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TOKAI CARBON GROUP

Tire Bead Insulation

The effects of replacing N660 with N990 on the properties of SBR tire bead insulation compounds were evaluated in this study. These compounds encapsulate the bead wires forming the bead core. Good adhesion is required between the bead insulation compound and bead wire to provide the tire with durability.

The benefits of N990 found in the study were:

- **>65% reduction** in dynamic compression set
- **>25% improvement** in hot pull-out force adhesion
- Up to 10% reduction in mixing energy consumption while improving the filler dispersion rating. Potential for shorter mixing times and increased daily mixing capacity.
- Up to 10% reduction in low strain dynamic elastic modulus (Payne Effect)
- Improvement in ultimate elongation
- Slight reductions in MDR and Mooney viscosity measurements
- Slight increase in scorch resistance
- **Up to 25% decrease** in dynamic compression heat build-up

The bead insulation compound test formulations are provided in Table 1. The N660 was replaced with N990 at 10%, 30%, and 50% levels at a 2:1 ratio to maintain a Shore A hardness of 80±5. Mooney, MDR, RPA, hardness, tensile, compression set, rebound, dynamic properties, adhesion, and dispersion were collected for each compound. The compounding and testing were performed by Smithers Rapra, Inc. in Akron, OH.

Table 1. Test Formulations

Ingredient	Control	A	B	C
SBR 1500	100	100	100	100
N660	100	90	70	50
N990	-	20	60	100
Naphthenic Process Oil	10	10	10	10
Zinc Oxide	4.0	4.0	4.0	4.0
Stearic Acid	1.5	1.5	1.5	1.5
SP-1068	2.5	2.5	2.5	2.5
6PPD	1.5	1.5	1.5	1.5
TMQ	1.0	1.0	1.0	1.0
DCBS	1.75	1.75	1.75	1.75
Crystex HD OT 20	6.0	6.0	6.0	6.0
Retarder CTP	0.2	0.2	0.2	0.2
Total	**228.5**	**238.5**	**258.5**	**278.5**

Detailed compound test results are provided in the figures and tables on the following pages.

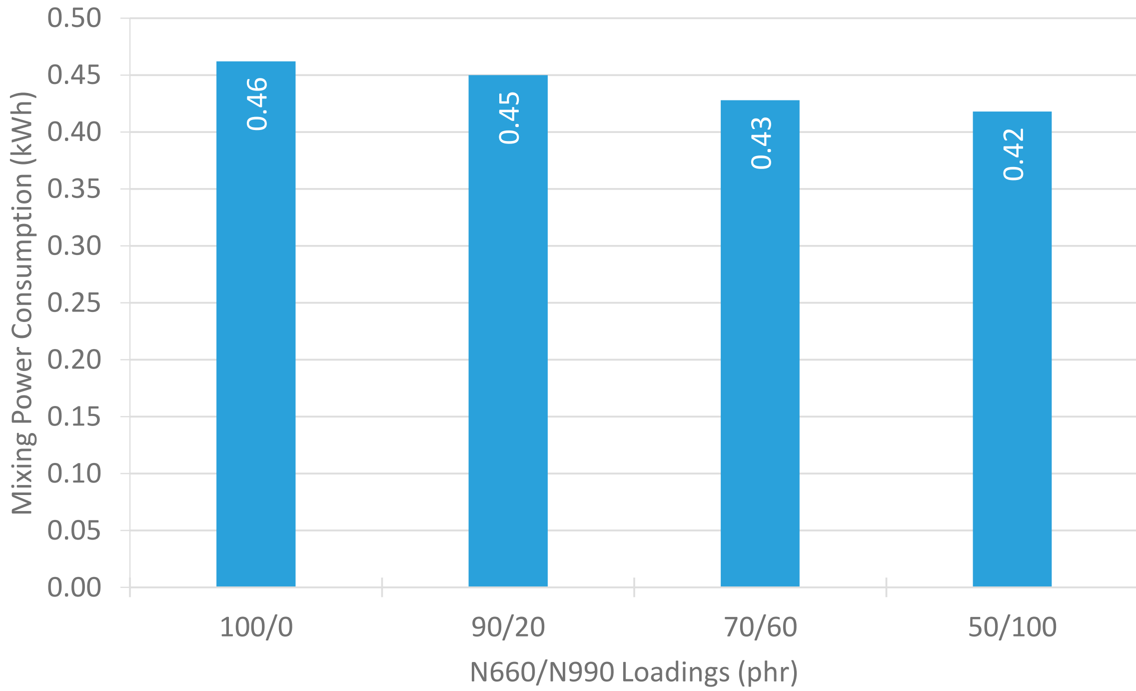

Figure 1. Mixing power consumption for each compound. Mixing power consumption decreased as N990 loading was increased, up to a 10% reduction at 50% replacement level.

