Butyl Rubber Tire Curing Bladder

In this study, the effects of replacing N330 with N990 and replacing castor oil with Münch Chemie additive INT-159/5 on the properties of butyl curing bladder compounds were evaluated. These compounds are essentially sealed flexible rubber bags which are inflated inside of uncured tires during the vulcanization process. The repeated cycles of inflation/deflation at curing temperatures necessitate the use of a compound with good steam, heat, flex, and tear resistance. The compound should also have excellent processing qualities, adequate physical properties, and good thermal conductivity.

The benefits of N990 found in the study were:

- Significant reduction in viscosity
- Increase in scorch safety
- Improved heat resistance
- Increase in thermal conductivity
- Decrease in permeability
- Reduction in compound cost due to higher filler loading

The butyl compound test formulations are provided in Table 1. The N330 was replaced with N990 at a 3.0:1.0 ratio to maintain a Shore A hardness of 60±5. The castor oil was replaced with INT-159/5 at a 0.5:1.0 ratio. Mooney, MDR, tensile, tensile set, tear, thermal conductivity, heat-aging, steam-aging, and gas permeability properties were collected for each compound. Compounding and testing were performed at Akron Rubber Development Laboratories (ARDL).

Table 1. Test Formulations

Ingredient	Control	N990	N990/INT
X_Butyl RB 301	100	100	100
Neoprene W	5	5	5
N330	50	30	30
Thermax® N990	**-**	**60**	**60**
Castor Oil	5	5	1
INT-159/5	-	-	2
Resin SP-1045	10	10	10
Kadoz 920C	5	5	5
Total	**175**	**215**	**213**

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

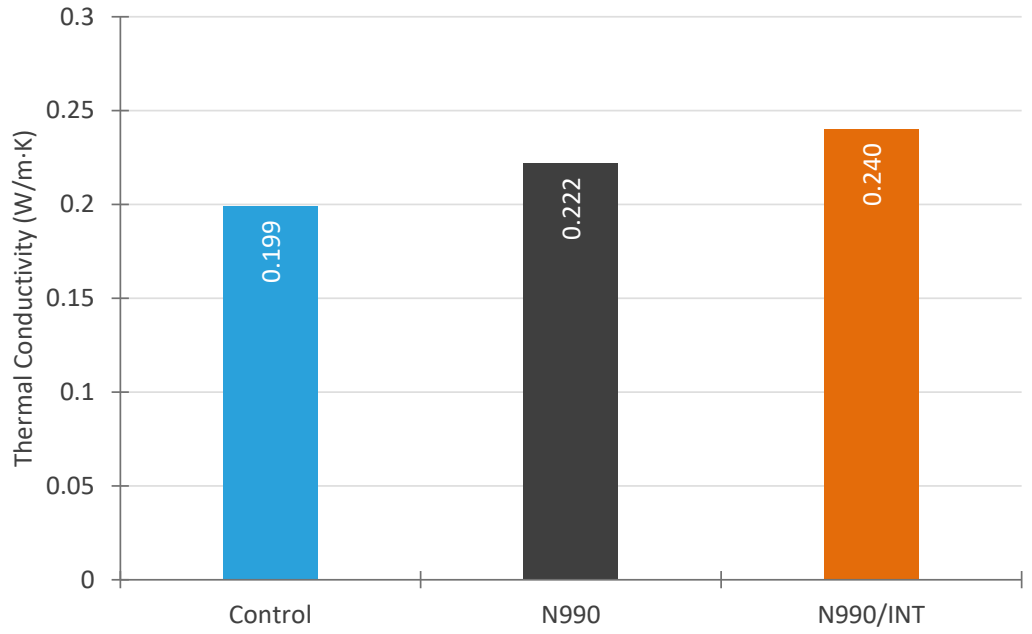

Figure 1. Thermal conductivity of the compounds. Thermal conductivity increased significantly when N990 replaced N330.

