile Modulus (MPa)</td>
<td>ISO 527</td>
<td></td>
</tr>
<tr>
<td>Elongation at Break (%)</td>
<td>Idemitsu method</td>
<td></td>
</tr>
</tbody>
</table>

*MFR of S400 and S401 is converted from viscosity data.
Characteristics of L-MODU™?

Based on Idemitsu’s metallocene technology, L-MODU™ has unique characteristics as shown below…

Properties of L-MODU™

- Low melting-point
- Slow crystallization rate
- Soft
- Transparent
- Soluble to some organic solvents

Advantages over other elastomers

- Higher thermal stability
- Odorless
- No stickiness at room temperature
- Higher compatibility to PP
L-MODU™ is a better blend partner with PP compared with other elastic polyolefins, such as propylene/ethylene copolymers.

TEM images of PP(80%) / elastic polyolefin(20%) blends

**L-MODU™-20%**
Uniform structure

**P/E Copolymer A-20%**
Phase separation structure
Characteristics of L-MODU™?

L-MODU™ localize only in amorphous regions
Characteristics of L-MODU™?

Crystallization rate of L-MODU™ is below one-tenth of general polyolefins.

Storage modulus

Table:

<table>
<thead>
<tr>
<th></th>
<th>m.p. (°C)</th>
<th>Co-monomer cont. (wt%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>L-MODU™</td>
<td>70</td>
<td>0</td>
</tr>
<tr>
<td>PP</td>
<td>70</td>
<td>10 (C2)</td>
</tr>
<tr>
<td>PE</td>
<td>70</td>
<td>50 (C8)</td>
</tr>
<tr>
<td>APAO</td>
<td>80</td>
<td>40 (C2,C4)</td>
</tr>
</tbody>
</table>
Characteristics of L-MODU™?

Crystallization rate of PP is reduced by adding L-MODU™.

⇒ Improve processability of PP

Flash DSC (Mettler Toledo) condition: isothermal crystallization after cooling from 230°C to 25°C at 2000°C/min.
Flowability can be controlled by addition of L-MODU™ to PP.

MFR of PP: 30 (g/10min)
Measurement conditions: 230 deg.C, 2.16kg

- Addition of S400 (Calc. value)
- Addition of S600 (Calc. value)
- Addition of S901 (Calc. value)
- Addition of S400 (measured value)
- Addition of S600 (measured value)
- Addition of S901 (measured value)
Flowability is increased especially in high shear rate due to making molecular weight distribution wider and reducing viscosity.

**Resins**

- Standard PP: MFR 30g/10min
- L-MODU™: S400 (MFR 2,000g/10min)

<table>
<thead>
<tr>
<th>Resin Type</th>
<th>Mw</th>
<th>MFR</th>
</tr>
</thead>
<tbody>
<tr>
<td>PP (MFR 30)</td>
<td>177,000</td>
<td>30</td>
</tr>
<tr>
<td>PP (MFR 30) + S400 20%</td>
<td>154,000</td>
<td>58</td>
</tr>
<tr>
<td>PP (MFR 60)</td>
<td>157,000</td>
<td>62</td>
</tr>
</tbody>
</table>

Frequency for injection: @1,000 (rad/s)
Characteristics of L-MODU™?

The softness of the resin blend (PP+L-MODU™) depends on the content of L-MODU™.

**Tensile Modulus**

**Tensile strength**

**Strain at Break**

PP : MFR 30g/10min  
L-MODU™ : S901 (MFR 50g/10min)
Characteristics of L-MODU™?

Softening point of PP becomes lower by adding L-MODU™.

**Vicat softening temperature**

![Graph showing the effect of L-MODU™ content on Vicat softening temperature.](image-url)
Applications of L-MODU™?

L-MODU™ can be applied to:

- Hot Melt Adhesive
- Nonwoven
- Film
- TPE / TPV
- Masterbatch for pigment / filler
Location

CHIBA, JAPAN

Capacity

40,000 t/y

Type of Packing

20 kg  Paper bag
500 kg  Flexible container bag

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