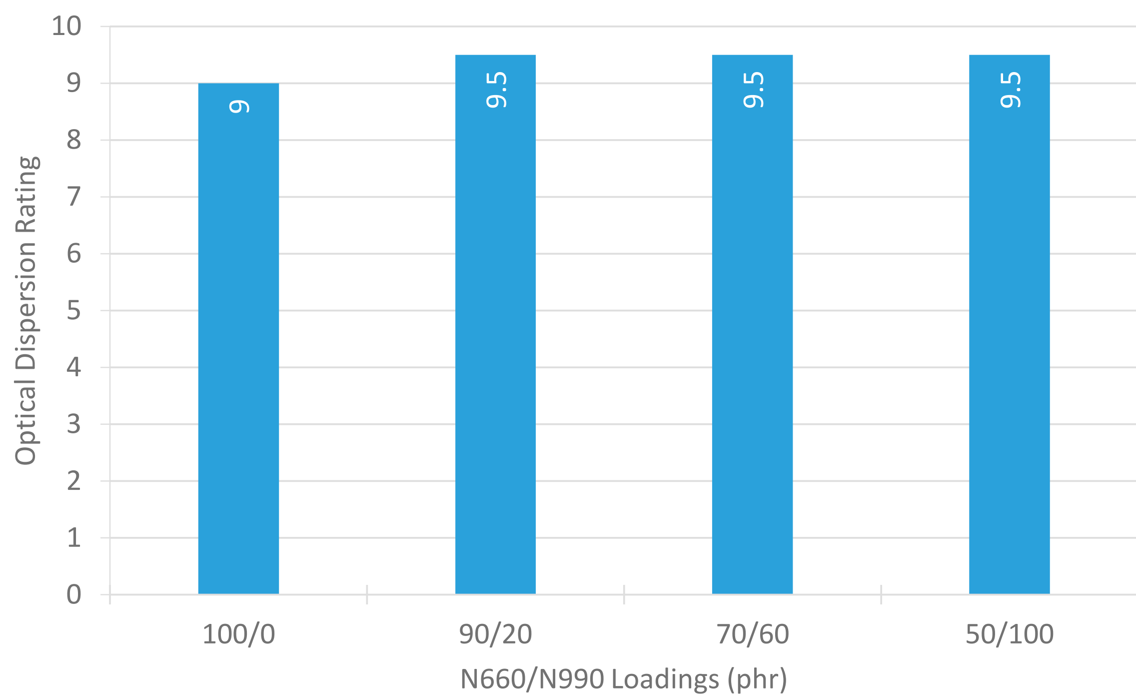

Figure 2. Optical dispersion rating for each compound. Uniform filler dispersion was achieved for all compounds. The N990 compounds had slightly better dispersion ratings than the control.

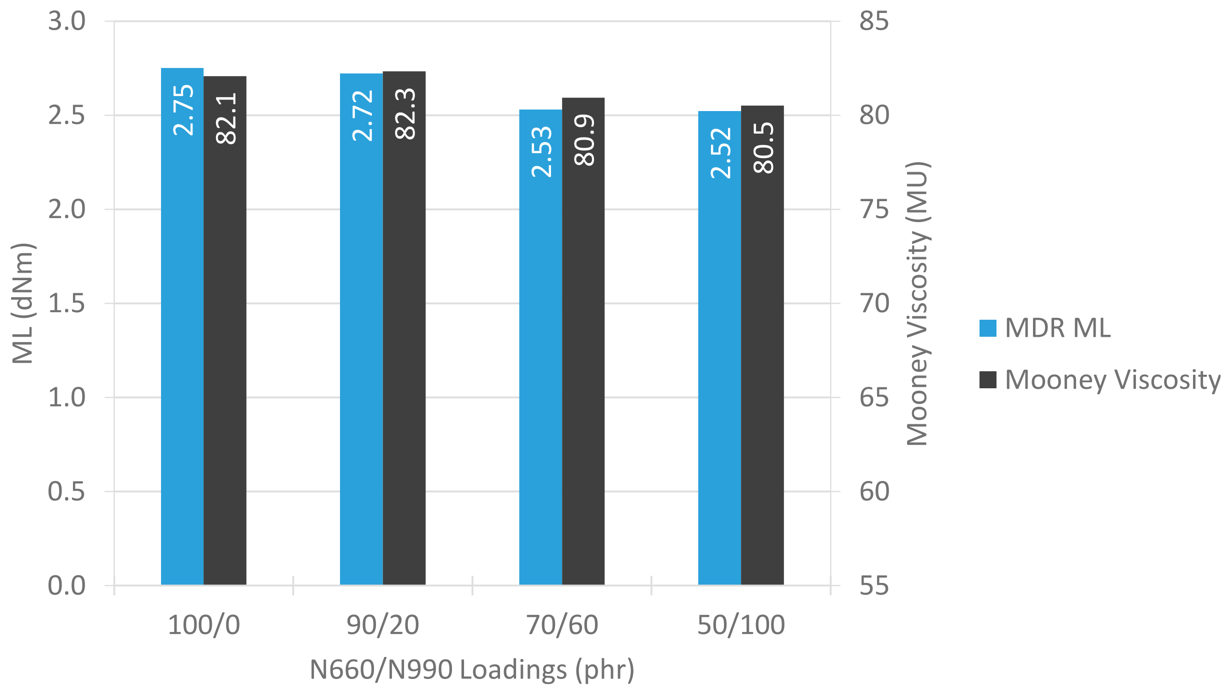

Figure 3. MDR ML and Mooney viscosity for all compounds. Slight reductions in compound viscosity were observed at high N990 replacement levels.

