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Polyolefin Resin Modifier

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Polyolefin resins such as polyethylene (PE) and polypropylene (PP) are popular plastic materials, widely used in myriad applications. They offer outstanding chemical and water resistance. Unfortunately, their non-polar character results in poor compatibility with high-polarity resins and low reinforcing filler dispersibility. Our UMEX additive was developed to eliminate these drawbacks.

UMEX is a highly modified polypropylene backbone bonded to pendant hydrophilic carboxylic anhydride groups. The polypropylene backbone provides an affinity for polyolefin resins while the hydrophilic carboxylic anhydride groups provide affinity for reinforcing fillers (e.g. glass fibers, carbon fibers and wood flour) and high-polarity resins (e.g. nylon and polyethylene terephthalate)(**Fig. 1**). Adding UMEX to polyolefin resins leads to higher dispersibility of fillers, and higher compatibility between polyolefin resin and high-polarity resin as well.

The preparation of this type of product is normally accomplished with a free-radical initiator to attach the carboxylic anhydride groups to the polypropylene backbone. However, since polypropylene is a saturated hydrocarbon, its reactivity is very low and the degree of acid modification of the product is low. What sets UMEX apart is our proprietary technology. This unique technology results in a reduction of polypropylene molecular weight and the addition of functional groups to the polypropylene chain. These new functional groups allow a much higher degree of acid modification. The resultant product exhibits a lower molecular weight and a higher degree of acid modification relative to conventional acid-modified polyolefins. Therefore, UMEX is better oriented at the interface between polyolefin resin and other material (e.g. high-polarity resin and fillers), and less modifier is needed to obtain the desired effect. Although UMEX has a smaller molecular weight, its melting point is comparable with that of polypropylene resin. Therefore, it can also be used for improving the heat resistance of hot melt adhesives. UMEX is also used for many of other applications, as shown in **Fig. 2**.

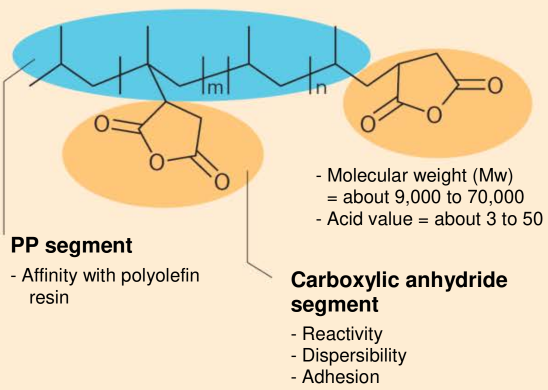


Fig. 1 Structure of UMEX

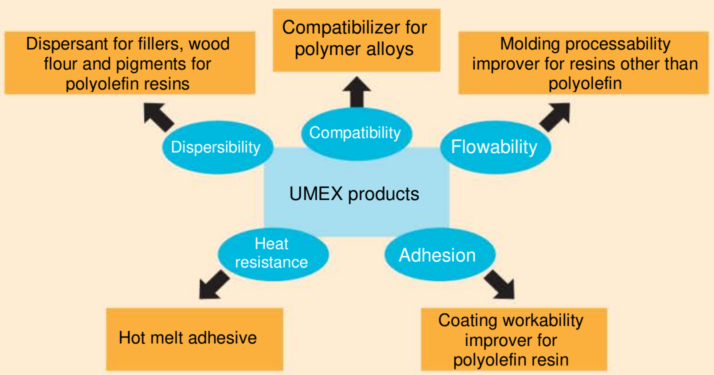
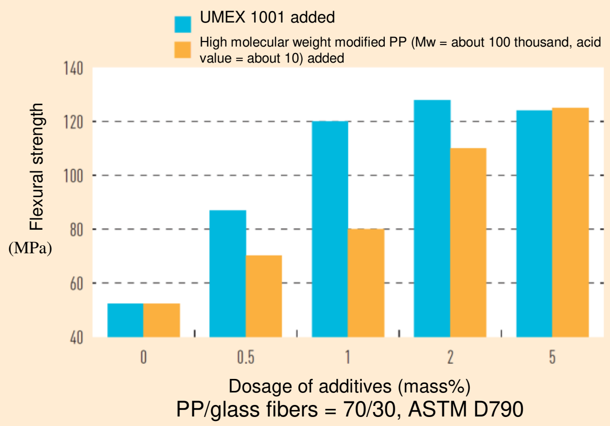
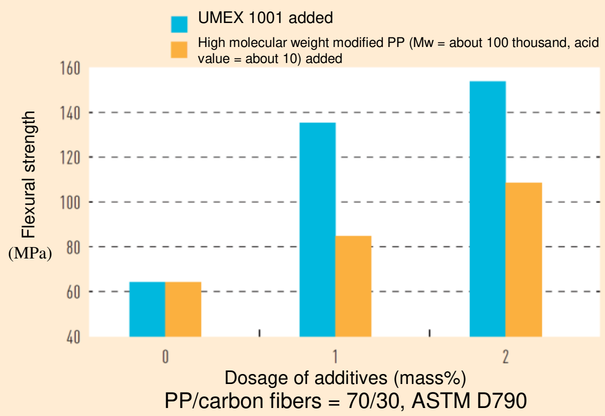


