Tensile Strength Distribution

It is well known that filler dispersion has a significant impact on compound properties. Typically, dispersion is measured directly using optical microscopes, profilometers, or electron microscopes or indirectly using rheological data or electrical resistivity data. Depending on the compound formulation some of these methods may or may not be effective.

Looking at the tensile strength distribution is another way to evaluate dispersion quality. Traditional tensile testing according to ASTM D412 requires three or five specimens to be tested; unfortunately, this is too small of a sample size to properly capture the tensile strength distribution. With the introduction of automated tensile testing equipment, it is now easier to run dozens of tensile tests and evaluate the tensile strength distributions of compounds which can provide insight into compound dispersion. This can be a helpful tool to use when developing compounds or investigating quality issues.

The benefits of Thermax® N990 found in this study include:

- Improvement in dispersion as evidenced by the narrowing of the tensile strength distribution
- Extension of polymer leading to potential cost reduction

The NBR formulations can be found in Table 1. Thermax® N990 replaced N550 at a ratio of 2.2:1 to maintain a compound hardness of 70. Mooney viscosity, MDR, Shore A hardness, and tensile tests were run on all compounds. Testing results can be found in the figures on the following pages. The compounding and testing were completed at ACE Laboratories in Ravenna, Ohio.

Table 1. NBR formulations

Ingredient	Control	A	B
Nipol DN3350	100	100	100
N550	70	60	40
Thermax® N990	**-**	**22**	**66**
Zinc oxide	5	5	5
Stearic acid	1	1	1
TMQ	2	2	2
MBTS	1.5	1.5	1.5
DOA	10	10	10
Sulfur	1.5	1.5	1.5
Total	**191.0**	**203.0**	**227.0**

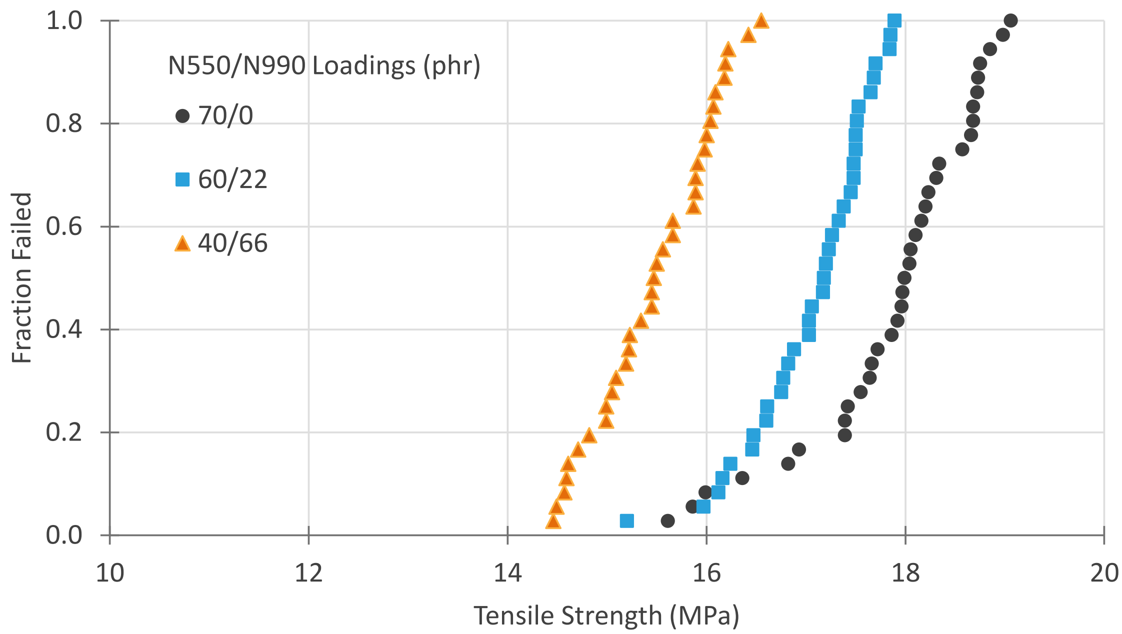

Figure 1. Tensile strength distribution of compounds. Results are from 36 tensile tests for each compound. Distribution was widest for the compound with no N990. This is indicative of worse dispersion.