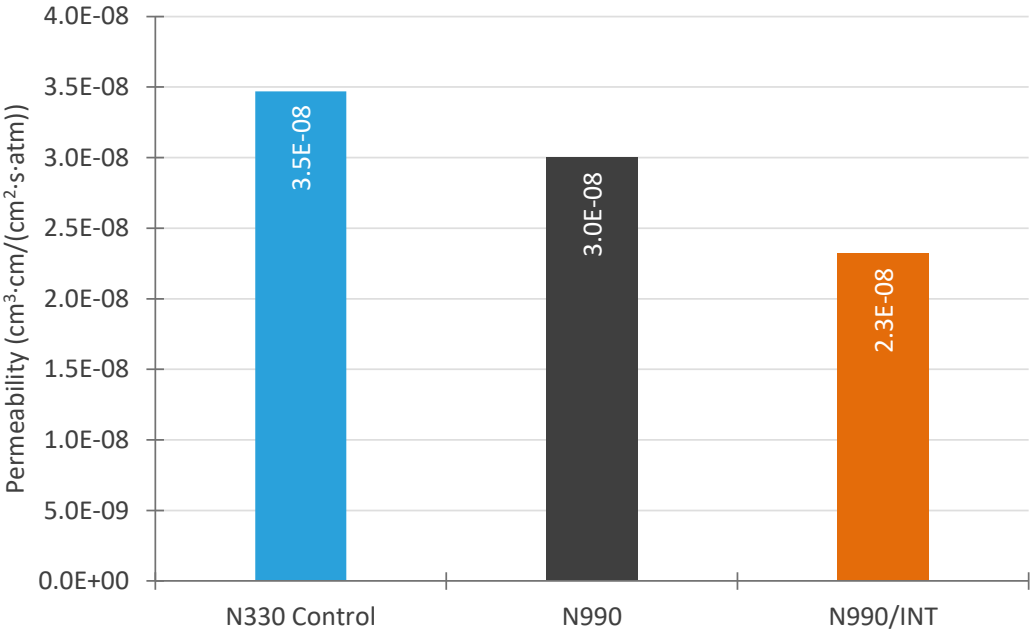

Figure 2. Permeability of the compounds. Permeability decreased when N990 replaced N330.

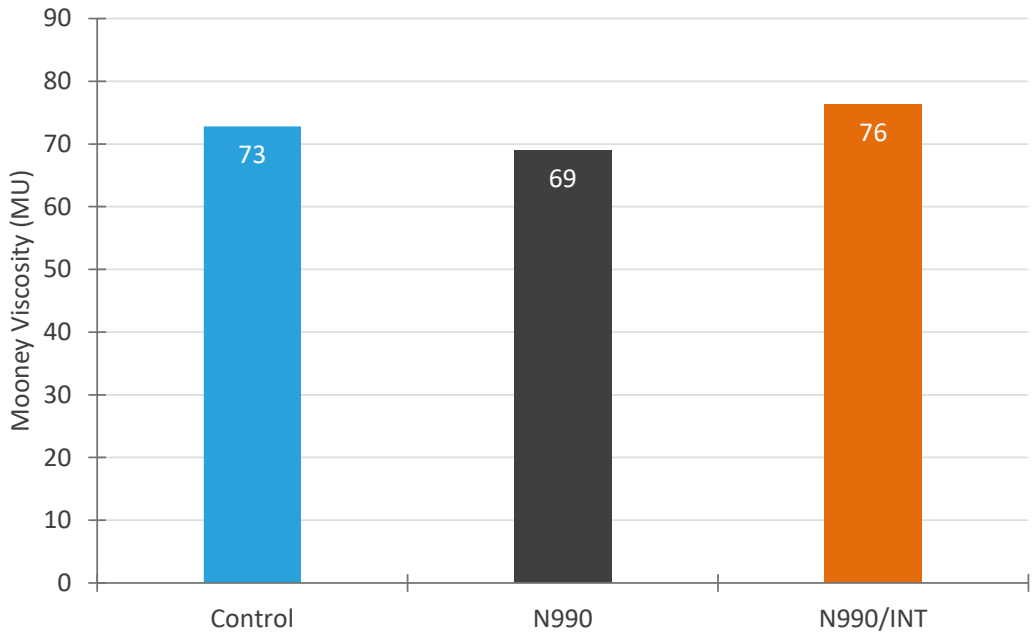

Figure 3. Mooney viscosity of the compounds measured at 100°C. The viscosity decreased when N330 was replaced with N990. Replacing castor oil with INT-159/5 led to an increase in viscosity.