Fig. 2 Major applications of UMEX products



A small amount of additives of UMEX can improve physical properties including flexural strength.

Fig. 3 Application for glass fiber reinforced PP



A small amount of additives of UMEX can improve physical properties including flexural strength.

Fig. 4 Application for carbon fiber reinforced PP

Application Detail

[1] Higher Dispersibility

<Glass Fiber Reinforced PP>

The purpose of adding a reinforcing filler to polyolefin resin is to improve the physical properties and heat resistance of the resin. Polypropylene reinforced with chopped strands of glass fiber is comparable to engineering plastics in terms of physical properties. They are used for automobile parts. Glass fibers are normally treated with a silane-coupling agent. Unfortunately, this only provides some adhesion between the polypropylene resin and the glass fibers, which means that the full reinforcing potential of glass fiber has not been captured. Adding UMEX having an affinity for silane-coupling agent significantly improves the adhesion between glass fibers and polypropylene resin. A small addition of UMEX can provide the same effect on physical properties as a conventional high molecular weight polyolefin resin modifier (**Fig. 3**). This is because UMEX has a lower viscosity and a higher degree of acid modification, allowing it to be oriented efficiently at the interface between glass fibers and polyolefin resin.

<Carbon Fiber Reinforced PP>

Polypropylene resin reinforced with carbon fiber provides higher physical properties and lower density than glass fiber reinforced polypropylene. Carbon fiber reinforced polypropylene is a next-generation advanced material offering "stronger than steel and lighter than aluminum" performance. It's appropriate for the demanding automotive industry in which weight reduction is key to achieving fuel economy targets. **Figure 4** shows how UMEX, added as a dispersant, boosts the physical properties of carbon fiber reinforced polypropylene resins. Adding UMEX improves the adhesion between the carbon fibers and polypropylene resin (**Photo 1**) and also the heat resistance of the carbon fiber reinforced polypropylene resin. Higher modulus can be achieved subject to using longer fibers. Carbon fiber is a major focus of our ongoing dispersant development activities.

<Wood Flour/Polypropylene Composite (WPC)>

WPC (Wood Plastic Composite) is a composite of wood flour (powdered wood) and synthetic resins.

It is woody in appearance but superior to wood with respect to the strength, dimensional stability, weather resistance, flame resistance, chemical resistance and abrasion resistance. It's used mainly for residential decks and outdoor structures. Since wood flour is mostly cellulose, it's a very polar material and has poor affinity for polypropylene

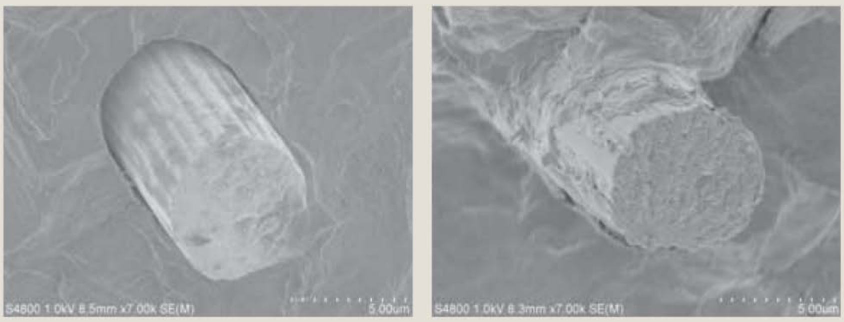


Photo 1 Interface between carbon fibers and PP resin (PP/carbon fibers = 70/30)
Left: without UMEX, there are gaps at the interface due to poor adhesion
Right: with 1% additives of UMEX, good adhesion is obtained