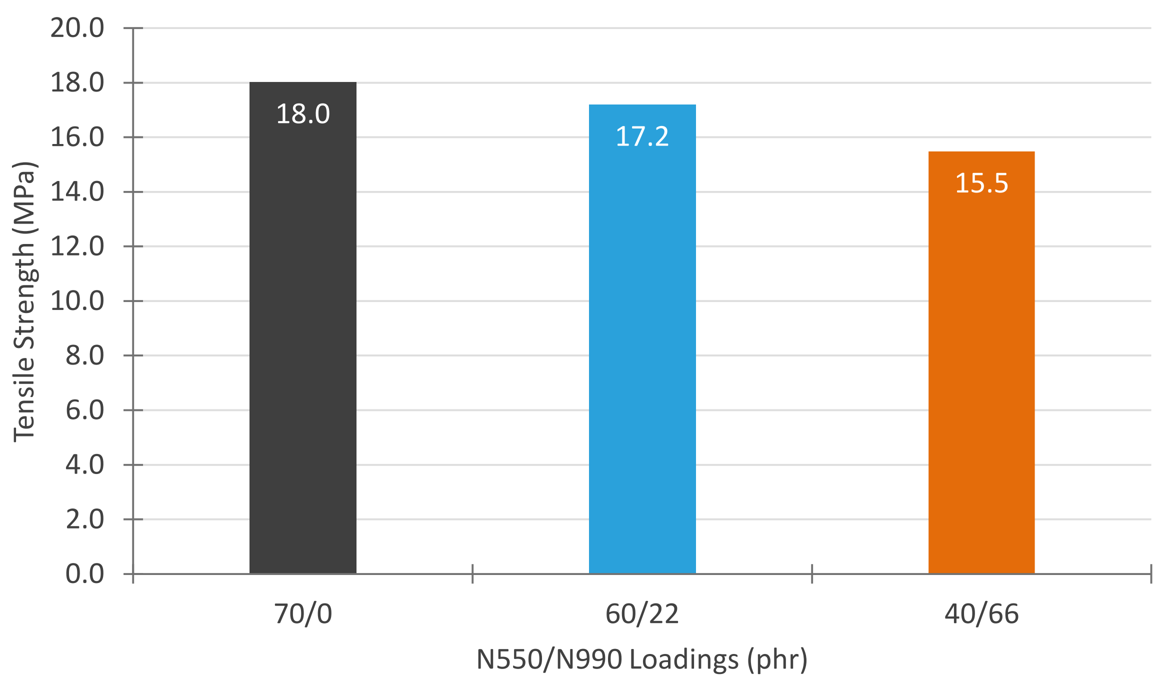

Figure 2. Median tensile strength of the compounds. Tensile strength decreased as N990 replaced N550.