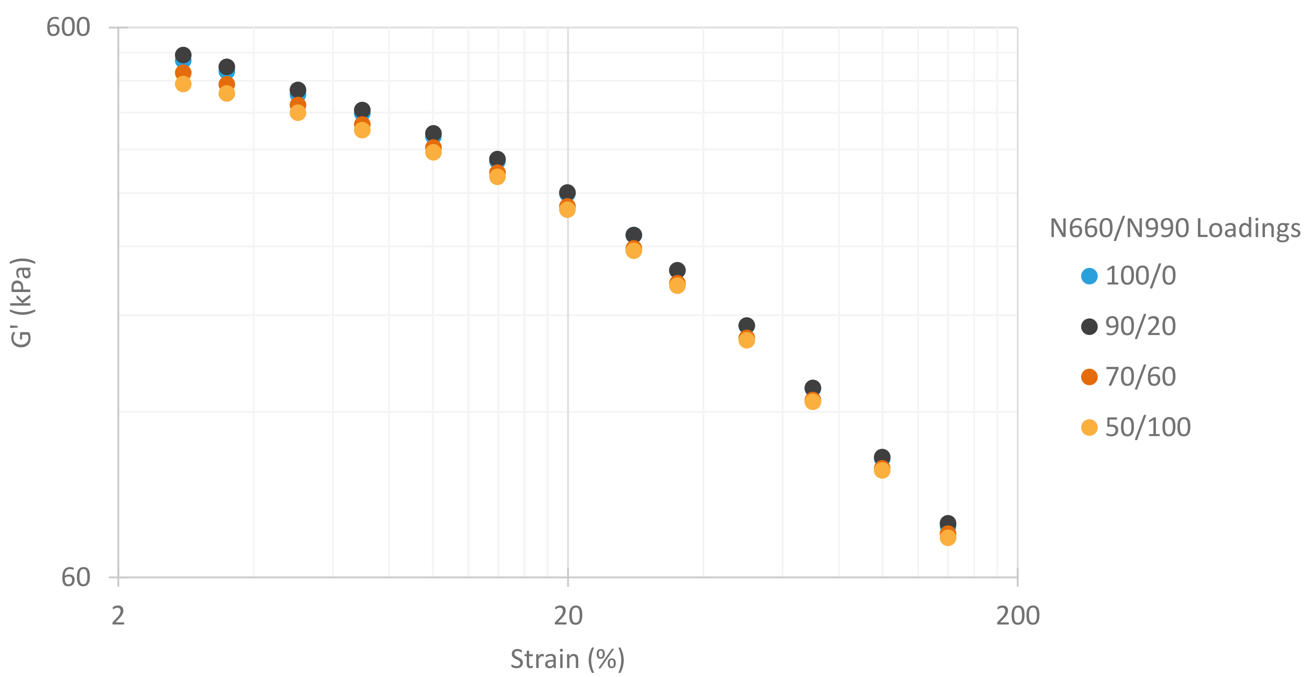

Figure 4. G' versus strain amplitude (Payne effect) for all compounds. At high replacement levels, low strain modulus was reduced by 10% and large strain modulus was reduced by 5%.

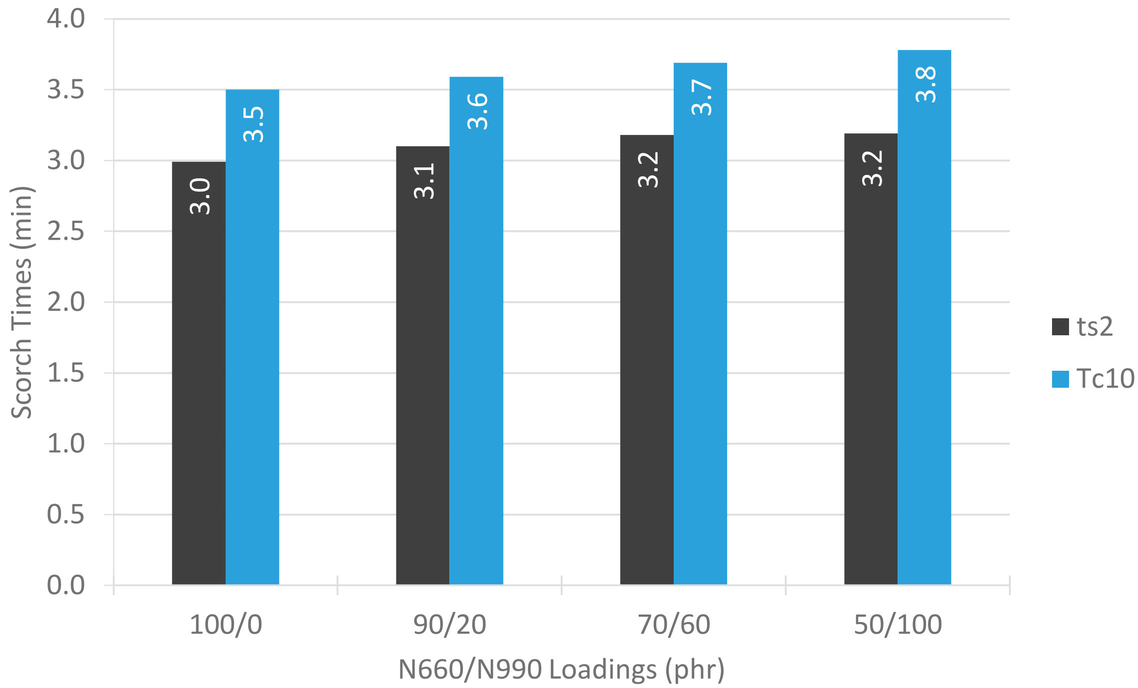

Figure 5. Scorch times, ts2 and Tc10, for all compounds. Scorch times tended to increase slightly as N990 loading was increased.

