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Thermax® N990 in Polyamide 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 polyamide (PA6) 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 thermoplastics:

- Potential cost reduction (~30% at high loadings)
- Lower density when replacing mineral fillers – **large potential weight savings** (~10% at high loadings)
- Less abrasive than mineral fillers
- Excellent dispersion
- **Higher elongation at break** than pristine polymer
- Increase in tensile modulus of up to 60% (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
Polyamide (PA6)	Ultramid® B27	BASF
Polyamide (PA6)	Ultramid® B3M6	BASF
*No coupling agents were used		

Table 2. Test formulations

Thermoplastic Matrix	Thermax® N990 Thermal Black						N762 Furnace Black	Mineral Filler
PA6	1 wt.%	3 wt.%	5 wt.%	10 wt.%	20 wt.%	40 wt.%	5 wt.%	30 wt.%

The effect of N990 loading on polyamide composites can be seen in the following figures and tables. The data for the formulation with 30 wt.% mineral filler was based on previously published data for BASF Ultramid® B3M6.

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

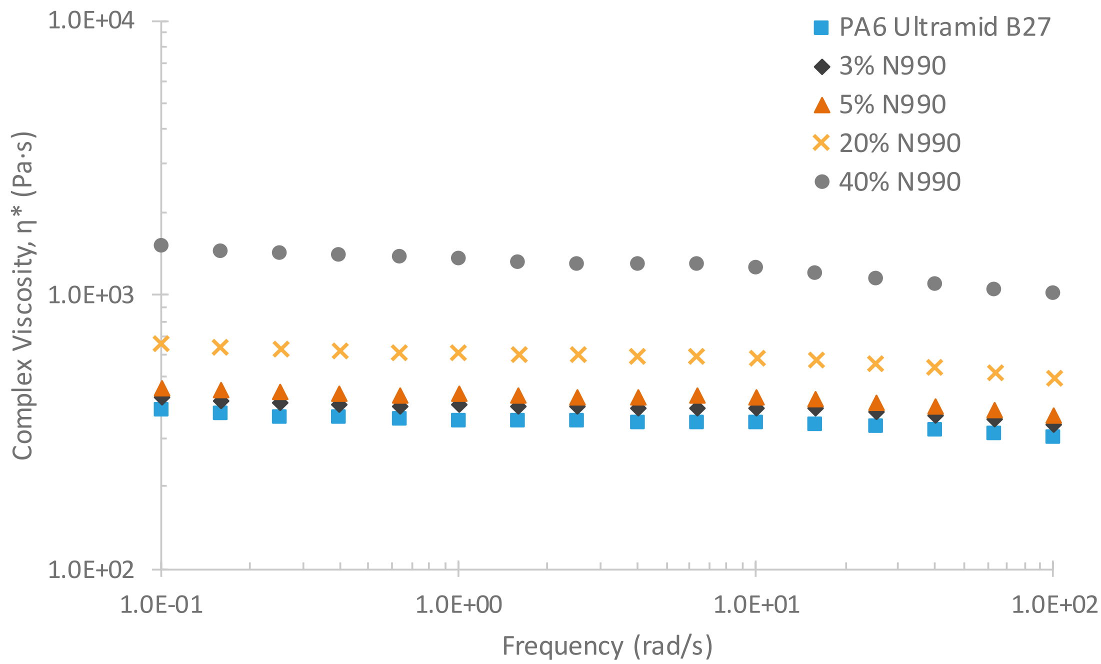

Figure 1. Complex viscosity curves at 240°C and varying frequency. As N990 loading increased, viscosity also increased. There was no significant viscosity change up to 5 wt.% N990 loading.

