Thermax® N990 in Polyphenylene Sulfide Composites

With the help of the National Research Council of Canada (NRC), Cancarb performed testing of Thermax® N990 in thermoplastic composites. Thermax® thermal carbon black was compounded in polyphenylene sulfide (PPS) at loadings ranging from 0 to 40 percent by weight. Thermoplastics are commonly compounded with mineral fillers to reduce cost and improve on properties such as tensile strength and heat deflection temperature. Testing results confirm that thermal carbon black can be used to replace the mineral fillers to reduce weight and cost among other advantages listed below.

Advantages of adding Thermax® N990 to PPS:

- Potential cost reduction (~35% at high loading)
- Lower density when replacing mineral fillers – **large potential weight savings** (~10% at high loadings)
- Less abrasive than mineral fillers
- Excellent dispersion
- Increase in tensile modulus up to 95% (elasticity)
- High electrical resistivity (non-conductive compounds)
- Increase in heat deflection temperature (HDT)
- Excellent black coloring at 1% loading
- Class A surface finish capable

Table 1. Polymer grades

Polymer Type	Grade	Manufacturer
Polyphenylene Sulfide (PPS)	FORTRON® 0214	Celanese
*No coupling agents were used		

Table 2. Test formulations

Thermoplastic Matrix	Thermax® N990 Thermal Black					N762 Furnace Black
PPS	1 wt.%	3 wt.%	5 wt.%	20 wt.%	40 wt.%	5 wt.%

The effect of N990 loading on polyphenylene sulfide (PPS) composites can be seen in the following figures and tables.

In Figure 1, the complex viscosity showed only modest increases up to 5 wt.% of N990. At 20 wt.% and 40 wt.%, significant increases in viscosity and changes in rheological behavior were observed.

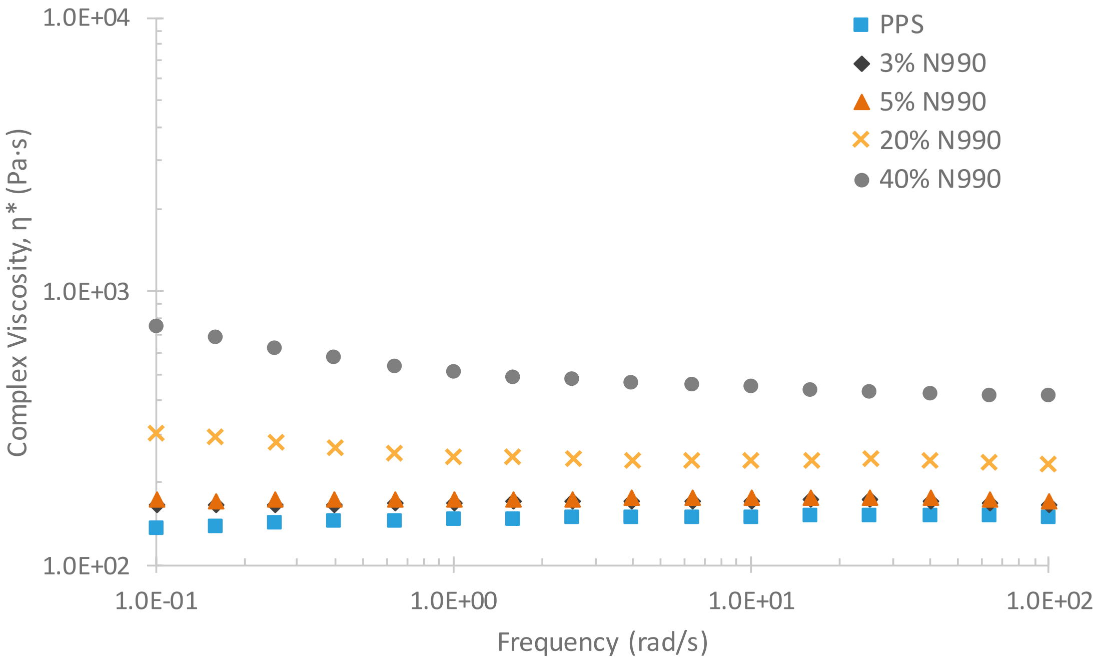

Figure 1. Complex viscosity curves at 300°C and varying frequency. As N990 loading increased, viscosity also increased. There was no significant viscosity change up to 5 wt.% N990 loading.

The tensile modulus values of the PPS composites are shown in Figure 2. A clear trend of increasing modulus with increasing filler loading was noted.