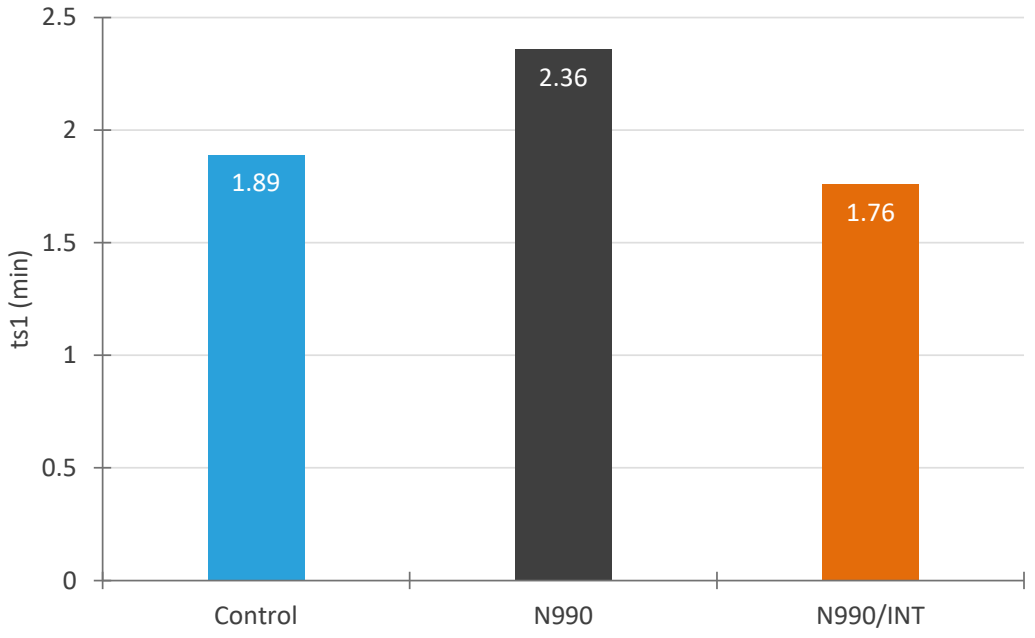

Figure 4. Scorch time of the compounds measured at 177°C. The scorch time increased when N330 was replaced with N990. Replacing castor oil with INT-159/5 led to a decrease in scorch time.

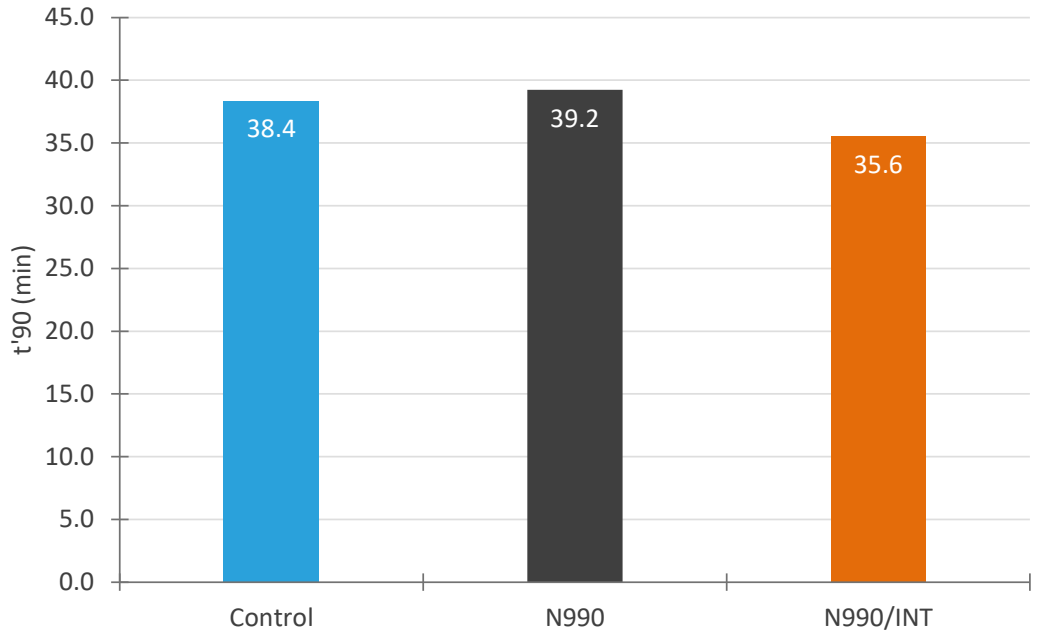

Figure 5. Cure time of the compounds measured at 177C. Cure time was slightly faster for the compound with INT-159/5.