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

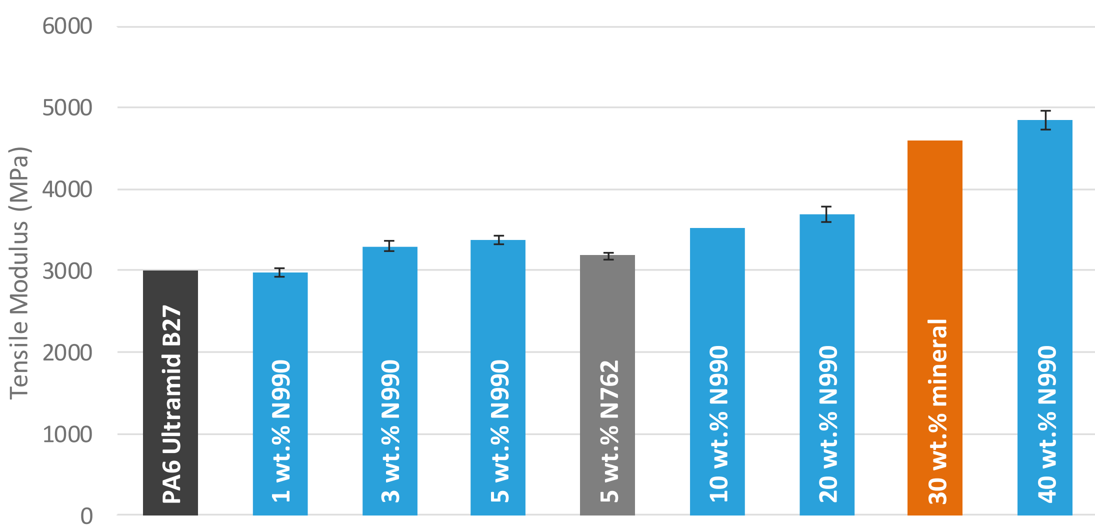

Figure 2. Tensile modulus of polyamide composites. Tensile modulus increased with filler loading.

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Figure 3 contains the ultimate tensile strength data which showed no significant change with increasing filler loading.

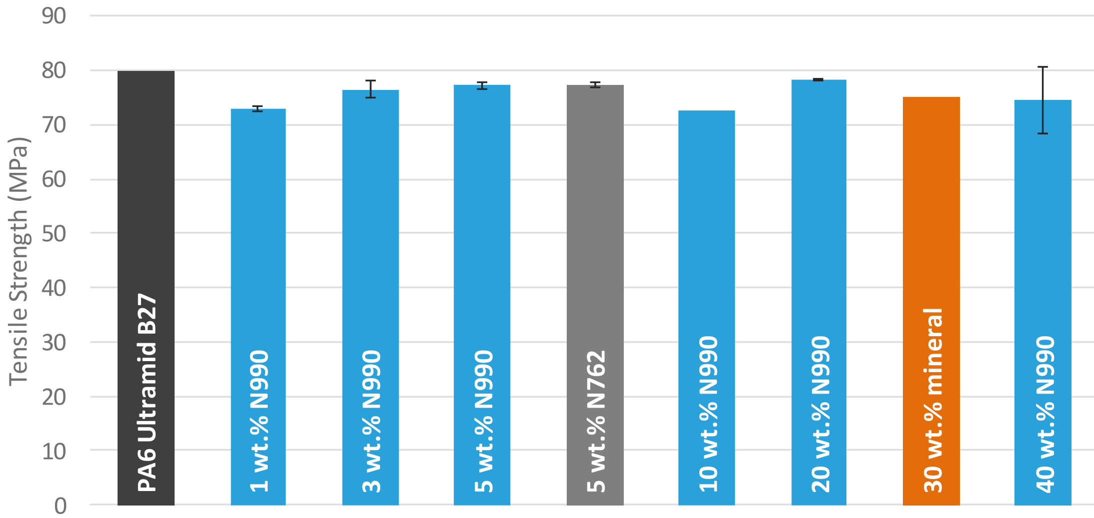

Figure 3. Ultimate tensile strength for polyamide composites. No significant change in tensile strength as filler loading increased.

Figure 4 shows the elongation at break of the materials. Elongation was significantly higher for composites up to 10 wt.% loading; in particular, the composite with 1 wt.% N990 loading exhibited drastically higher elongation than the pristine polymer. Above 10 wt.% loading, the elongation tended to decline with increasing loading.