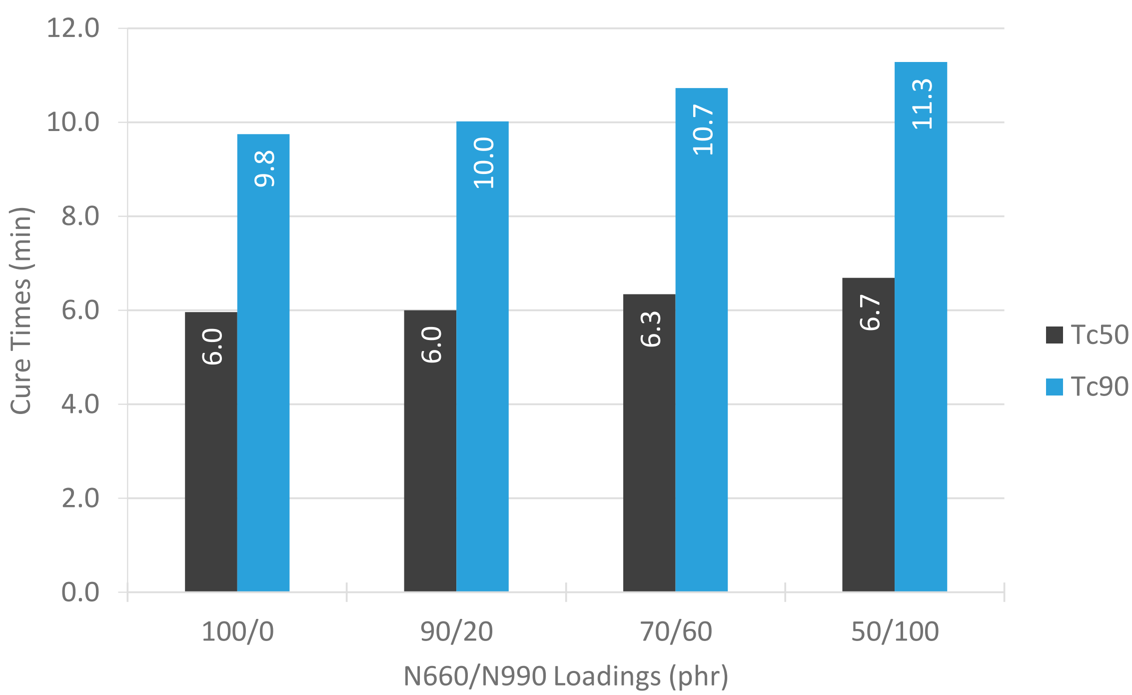

Figure 6. Cure times, Tc50 and Tc90, for all compounds. Cure times tended to increase slightly as N990 loading was increased.

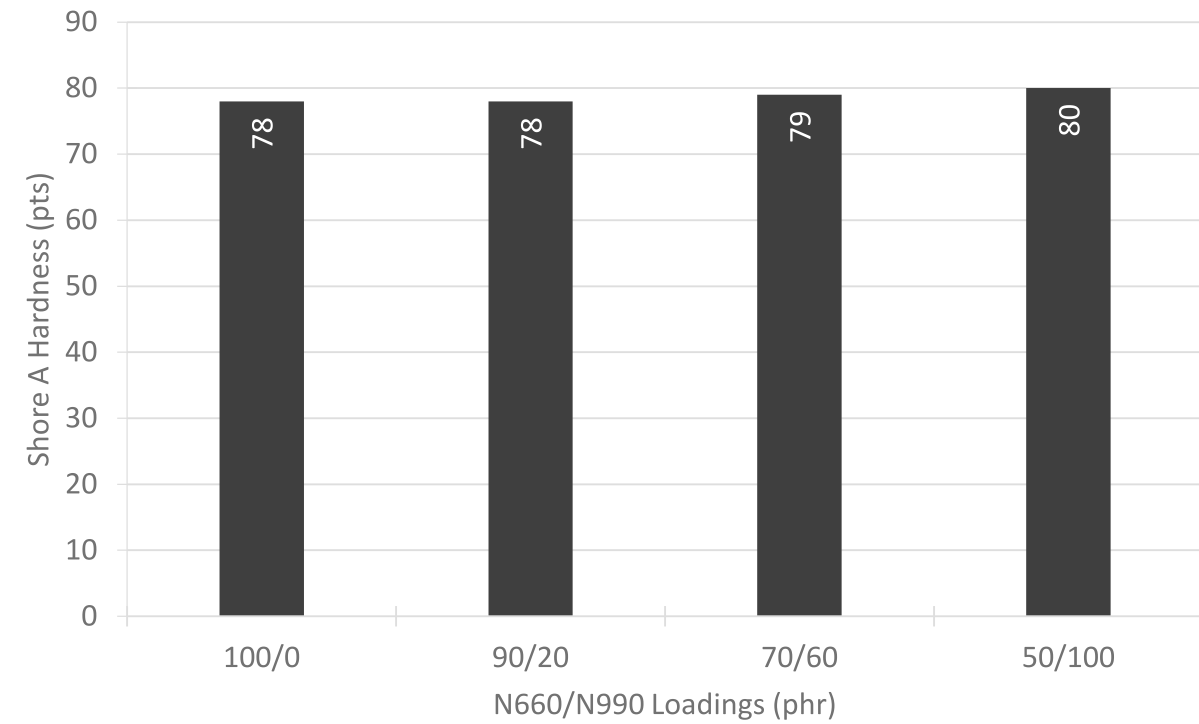

Figure 7. Shore A hardness for all compounds. All compounds were 80±5 Shore A.