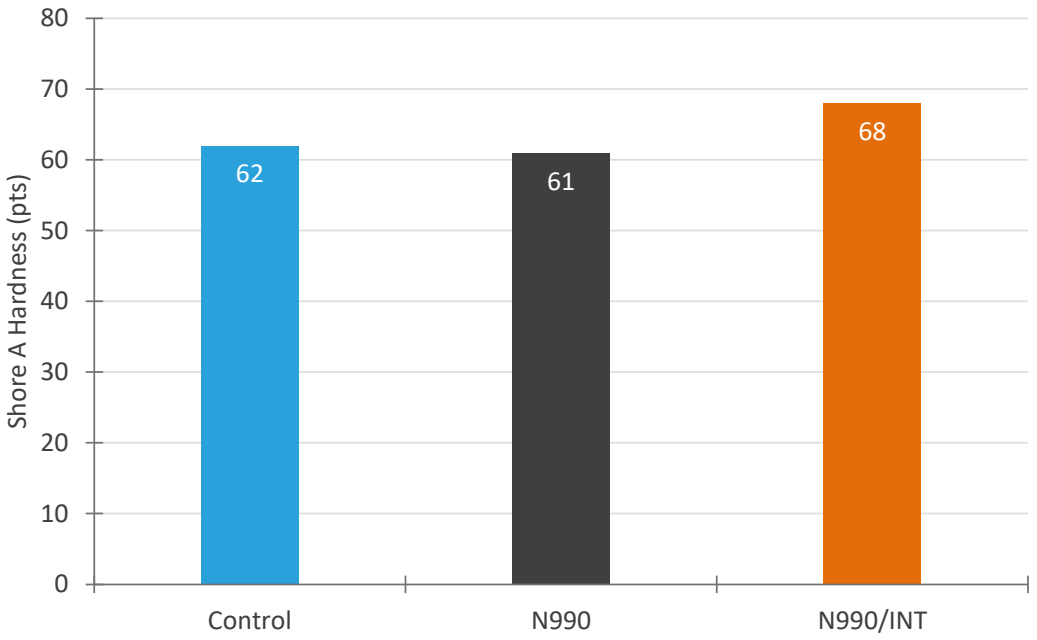

Figure 6. Shore A hardness of the compounds. Hardness was 60±5 for the control and N990 compounds. The addition of INT-159/5 significantly increased the durometer.

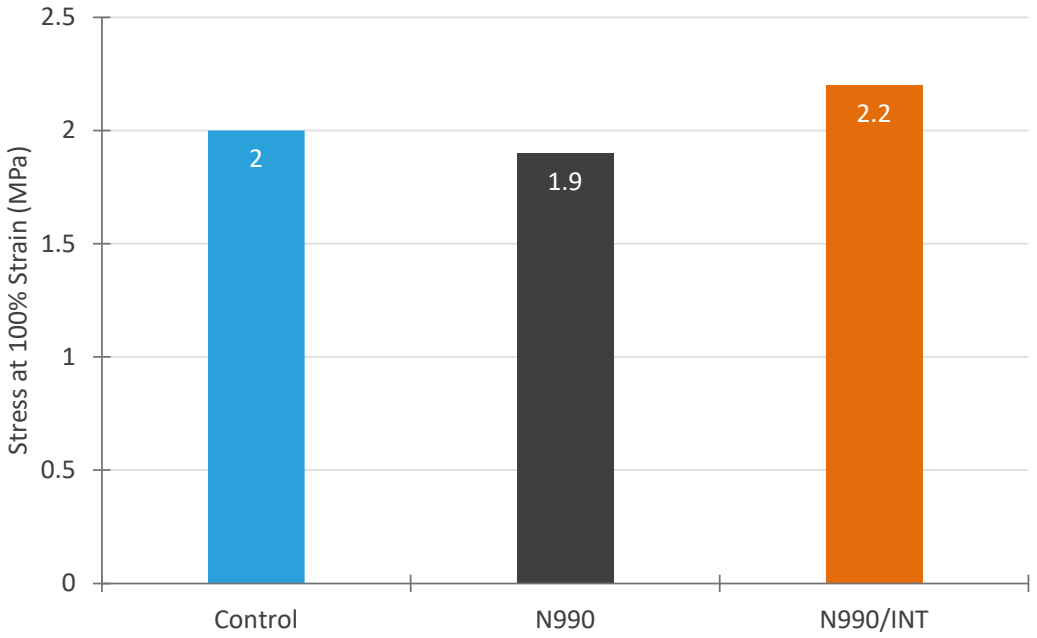

Figure 7. Stress at 100% strain of the compounds. Replacing N330 with N990 led to a slight decrease in 100% modulus. The 100% modulus increased slightly when castor oil was replaced with INT-159/5.