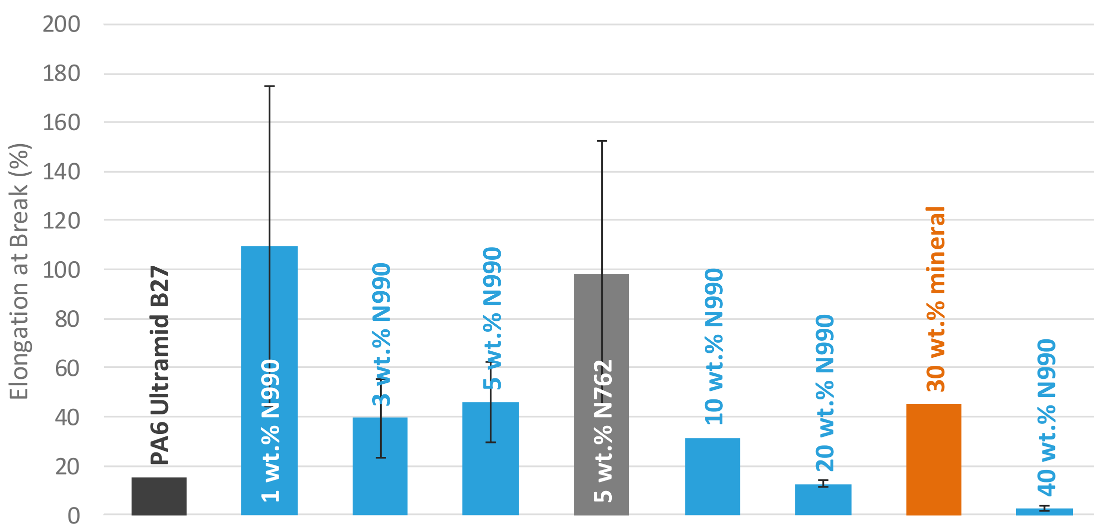

Figure 4. Elongation at break of polyamide composites. Elongation was significantly higher at low N990 loadings. At loading greater than 10 wt.%, elongation tended to be reduced.

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The impact strengths of the materials, shown in Figure 5, were higher for composites with up to 5 wt.% loading and were maintained at levels similar to the pristine polymer at N990 loadings up to 40 wt.%.

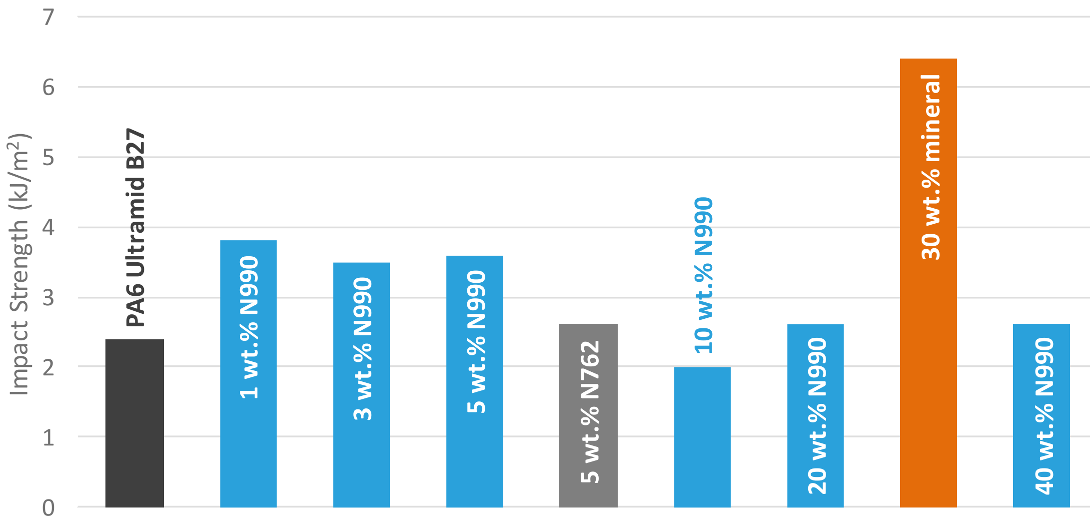

Figure 5. Izod impact strength of polyamide composites. Impact strength was higher for composites with up to 5 wt.% N990 and was maintained for composites with up to 40 wt.% N990.

Figure 6 shows the heat deflection temperatures for the composites which were significantly higher than the pristine polymer at loadings of 3 wt.% and above.