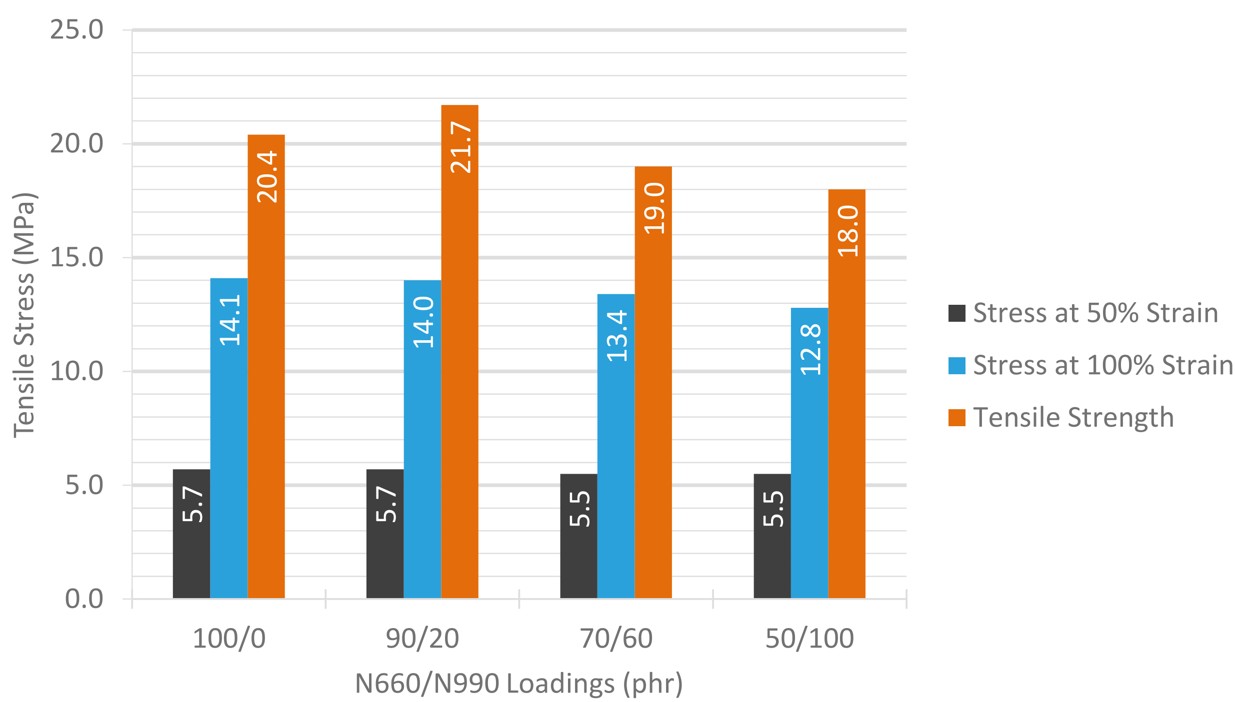

Figure 8. Tensile stress and strength for all compounds. No significant difference in stress at 50% strain was recorded. Stress at 100% strain and tensile strength decreased slightly at high N990 replacement levels. The compound with a 10% replacement level had a higher tensile strength than the control compound.

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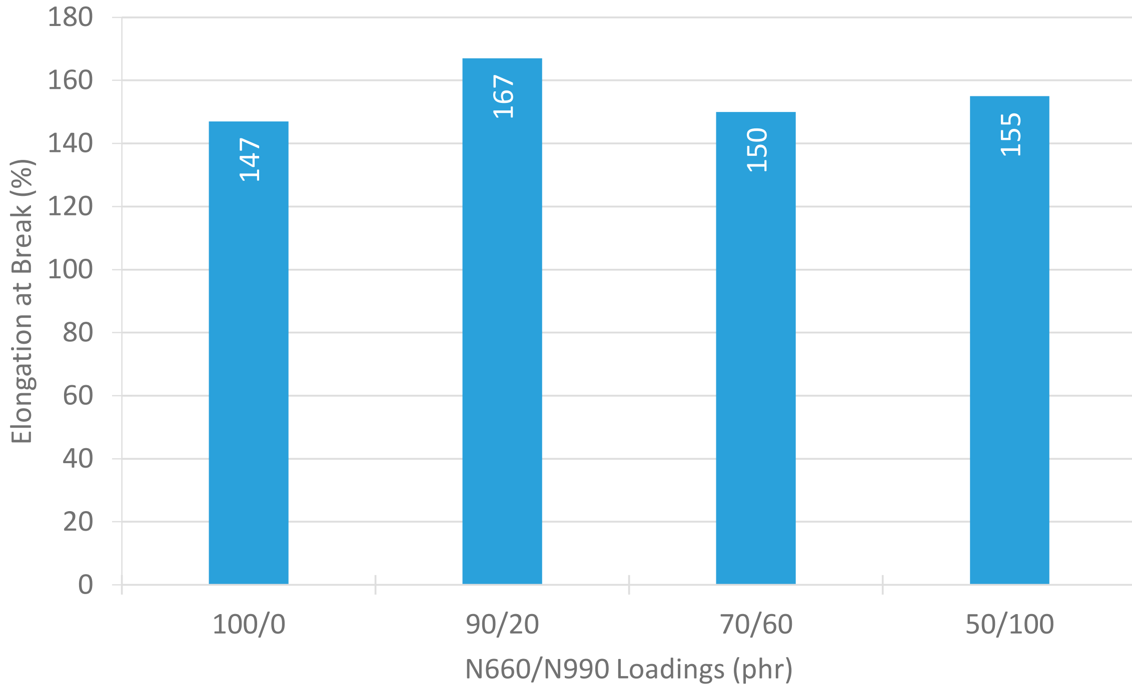

Figure 9. Elongation at break for all compounds. The compound with a 10% replacement level had a significantly higher elongation than the control compound, possibly due to the improvement in dispersion noted earlier.