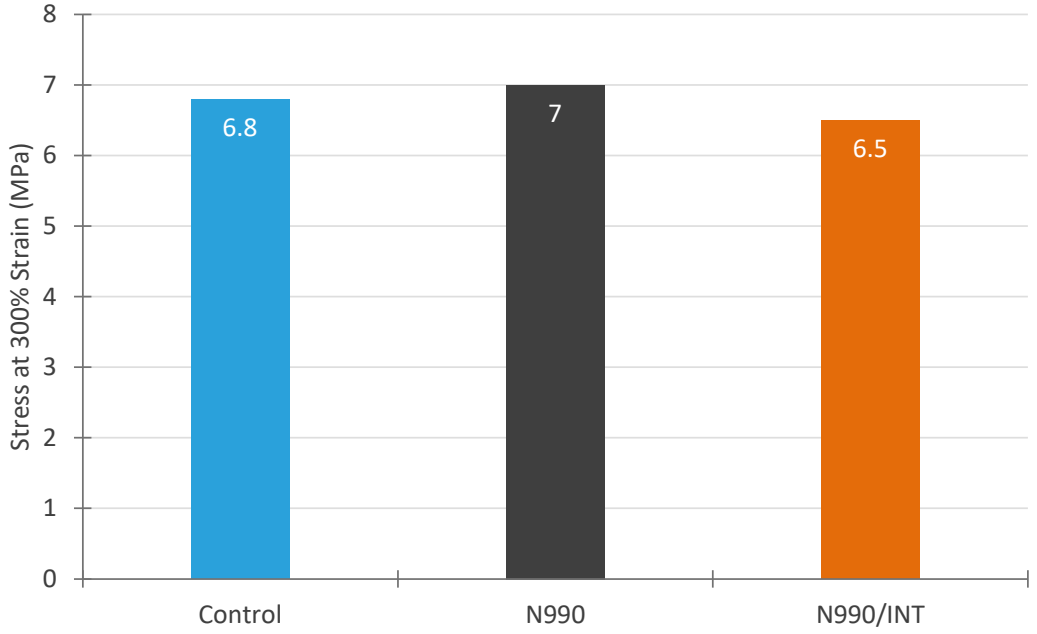

Figure 8. Stress at 300% strain of the compounds. There was a slight increase in 300% modulus when N330 was replaced with N990. Replacing castor oil with INT-159/5 led to a small decrease in 300% modulus.

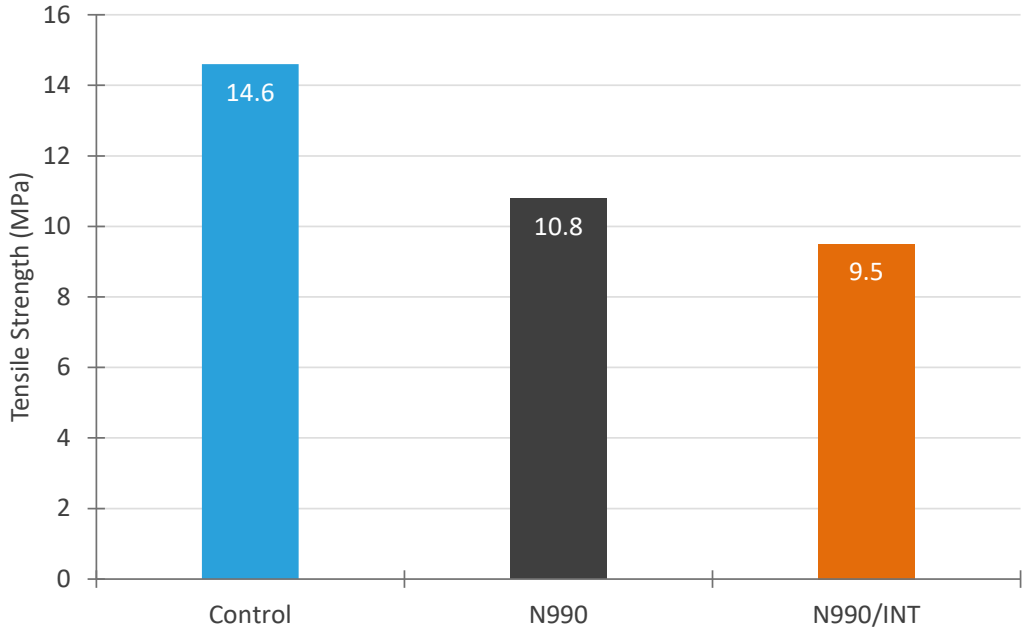

Figure 9. Tensile strength of the compounds. Tensile strength declined when N990 replaced N330 and when INT-159/5 replaced castor oil.