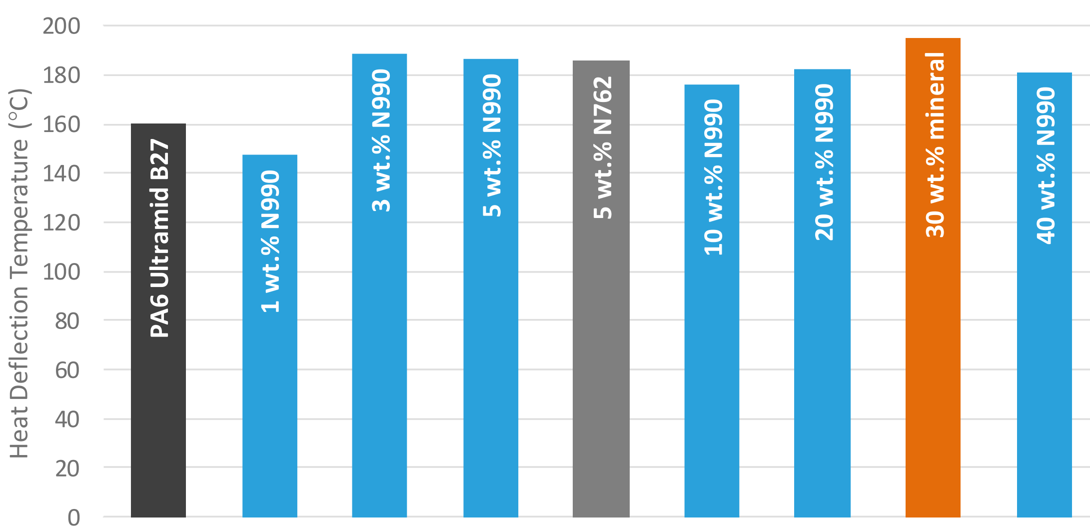

Figure 6. Heat deflection temperature of polyamide composites. At N990 loadings of 3 wt.% and above, heat deflection temperature increased significantly over the pristine polymer.

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 slight blue undertone. With increasing loading, the color tended to lighten up a bit, possibly due to poorer dispersion of the carbon black. The undertone remained consistent as loading increased. At 20 and 40 wt.% N990 loading, the samples had a non-uniform color.

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

Filler Loading	L*	a*	b*
1 wt.% N990	17.5	-0.2	-1.5
3 wt.% N990	20.9	-0.3	-1.4
5 wt.% N990	21.1	-0.4	-1.7
5 wt.% N762	20.6	-0.3	-1.4
20 wt.% N990	27.0	-0.5	-2.1
40 wt.% N990	32.2	-0.8	-3.1

Figure 7 shows the potential weight savings from using N990, with a specific gravity of 1.8 g/cm^3, instead of mineral filler, with a specific gravity of 2.6 g/cm^3. At high loadings, the density of the composite loaded with N990 is about 10% less than the one loaded with mineral filler.

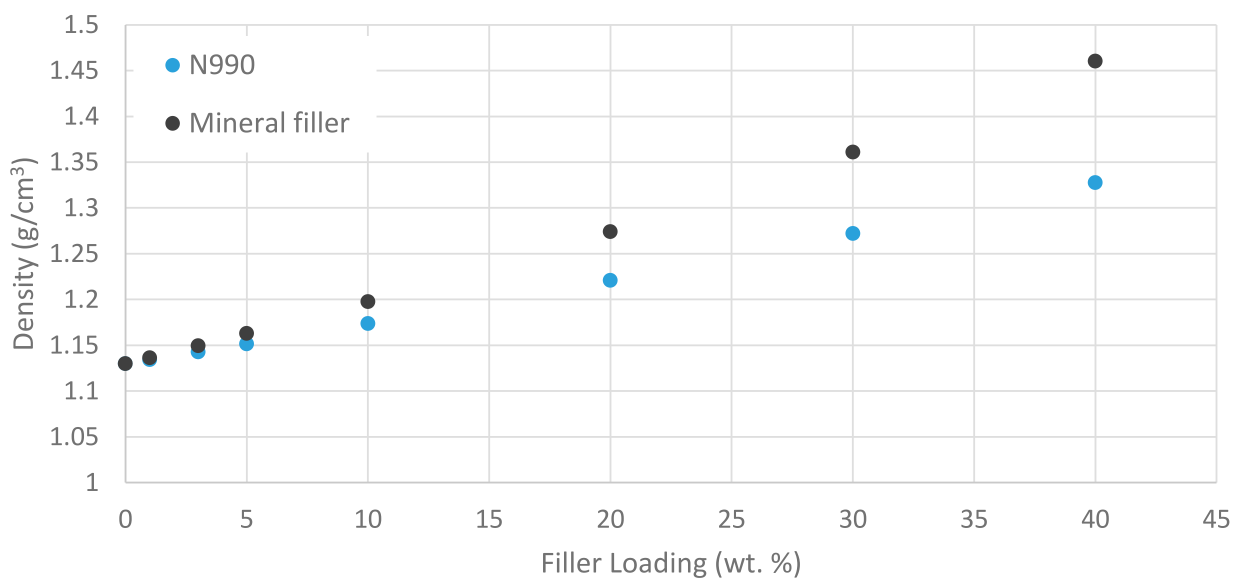

Figure 7. Density of polyamide composites as a function of filler loading. At high loadings, weight savings of greater than 10% can be realized by using N990 over mineral fillers.