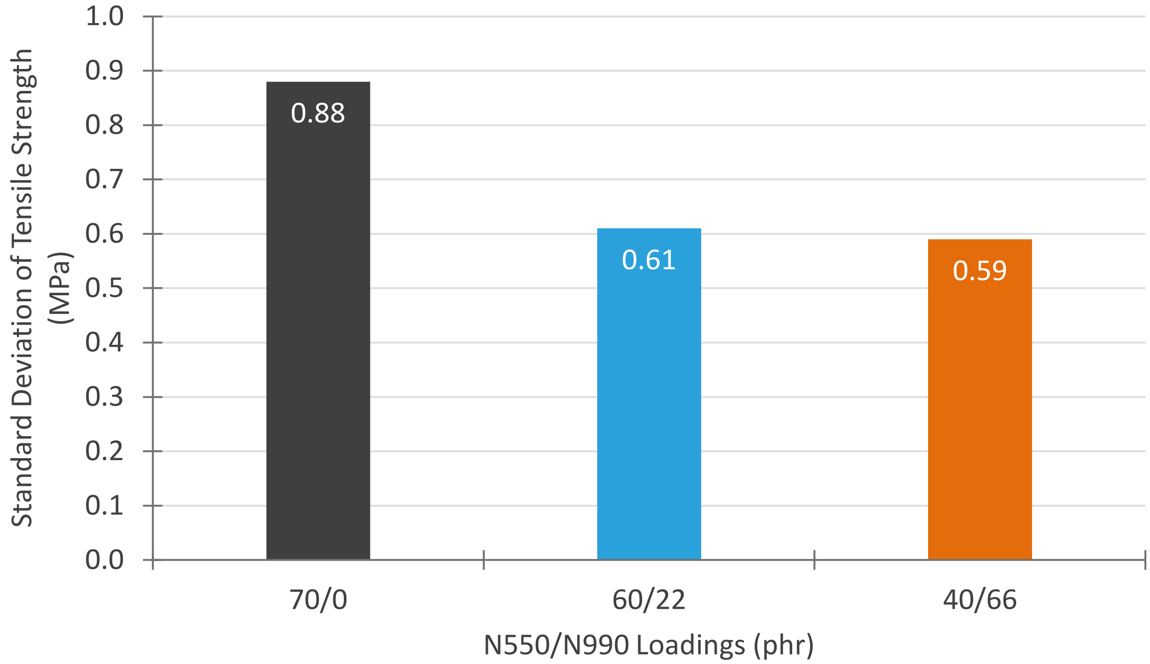

Figure 3. Standard deviation of tensile strength results of the compounds. Standard deviation was lower for the compounds with N990 indicating improved dispersion.

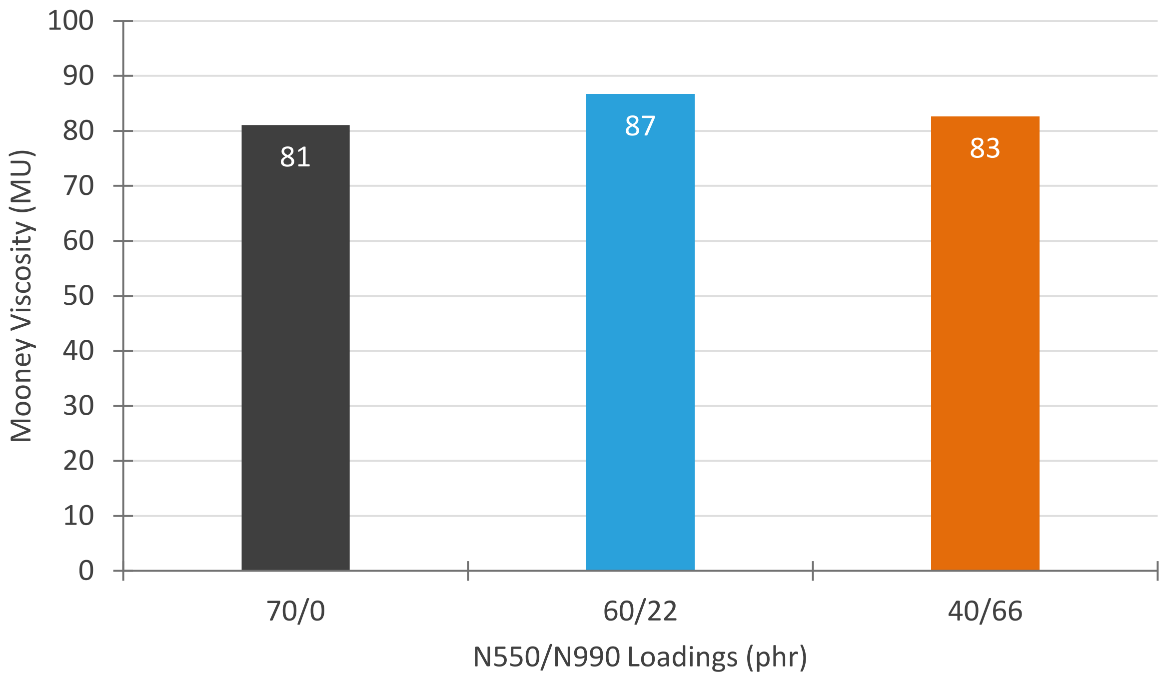

Figure 4. Mooney viscosity, ML1+4, of the compounds measured at 100°C. Values were substantially the same.