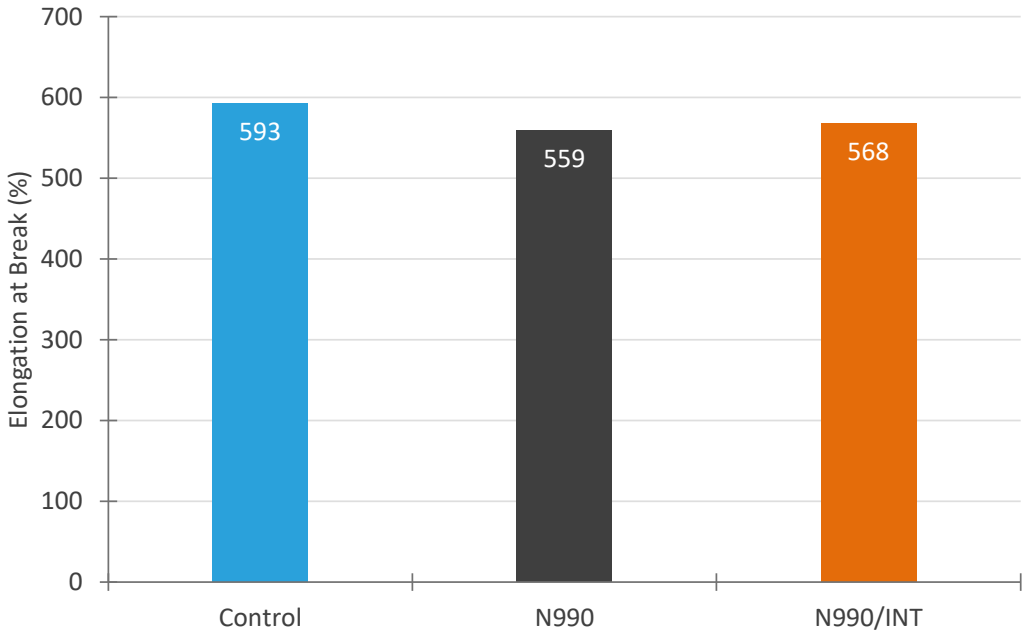

Figure 10. Elongation at break of the compounds. There were no significant differences in elongation of the compounds.

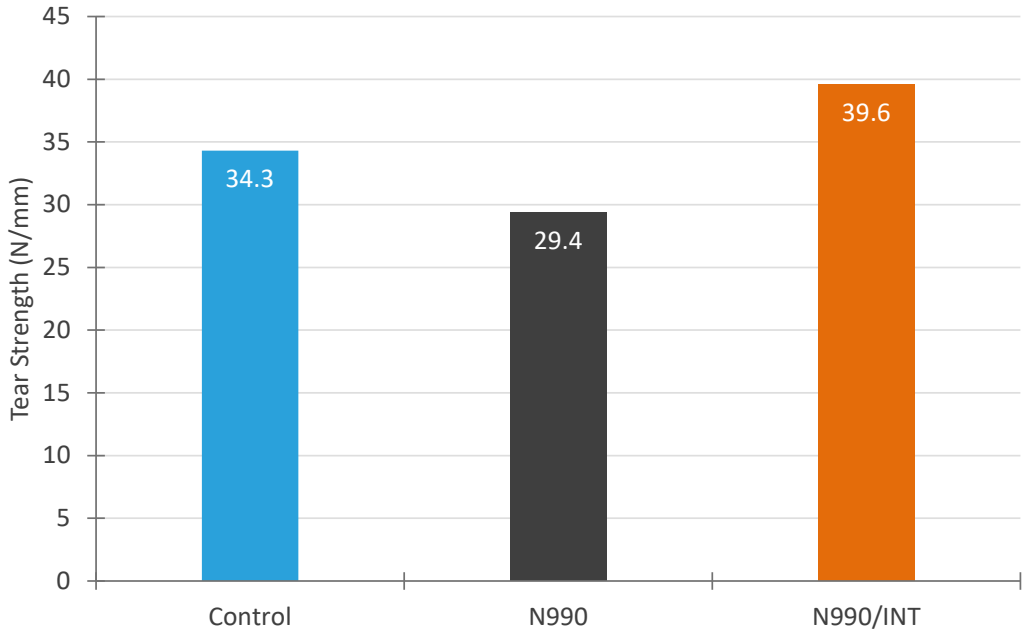

Figure 11. Tear strength of the compounds. Tear strength decreased when N330 was replaced with N990. The tear strength increased when castor oil was replaced with INT-159/5.