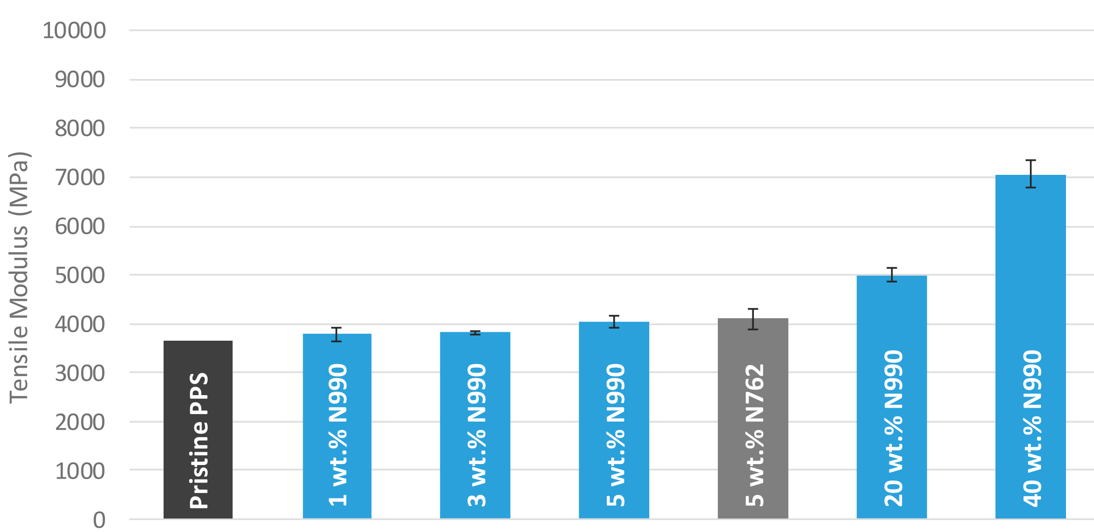

Figure 2. Tensile modulus of PPS composites. Tensile modulus increased with filler loading.

Figure 3 contains the ultimate tensile strength data which tended to decrease with increasing filler loading.

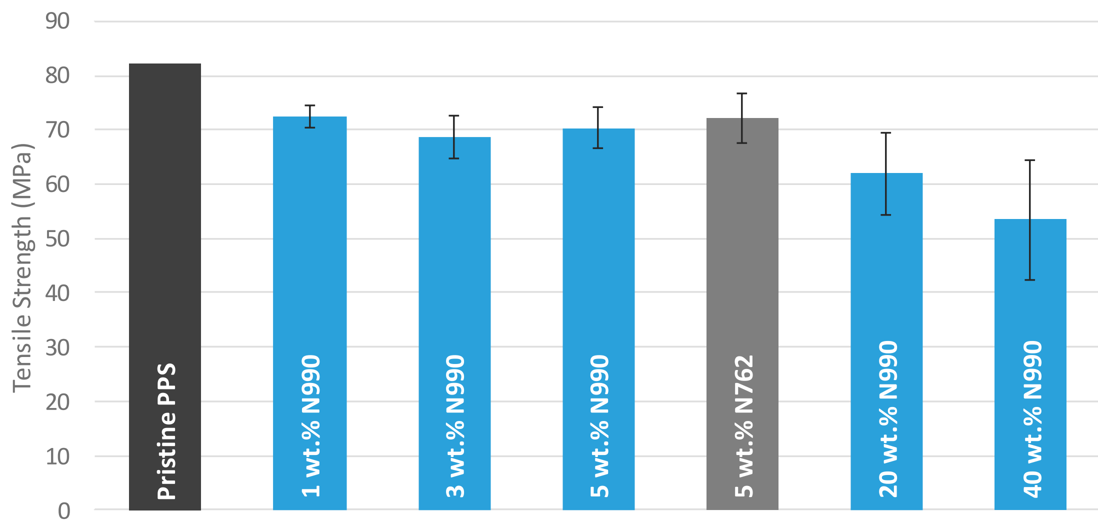

Figure 3. Ultimate tensile strength for PPS composites. Tensile strength tended to decrease as filler loading increased.

Figure 4 shows the elongation at break of the materials. Elongation also tended to decrease with increasing filler loading.

