



Z E E M A I L



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Use of ZEEOSPHERES® to Reduce Warpage, Improve Flow, and Enhance Processability in Thermoplastics

The following describes how the addition of **ZEEOSPHERES®** to glass fiber reinforced polypropylene can improve flow, reduce or eliminate warpage, and enhance processability.

A number of plastic processors have indicated that warpage and poor flow and increasingly serious problems with many polymers containing any type of fibrous reinforcement. For this study, polypropylene resin and glass fiber were selected because both are widely used. It is worth pointing out to customers, however, that the same effects observed from the addition of **ZEEOSPHERES®** to glass filled polypropylene could be expected in other types of injection molded reinforced plastics.

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A number of articles have appeared in technical publications describing the advantages of combinations of fibers and spheres in polymer systems. In an attempt to quantify these advantages with ZEEOSPHERES®, a study was undertaken evaluating combinations of ZEEOSPHERES® and glass fibers in injection molded polypropylene.

The key finding of this study is that optimized combinations of ZEEOSPHERES® and glass fibers can reduce or eliminate the warpage problems normally encountered in glass fiber reinforced systems while maintaining an excellent balance of strength vs. stiffness and good heat deflection properties. Additionally, ZEEOSPHERES®/glass fiber combinations improve mold flow, minimize “tear drop” fiber voids around mold inserts and reduce shrinkage.

Additional detailed highlights of these test results include the following:

Warpage

Polypropylene composites containing ZEEOSPHERES® alone or in combination with glass fiber reinforcement produce parts that exhibit dramatically less warpage than straight glass fiber reinforced polypropylene. The degree of warpage (as with other physical properties tested) varies with the ratio of ZEEOSPHERES® to glass fiber, indicating that the system should be optimized for best results in individual applications.

Systems 5 and 6 in the accompanying data indicate that an optimum system with this resin and mold completely eliminated warpage while still maintaining a good balance of other physical properties.

Shrinkage

Polypropylene filled with ZEEOSPHERES® exhibits substantially less shrinkage than unfilled polypropylene. It has also been shown in previous studies to exhibit less shrinkage than conventional mineral-filled PP. Glass fiber filled polypropylene has traditionally been shown to have the lowest shrinkage of any system; however, in this study, combinations of ZEEOSPHERES® and glass fiber were shown to exhibit shrinkage as low as that of straight glass fiber-reinforced polypropylene.

Heat Deflection Temperature (HDT)

ZEEOSPHERES® filled polypropylene gives higher HDT's than unfilled polypropylene. Higher levels of ZEEOSPHERES® produce even higher HDT's. Glass fiber increases HDT even more. Polypropylene composites containing ZEEOSPHERES® plus glass fiber yield HDT's that are on par with those reinforced at the same levels with glass fiber alone.

Specific Gravity

ZEEOSPHERES® are lower in specific gravity than glass fiber. Therefore, replacing some of the chopped glass with ZEEOSPHERES® lowers the specific gravity of the composite.

Flexural Modulus

The addition of ZEEOSPHERES® to unfilled or glass reinforced polypropylene consistently increases flexural modulus. (Systems 7, 8, & 9 vs. 1; System 5 vs. 3).

Impact (Notched Izod)

Because they have little reinforcing effect, the addition of ZEEOSPHERES® to unfilled polypropylene has essentially no effect on notched Izod. Glass fibers, by contrast, will improve notched Izod impacts.

SUMMARY

This work demonstrated that substituting ZEEOSPHERES® for a fraction of the glass fibers or resin in a glass-reinforced composite will improve warpage and processability while maintaining a good balance of strength and stiffness properties.

As with any unique material, however, optimum properties are obtained only when a customer's system is properly balanced. Simply inserting ZEEOSPHERES® into an existing plastic formula can produce varied and not necessarily optimum results. Actual test data for the various systems and tests described here is attached.

Table 1: Properties of Reinforced Polypropylene Compounds

Filler Reinforcement	Warpage mm	Flexural Modulus x 10³ psi	Flexural Strength x 10³ psi	Notched Izod Impact 23°C Ft. Lbs/In.	Shrinkage In./in.	Heat Deflection Temp °C	Tensile Yield Strength x 10³ psi	Z Elongation Break
1. Control	0.0	254	8.2	0.8	0.018	122	5.40	425
2. 20% GF	4.0	445	10.2	1.4	0.002	160	6.45	>10
3. 30% GF	3.2	636	11.2	1.5	0.001	160	6.75	>10
4. 40% GF	2.2	870	11.7	1.4	0.001	161	6.11	>10
5. 30% GF 10% G-600	0.0	680	9.7	1.1	0.001	157	5.13	>10
6. 25% GF 15% G-600	0.0	528	8.7	1.0	0.001	159	4.80	>10
7. 20% G-600	0.0	303	7.4	0.7	0.017	123	4.50	269
8. 30% G-600	0.0	308	7.0	0.8	0.016	126	3.87	225
9. 40% G-600	0.0	366	7.1	0.8	0.014	129	3.45	114

GF= Glass Fiber

G-600 = ZEEOSPHERES® G-600 product