The Superior Coupling Agent for Glass Filled Polypropylene Composites

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Abstract

Maleic anhydride grafted polypropylenes [MA-g-PP] are widely used to improve polymer/filler coupling and to enhance physical properties of the composite. OPTIM® P-425 [MA-g-PP] improves compatibility of non polar thermoplastics with polar fillers such as glass fibers. Coupling agents substantially improve an already good cost/performance ratio of PP composites. There is a dramatic increase in tensile strength and other mechanical properties of fiberglass reinforced polypropylene composites at addition levels of 0.5-2% OPTIM® P-425.

Introduction

Fiber glass reinforcement extends the range of mechanical properties of polypropylene (PP). As a result, glass filled polypropylene is extensively used in automotives, domestic appliances and white goods applications. Polypropylene is non polar and glass is highly polar. Effective reinforcement of PP by glass fiber requires the use of coupling agents which promote polymer/glass adhesion. OPTIM® P-425 (MA-g-PP) is an effective polymeric compatibilizer for composites of PP and inorganic fillers, including glass fiber. MA-g-PP is compatible with PP and has polar functionality. The addition of MA-g-PP to PP/glass composites enhances PP/glass adhesion, resulting in increased composite tensile strength and other mechanical properties.

Coupling: Effects on Mechanical properties

All composite materials require good bonding between the polymer and the reinforcement. This is needed for good mechanical properties. Without proper bonding any added particles/fillers act as stress raisers within the continuous polymer phase. Many polymer systems do not form chemical bonds with inorganic surfaces. The coupling agent provides the required chemical interface between the polymeric and non polymeric phases.
Coupling agents consist of molecules with dual functionality: one part contains a group which can bond strongly to the surface of the reinforcement, while the other is compatible with matrix polymer. Fig. 1 explains the mechanism of coupling action between amino silane coated glass fiber and maleic anhydride grafted polypropylene coupling agent.

Fig.1 Mechanism of Coupling Action

Figures 2-4 show the variation of three key mechanical properties of glass/polypropylene systems as a function of glass content. The effect of coupling is remarkable. It can be seen that without a compatible glass surface treatment there is little or no increase in strength or toughness as glass content is increased. The most strongly synergistic coupling effect is achieved by the use of a combination of compatible glass surface treatment and a chemically modified polyolefin.

Fig.2 The effect of Coupling Agent on tensile strength of PP/Glass Fiber
Fig. 2 shows trend of tensile strength of glass filled PP at varying glass filler content. The addition of coupling agent improves the tensile strength of glass filled polypropylene.

![Fig. 2](image)

**Fig. 2.** The effect of Coupling Agent on tensile strength of PP/Glass Fiber

Fig. 3 shows the flexural strength improvement of glass filled PP. The addition of Optim P425 improves the flexural strength compared to sized and unsized glass fibers.

![Fig. 3](image)

**Fig. 3.** The effect of Coupling Agent on flexural strength of PP/Glass Fiber

Fig. 4 shows the impact strength enhancement of glass filled PP which shows a different trend from tensile and flexural behaviour. Impact strength decreases with the increasing glass content. The addition of MAH-g-PP improves the impact strength to yield the high impact values compared to unsized glass filled PP.

MAH-g-PP not only improves PP/filler adhesion, but also improves composite processability. MAH-g-PP generally has a much lower viscosity than the base PP resin.
so, in addition to providing sites for coupling, it generates a further beneficial effect by reducing fiber breakage during compounding, through the reduced viscosity of the matrix resin.

**OPTIM® P425** from Pluss Polymers provides excellent coupling action between the filler and the polymer matrix. The tensile strength can be increased by 30-40% and flexural strength by 40-50% for the 10-40% glass fiber reinforced PP composites.

<table>
<thead>
<tr>
<th>Properties</th>
<th>Composition</th>
<th>Unit</th>
<th>PP-78%+Glass-20%</th>
<th>OPTIM® P-425-2%</th>
<th>PP-68%+Glass-30%</th>
<th>OPTIM® P-425-2%</th>
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</thead>
<tbody>
<tr>
<td>Tensile Strength</td>
<td></td>
<td>MPa</td>
<td>77</td>
<td>58</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Elong. @ Break</td>
<td></td>
<td>%</td>
<td>7.5</td>
<td>3.0</td>
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<tr>
<td>Flex. Modulus</td>
<td></td>
<td>MPa</td>
<td>4050</td>
<td>4525</td>
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<tr>
<td>Impact Strength</td>
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<td>J/m</td>
<td>102</td>
<td>98</td>
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</tr>
</tbody>
</table>

**Market Report/Trend**

According to Plastics Today, Asia already accounts for around 42% of global composites production. By 2015 it could well account for half, based on current growth trends.

Reinforced Plastics News mentioned that reinforced thermoplastics demand is forecast to grow 3.0 percent annually to reach 2 million tons in 2011 due to their competitive cost, high performance capabilities, processing advantages and better design possibilities. Polypropylene will remain the leading thermoplastic and present above average growth based on its low cost, stiffness and dimensional stability, particularly in motor vehicle uses. Glass fibers, due to their low cost and good performance, will continue to be the dominant reinforcement material in 2010 and beyond.
Applications

Glass fiber reinforced compounds “Bridge the Gap” between general purpose polymers and engineering resins. Glass filled polypropylene provides good rigidity, high toughness and excellent heat resistance. Some of the applications of Glass filled polypropylene include:

- Electrical & Electronic Parts
- AC Shrouds, Surge tank
- Automotive parts
  - Instrumental panel retainers
  - Bumper Beams
  - Mirror housings
  - Door Modules
  - Lift gates and Tail gates
  - Under the bonnet engine covers
  - Under the bonnet skid plates
- Automotive parts for higher HDT & strength
- Washing machine parts
- Lawnmower