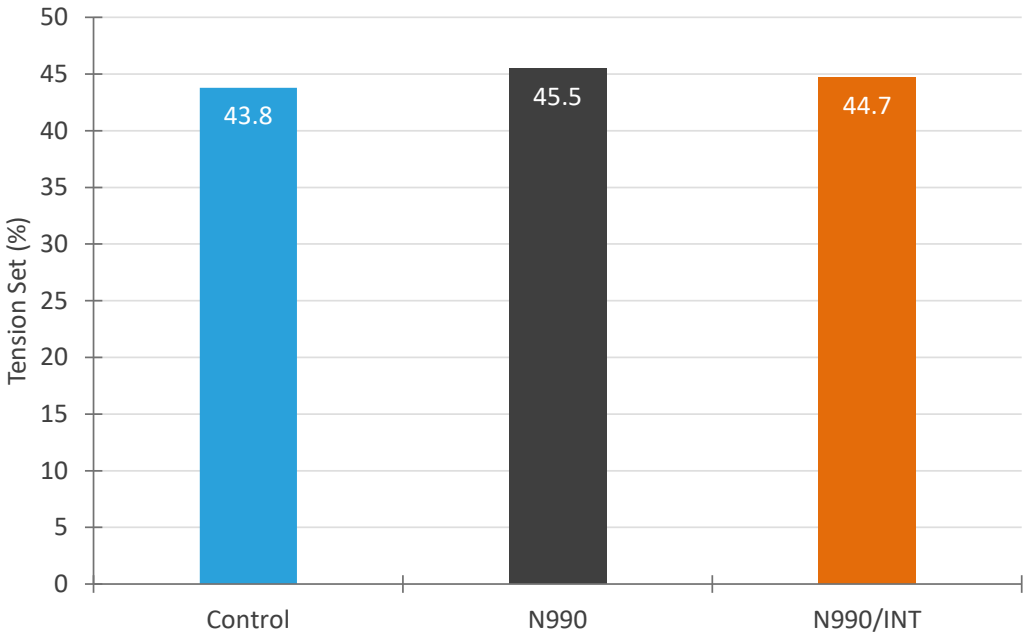

Figure 12. Tension set of the compounds after 24 hours at 180°C. There were no significant differences in the tension set of the compounds.

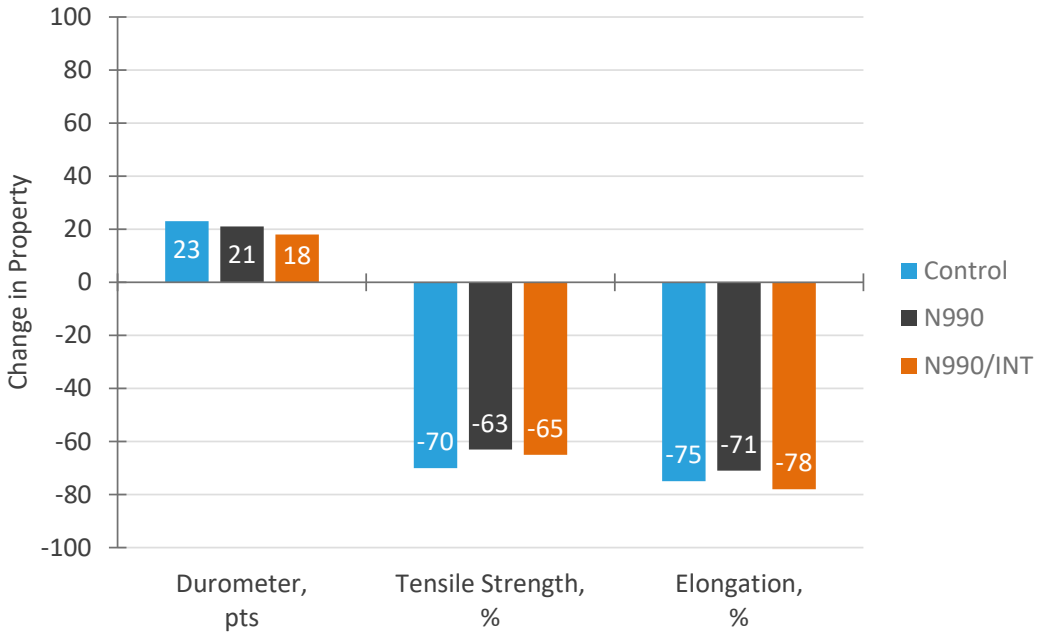

Figure 13. Change in physical properties after heat aging 96 hours at 180°C in air. Replacing N330 with N990 improved the heat resistance of the compound.