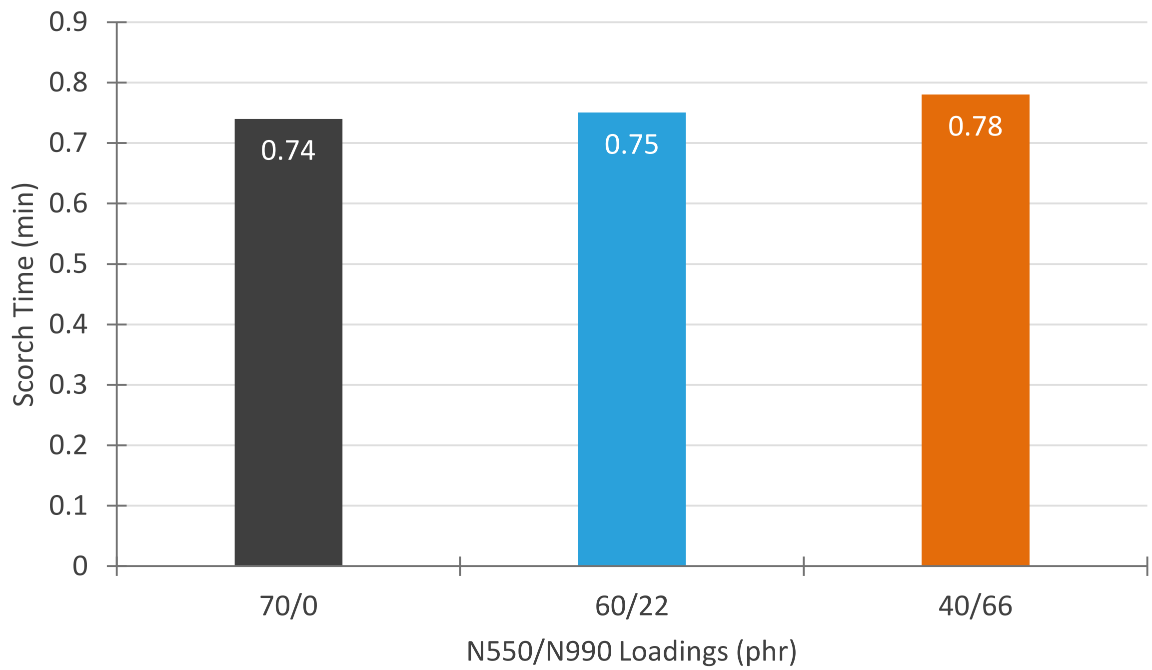

Figure 5. Scorch time, ts2, of the compounds measured at 177°C. There were no significant differences in scorch times.