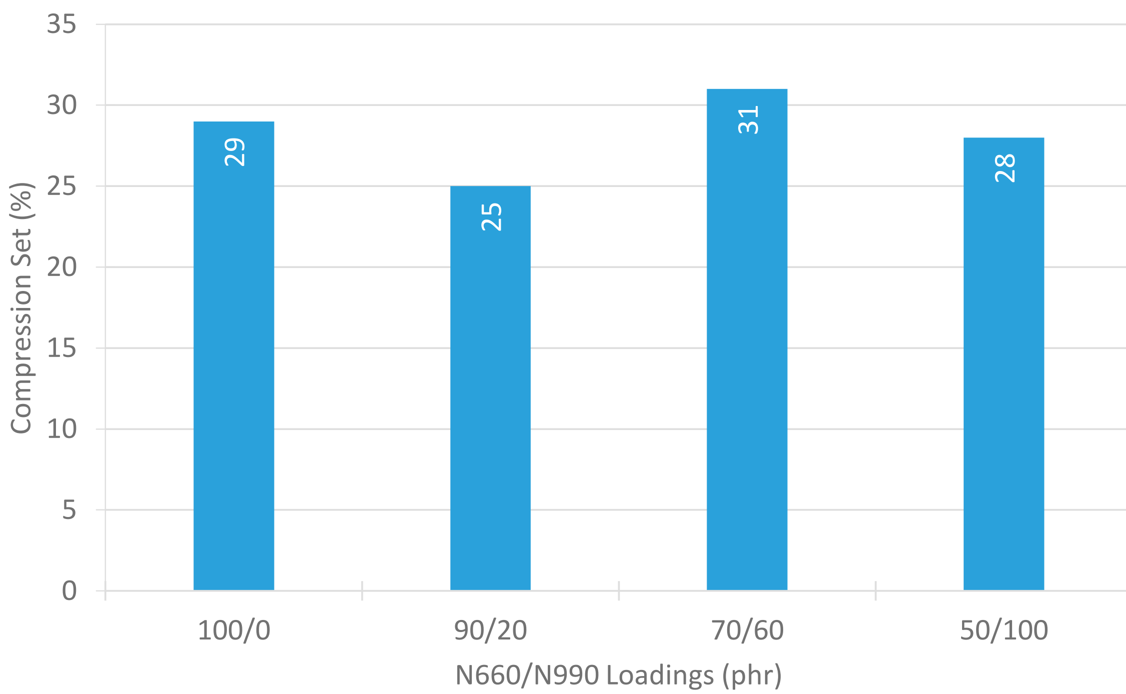

Figure 10. Compression set for all compounds. The compound with a 10% replacement level exhibited the lowest compression set.

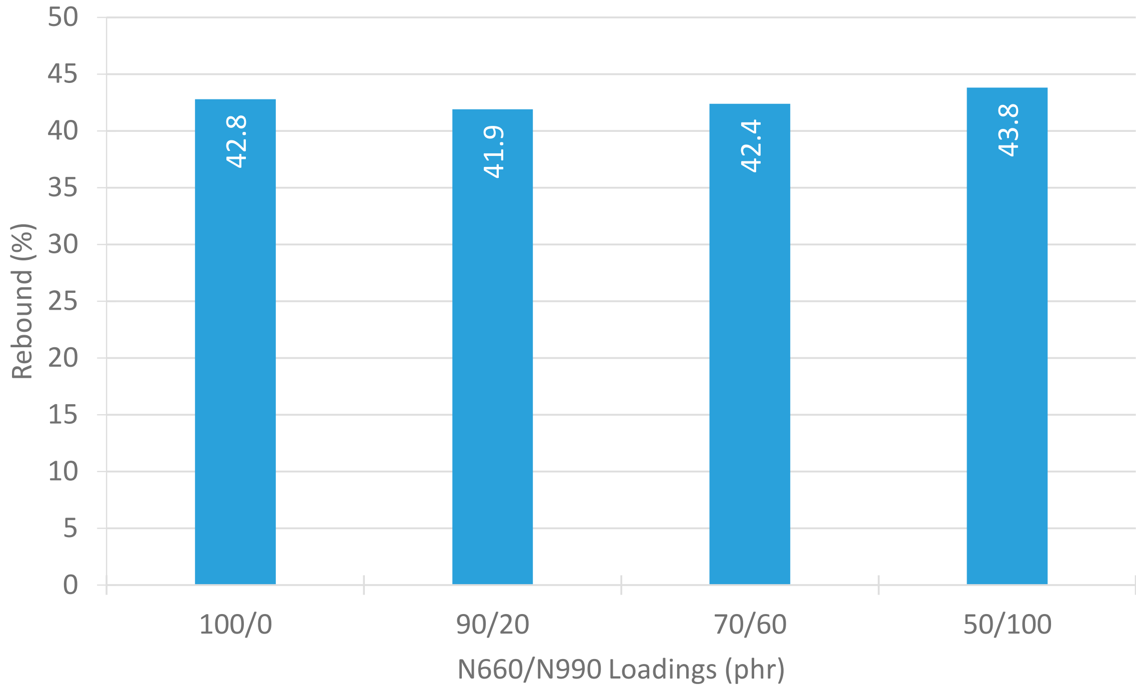

Figure 11. Rebound for all compounds. The compound with the highest replacement level had the highest rebound with no significant differences between the other compounds.