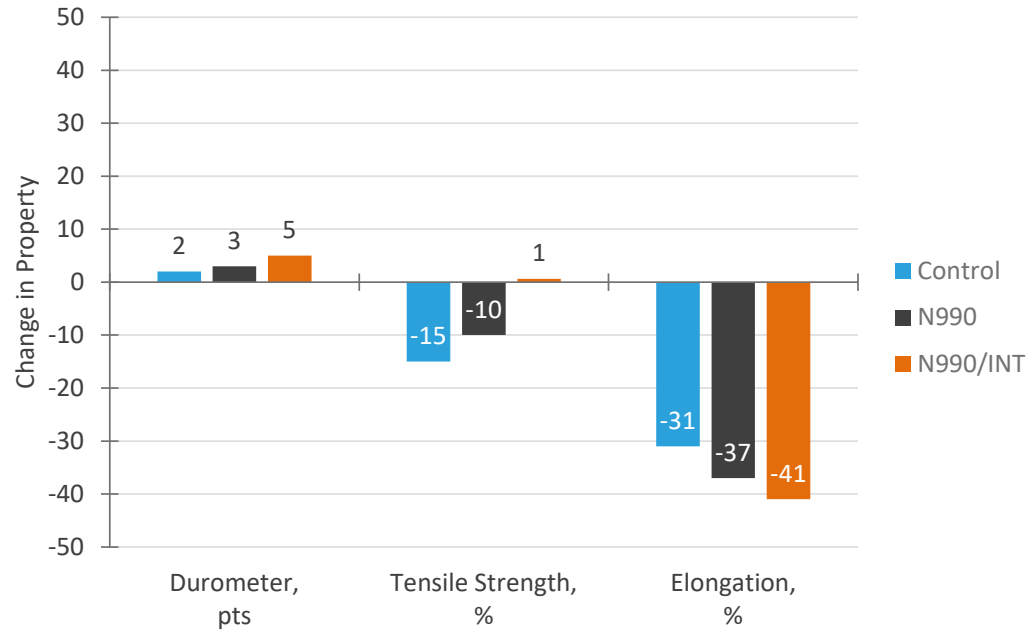

Figure 14. Change in physical properties after steam aging 96 hours at 190°C. Replacing N330 with N990 led to improved tensile strength retention but worse elongation retention.

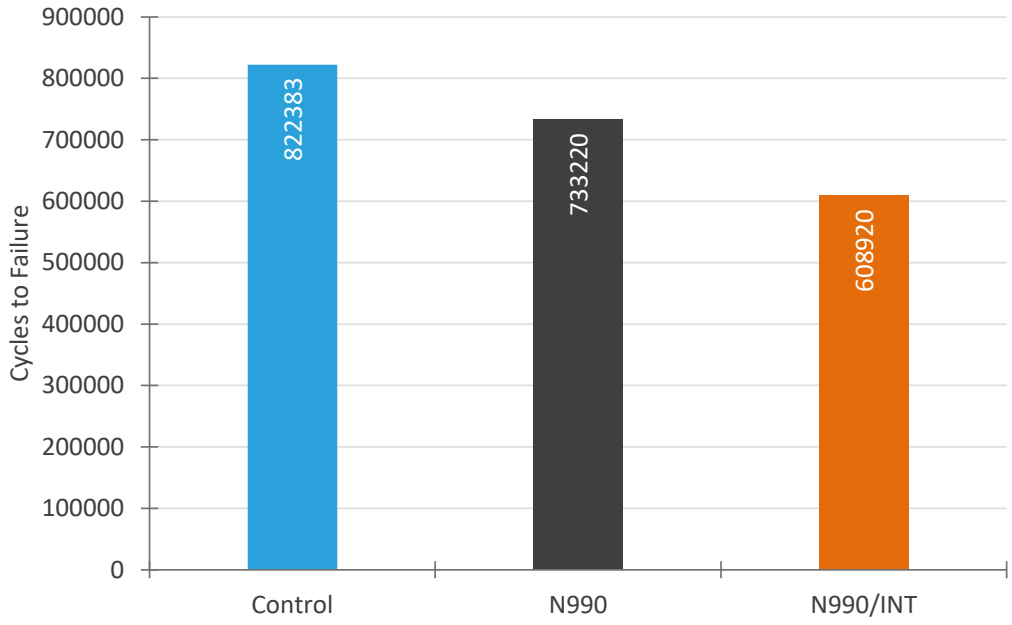

Figure 15. Average number of cycles to failure measured at a frequency of 1.7 Hz and an extension ratio of 1.6. Cycles to failure were slightly reduced with the addition of N990.