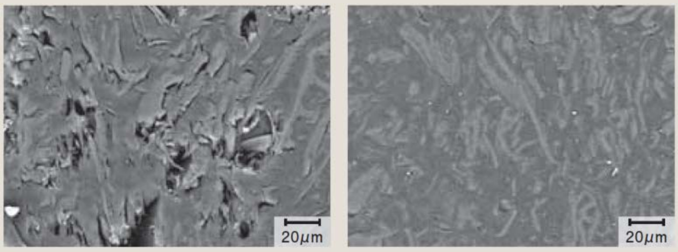


Photo 2 **Composite of wood flour and PP (PP/wood flour = 50/50)**
Left: without UMEX, poor adhesion at the interface
Right: with 1% additives of UMEX, good adhesion between wood flour and resin, and uniform dispersion

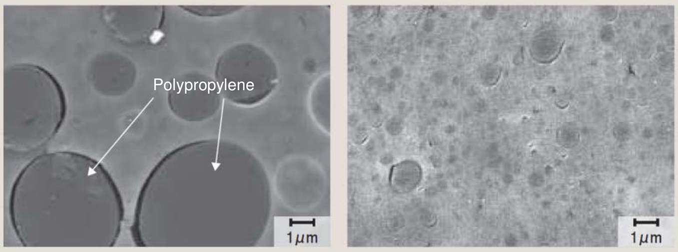
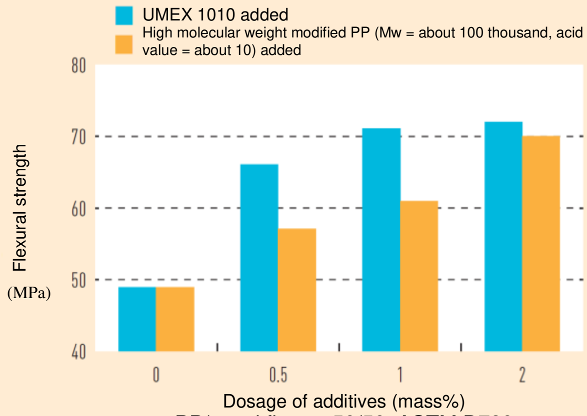


Photo 3 **Composite of PP and nylon 6 (PP/nylon 6 = 30/70)**
Left: without UMEX, there are large lumps of PP leading to phase separation. Right: with 5% additives of UMEX, PP is micro-dispersed uniformly in nylon 6



PP/wood flour = 50/50, ASTM D790

A small amount of additives of UMEX can improve physical properties including flexural strength.

Fig. 5 **Application for a composite of wood flour/PP (WPC)**

resins. As a result, polypropylene shows low adhesion to wood flour (**Photo 2 [left]**). However, adding UMEX significantly improves the adhesion (**Photo 2 [right] and Fig. 5**). As a result, polypropylene shows low adhesion to wood flour (Photo 2 [left]). However, adding UMEX significantly improves the adhesion (Photo 2 [right] and Fig. 5). We now see that plastic packaging waste is increasingly being recycled, creating new feed streams to augment virgin polypropylene. We are currently involved with the development of new dispersants to respond to the growing role of recycled polypropylene.

<Others>

Used as a dispersant for calcium carbonate, silica and talc.

[2] Higher Compatibility with High Polarity Resins Using UMEX

An intriguing method of improving the physical properties of a thermoplastic resin is to physically mix multiple resins, producing a "polymer alloy". However, polyolefins are non-polar and crystalline, so they have poor compatibility with other polymers and thus generally make poor polymer alloys. UMEX is based on a polyolefin backbone with bonded pendant carboxylic anhydride groups. When preparing a polymer alloy of polyolefin resin and nylon, UMEX is a useful compatibilizer. The carboxylic anhydride groups from UMEX and the amino end groups and amide linkages of the nylon react, resulting in a reduction of interfacial tension between the resins, leading to a state of micro-dispersion. Photo 3 shows how UMEX affects the state of dispersion. UMEX is available for use with not only nylon but also other high polarity resins such as polybutylene terephthalate and polyethylene terephthalate to improve their compatibility with polypropylene resins.