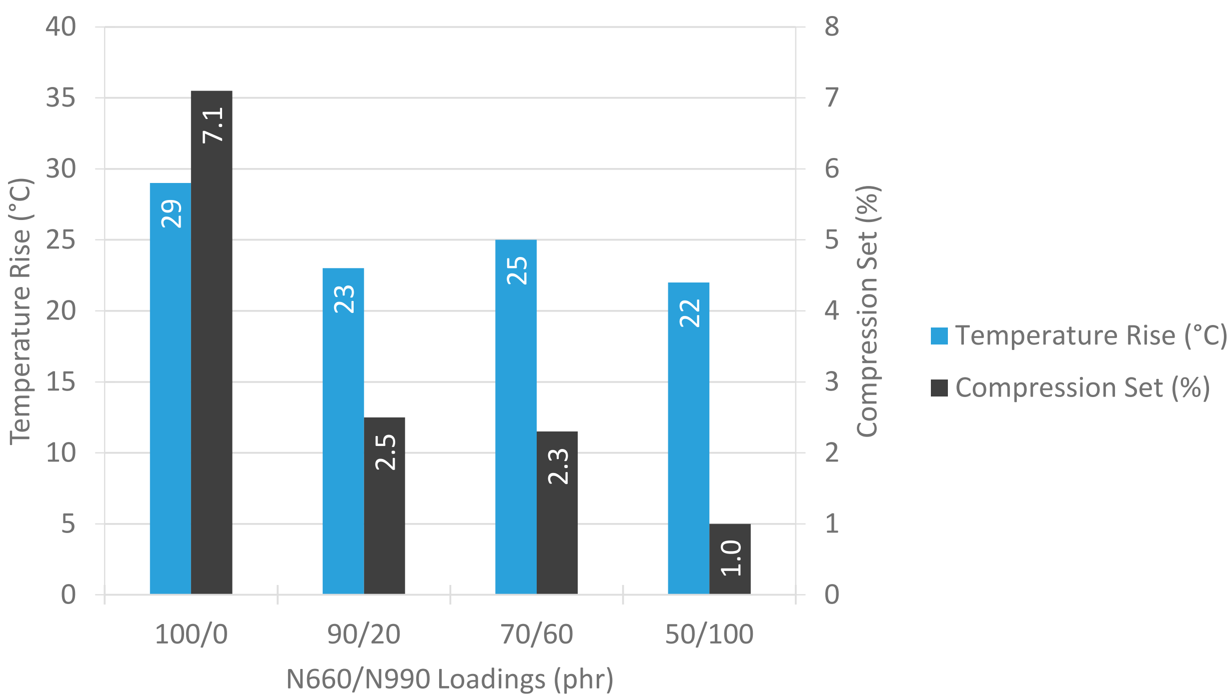

Figure 12. Goodrich flexometer results for all compounds. Temperature rise was moderately reduced and percent set was significantly reduced after dynamic compression flexing as N990 loading was increased. Even at a low replacement level of 10%, temperature rise was reduced 20% and set was reduced 65%.

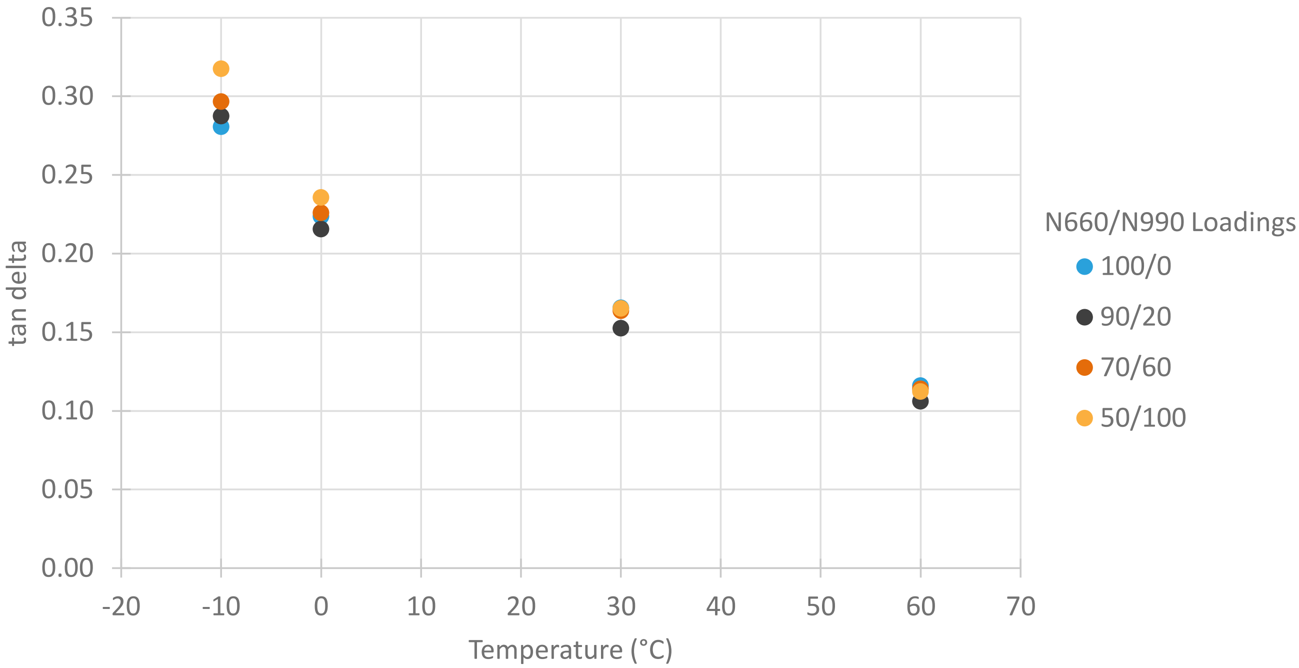

Figure 13. Tan delta as a function of temperature for all compounds. Tan delta tended to increase at low temperature (-10°C and 0°C) as N990 loading was increased. At 30°C and 60°C, there were no significant differences.