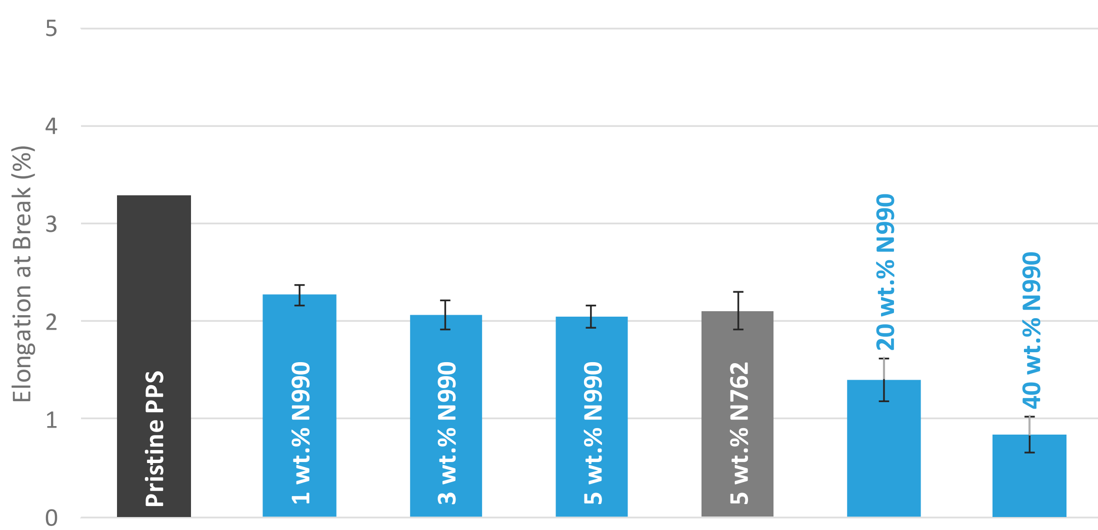

Figure 4. Elongation at break of PPS composites. Elongation tended to decrease with increasing filler loading.

The impact strengths of the materials, shown in Figure 5, were stable up to 5 wt.% loading and declined sharply at 20 wt.% and 40 wt.% N990.

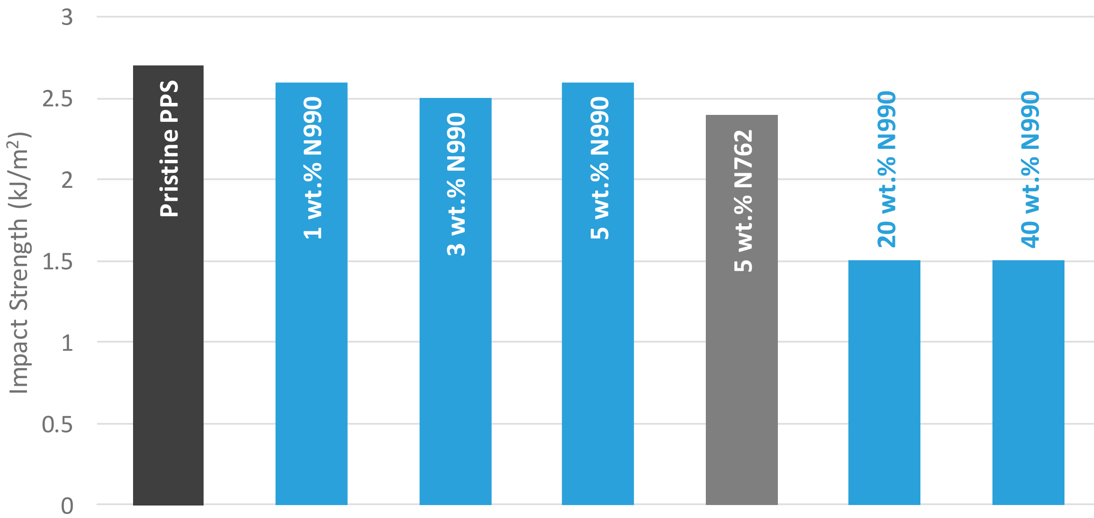

Figure 5. Izod impact strength of PPS composites. Impact strength was stable up to 5 wt.% N990 loading and decreased sharply at 20 wt.% N990 loading.

Figure 6 shows the heat deflection temperatures for the composites which tended to increase with increasing filler loading. At 40 wt.% N990 loading, the heat deflection temperature was 50°C higher than the pristine polymer.