[3]Higher heat resistance of hot melt adhesive

Hot melt adhesives are environmentally conscious adhesives because they are free of solvents and emit little or no volatile organic compounds (VOCs). However, conventional hot melt adhesives, being thermoplastic, often exhibit unsatisfactorily low adhesive strength under hot conditions (in transit during summer). UMEX, which has a melting point similar to that of crystalline polypropylene resin, is an effective additive for the improvement of heat resistance. UMEX also exhibits low viscosity – a benefit when formulating hot melt adhesive for fast application and high productivity.

Low-melting point type UMEX

Polypropylene resins having a lower melting point are needed in view of better handling and for processes that use lower processing temperatures. PP resins having a lower melting point can be obtained through random copolymerization with ethylene resins (random PP process). A recently developed "random PP" with a low concentration of ethylene, produced using a metallocene catalyst, exhibits

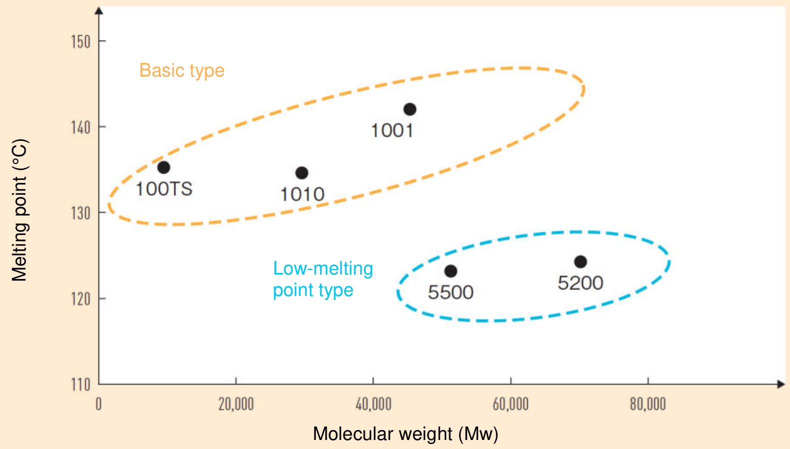


Fig. 6 **Features of UMEX products (relationship between molecular weight and melting point)**

significantly reduced crystallinity and a lower melting point than conventional random-PP resins. “Low melting point type” UMEX grades, developed based on this new random PP, feature lower melting points than other versions of UMEX (Fig. 6). Compared to other versions of UMEX, “low melting point type” UMEX grades feature better handling and higher production efficiency, yielding impressive energy savings. “Low melting point type UMEX” grades are available as dispersants for applications requiring low processing temperatures. One example would be WPC, due to the temperature sensitivity of cellulose fillers. Another would be floor wax compounds which must be emulsifiable at low temperatures. Moreover, they have better compatibility with polyethylene due to the ethylene component in the backbone. Thus, they perform well in polyethylene applications (for example as a dispersant for calcium carbonate or magnesium hydroxide in polyethylene).

Prospects

The transportation industry demands continuing improvements in fuel efficiency as well as productivity. For these reasons steel continues to be replaced by plastic for weight reduction. Also, fiber-reinforced composite usage continues to expand globally. Service conditions very widely, from frigid near-arctic climates to steamy equatorial conditions. Resin modifiers play an increasingly important role in addressing the needs of this wide range of service environments. We continue to work diligently to expand the performance envelope of UMEX additives.

Table 1 **Properties of UMEX Series**

Product name	UMEX 1001	UMEX 1010	UMEX 100TS	UMEX 5200	UMEX 5500
Appearance	Yellow pellet	Yellow pellet	Pale yellow powder	Yellow pellet	Yellow pellet
Melting point (°C)	142	135	136	124	123
Melt viscosity (mPa•s)	15,000	6,000	120	20,000	6,200
Acid value	26	52	3.5	11	17
Molecular weight (Mw)	45,000	30,000	9,000	70,000	52,000
Features	Basic type			Low melting point	
Major use	• Glass fiber dispersant	• Wood flour dispersant • Hot melt adhesive	• Hot melt adhesive	• Glass fiber dispersant	

• Melting point: DSC method • Melt viscosity at 160°C
• Acid value: per ASTM D1386 • Molecular weight: high-temperature GPC method

References

1)Pasquini Nello, “*Shinpan Poripropiren handobukku kiso kara youtokaihatu made* (New version Polypropylene Handbook from foundation to application development)” Nikkann Kogyo Shimbun

[Contact (about the product)]
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