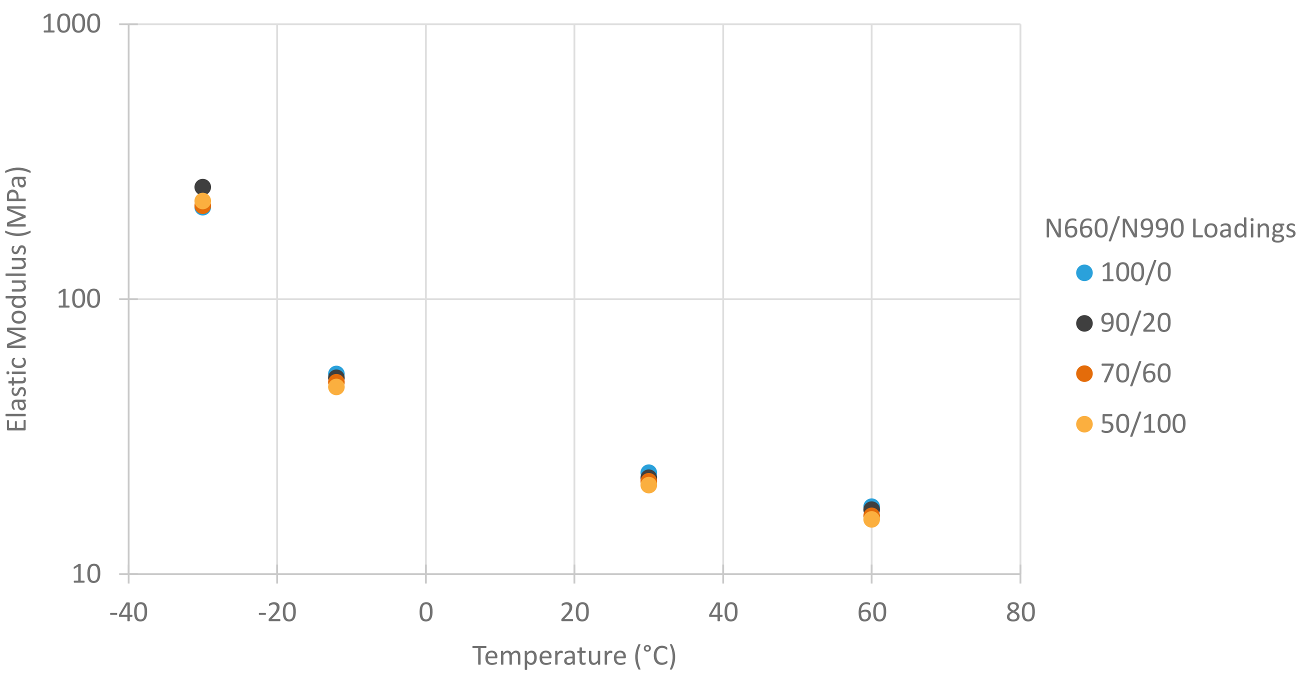

Figure 14. Elastic modulus as a function of temperature for all compounds. At temperatures of -12°C, 30°C, and 60°C, modulus tended to decrease slightly as N990 loading was increased.

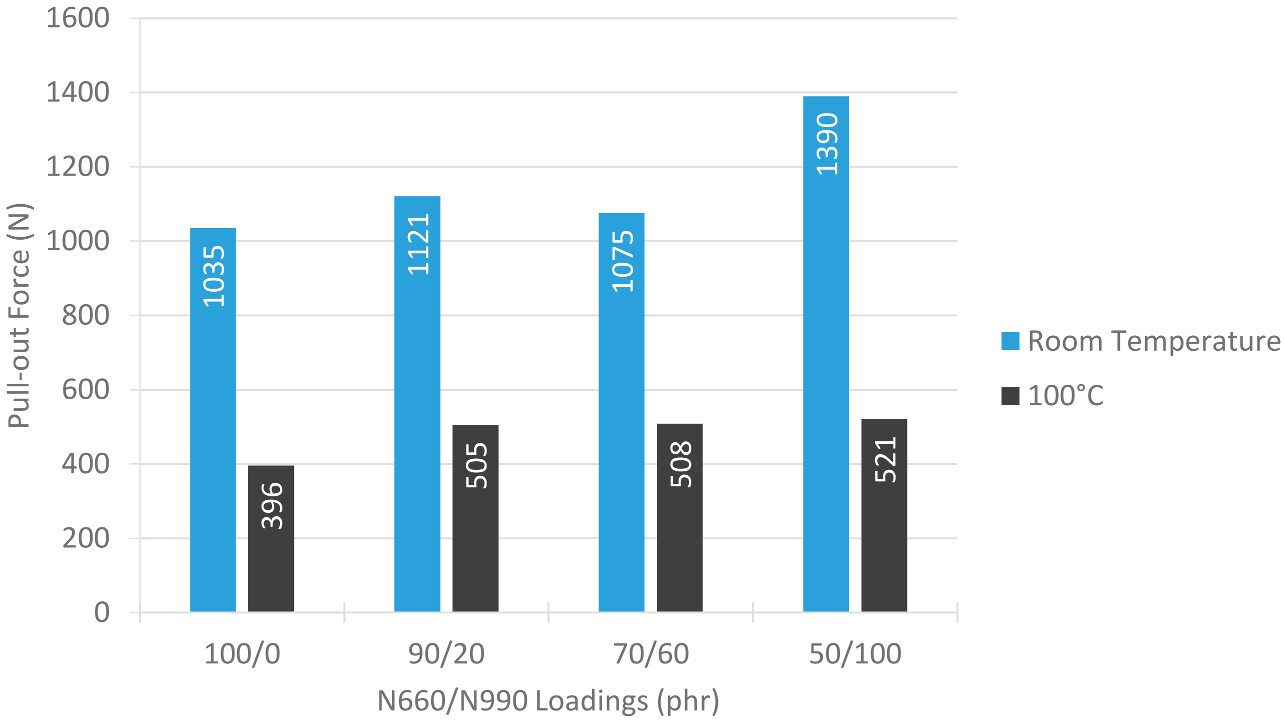

Figure 15. Room temperature and hot wire adhesion for all compounds. The compound containing 100 phr of N990 and 50 phr of N660 had the highest room temperature pull-out force with no significant difference between the other compounds. At 100°C, all the N990 containing compounds exhibited >25% higher pull-out forces than the control compound.