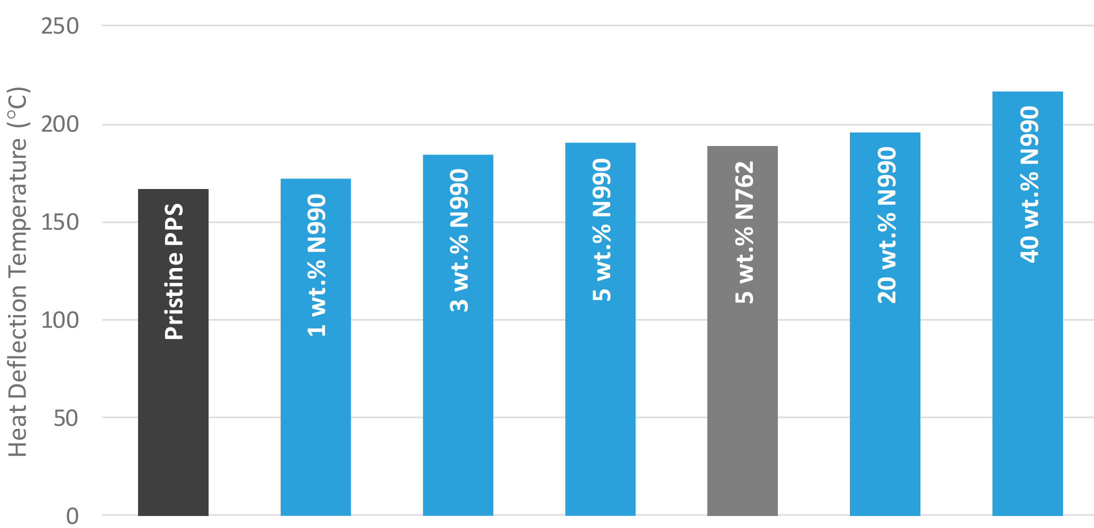

Figure 6. Heat deflection temperature of PPS composites. Heat deflection temperature increased steadily with increasing N990 loading. At 40 wt.% N990 loading, HDT was 50°C higher than the pristine polymer.

Color data for the composites is contained in Table 3. The **CIELAB color space** was used which represents color as three values: *L** for the lightness from black (0) to white (100), *a** from green (−) to red (+), and *b** from blue (−) to yellow (+). At 1 wt.% N990, the material was a very dark gray with a notably blue undertone. With increasing loading, the color tended to darken slightly, and the blue undertone was slightly reduced.

Table 3. L*a*b* color data for PPS composites

Filler Loading	L*	a*	b*
1 wt.% N990	26.3	-0.3	-5.9
3 wt.% N990	24.5	-0.3	-3.8
5 wt.% N990	25.6	-0.5	-4.2
5 wt.% N762	24.7	-0.5	-4.0
20 wt.% N990	24.7	-0.5	-4.0
40 wt.% N990	23.9	-0.4	-3.9

Figure 7 shows the potential weight savings from using N990, with a specific gravity of 1.8 g/cm^3, instead of glass fiber, with a specific gravity of 2.5 g/cm^3. At high loadings, the density of the composite loaded with N990 is about 10% less than the one loaded with glass fiber.

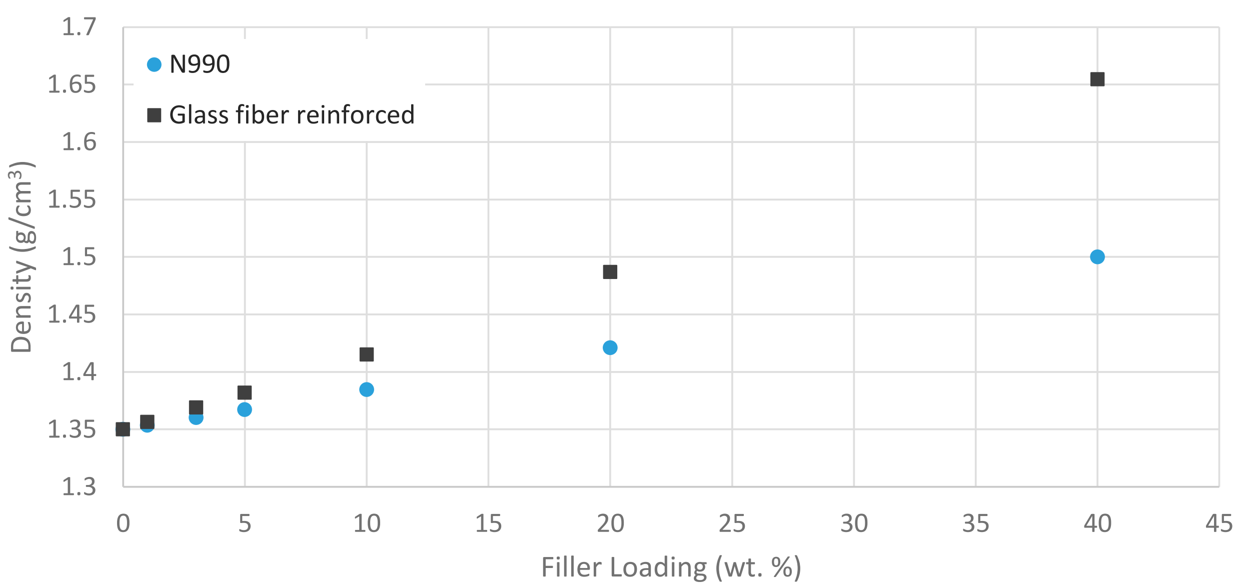

Figure 7. Density of PPS composites as a function of filler loading. At 40 wt.% loading, weight savings of greater than 10% can be realized by using N990 over glass fibers or mineral fillers.