MECHANICAL PROPERTIES OF ENGINEERING PLASTICS BASED ON PYROGRAF-III™ CARBON FIBER

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Introduction

Pyrograf-III™ carbon fiber is a low-cost version of vapor grown carbon fiber. Tensile and flexural tests were performed on several engineering plastics reinforced with Pyrograf-III™ carbon fiber. Both the modulus and strength were found to be comparable or exceed that of maybe use similar plastics reinforced with glass fiber.

Experimental

Pyrograf-III™ carbon fiber was produced by a floating catalyst method described in detail elsewhere. [1] Various versions of fibers, prepared using different growth recipes (Table I), were used. Fibers were used in as-grown, de-bulked, or ball-milled product form. The de-bulk process involved the use of a water slurry process described elsewhere. [2] Composites with matrices of polyphenylene sulfide (PPS), polyester, and polypropylene (PP) were fabricated using either injection molding process, or bulk molding process. Specimens of these composites were tested for tensile properties according to ASTM D638. Selected specimens were also tested for flexural properties according to ASTM D790, deflection temperatures according to ASTM D648, and impact strength according to ASTM D256.

Results and Discussion

Table II lists all the composites fabricated. In general, it appears that most of the composites are porous with a porosity > 5%, except Composite P3PP-1, as shown in Table III. However, improvement of mechanical properties were observed despite of the porosity. For PPS composite properties, a comparison to published data [3] for PPS, 40% glass fiber (GF)/PPS, and 40% long glass fiber (LGF)/PPS is given in Fig. 1. It is apparent that Pyrograf-III™ carbon fiber increased the tensile modulus of PPS, and the resulting composite is better than 40% GF/PPS composites and approaching 40% LGF/PPS composites.

Polyester composites reinforced with Pyrograf-III™ carbon fiber also exhibit better tensile moduli than neat polyester (0.30 to 0.64 msi, Ref. 3).

Among the composites fabricated, the PP composite, i.e., P3PP-1, reinforced with 30% Pyrograf-III™ carbon fiber exhibited the best overall properties. A comparison of mechanical properties of several PP composites is given in Table IV. Data for glass fiber reinforced PP composites were obtained from Ref. 3 and some data for PP were obtained from the manufacturer. Significant increases in both tensile and flexural moduli and a moderate increase in tensile strength for PP were obtained by the addition of 30%, by weight Pyrograf-III™ carbon fiber. A significant incease in deflection temperature was also observed. Tensile properties of this composite are also very compatible with that of PP reinforced with 10 to 30% glass fiber.

Conclusion

Polymer composites based on Pyrograf-III™ carbon fiber were fabricated and tested for mechanical properties. Improvement in tensile modulus and deflection temperature was observed while tensile strength is less satisfactory due to the lack of desired interface and the high percentages of porosity.

References

[1] J.-M. Ting, M. Saqib, and D.J. Burton, "TEM Observation of VGCF Produced by a Continuous Process," Ext. Abs. Carbon'97, State College, PA, July, 1997.

[2] R.L. Alog, J.R. Guth, D.J. Burton, U.S. Patent #5,594,060, Jan. 14, 1997.

[3] Handbook of Plastics, Elastomers, and Composites, C.A. Harper, 2nd ed., McGraw-Hill (1992).

Table I. Various versions of Pyrograf-III™ carbon fibers used in composites.

Fiber Type	Recipe	Treatment
P-3	control	de-bulked
P-0	low air	ball milled
P-7	high sulfur	de-bulked
V1	high flow rate	none
V2	high air	none
V2a	same as V2	de-bulked

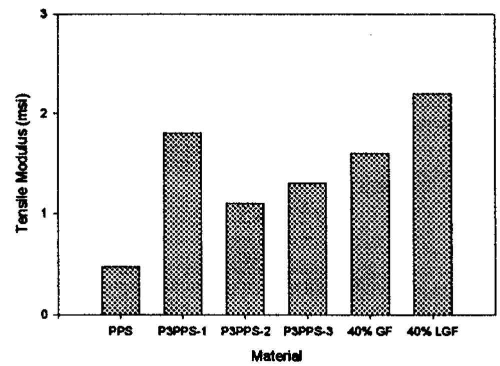

Fig. 1. Tensile modulus of various PPS composites.
40% GF: PPS w/ 40% glass fiber.
40% LGF: PPS w/ 40% long glass fiber.

Table II. Polymer composites based on Pyrograf-III™ carbon fiber.

ID	Fiber Type	Matrix	Molding	Fiber, by wt
P3PPS-1	P-3	PPS	Injection	30%
P3PPS-2	P-0	PPS	Injection	30%
P3PPS-3	P-7	PPS	Injection	30%
P3V1PER-1	V1	Polyester	Bulk	20.8%
P3V2PER-1	V2	Polyester	Bulk	20.8%
P3PP-1	V2a	PP	Injection	30%
P3V1PP-1	V1	PP	Injection	15%
P3V2PP-2	V2	PP	Injection	15%
PP	none	PP	Injection	0%

Table III. Properties of various polymer composites based on Pyrograf-III™ carbon fiber.

Composite	Test	Strength, ksi	Modulus, msi	Density, g/cc	Porosity	Other
P3PPS-1	Tensile	4.1	1.8	1.56	-	
P3PPS-2	Tensile	7.0	1.1	1.43	6.5%	
P3PPS-3	Tensile	4.2	1.3	1.49	2.6%	
P3V1PER-1	Tensile	5.14	0.8708	1.30	9.7%	
P3V2PER-1	Tensile	3.98	0.9197	1.32	8.3%	
P3PP-1	Tensile	6.7	0.82	1.101	1.5%	
P3PP-1	Flexural	7.59	0.753	1.101	1.5%	
P3PP-1	Deflection			1.101	1.5%	Deflection Temperature: 137.1 °C
P3PP-1	Impact			1.101	1.5%	Impact Strength: 0.493 ft-lb/in
P3V1PP-1	Tensile	4.45	0.363	0.8555	16.2%	
P3V2PP-2	Tensile	5.5	0.488	0.9799	4.0%	
PP	Tensile	4.35	0.273	0.935	0.5%	

Table IV. Properties comparison for various PP composites.

Material	Tensile Modulus, msi	Tensile Strength, ksi	Flexural modulus, msi	Deflection Temp., °C	Impact, ft-lb/in
PP	0.273	4.35	0.175*	91*	0.6*
P3PP-1	0.82	6.7	0.753	137.1	0.493
PP w/ 10 to 30% GF**	0.7 to 1.0	6.5 to 10.0			

* Data from the manufacturer. ** Data from Ref. 3.