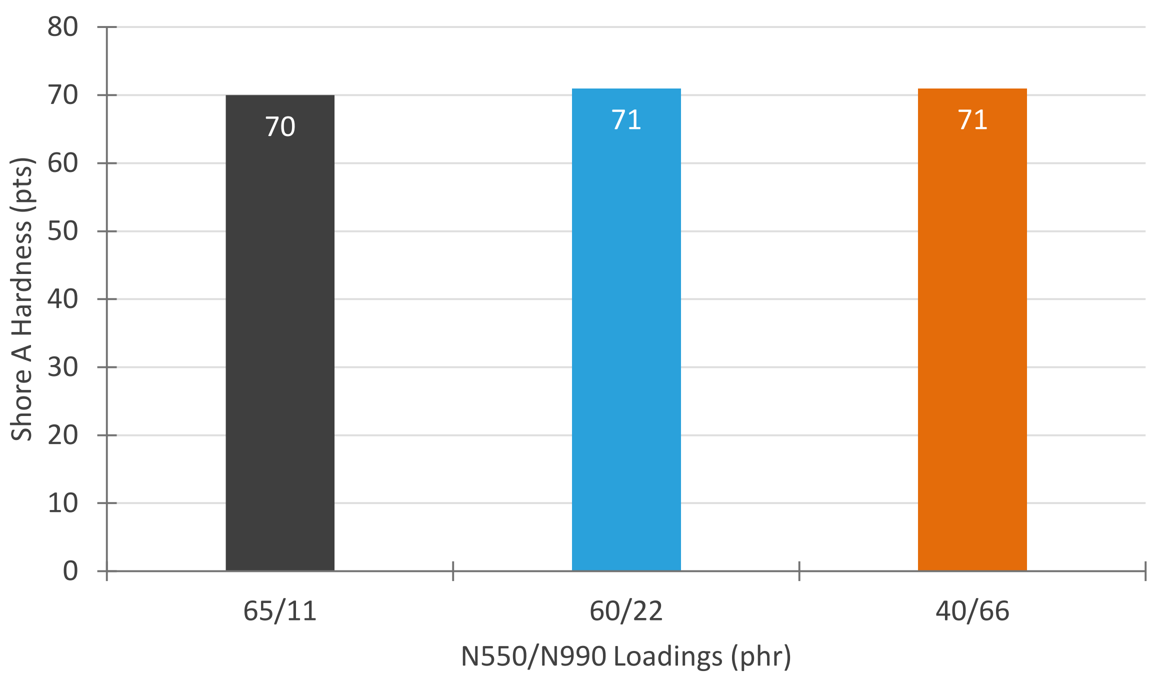

Figure 6. Shore A hardness of the compounds. All compounds were at 70±3 pts.

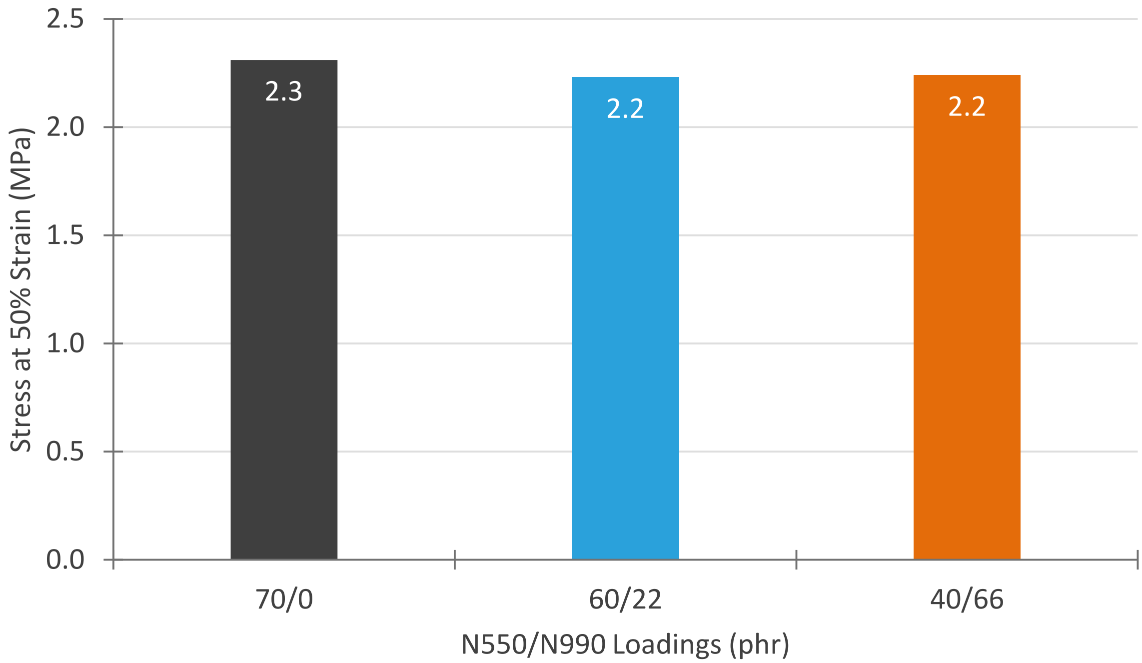

Figure 7. Stress at 50% strain of the compounds. No significant differences were observed.

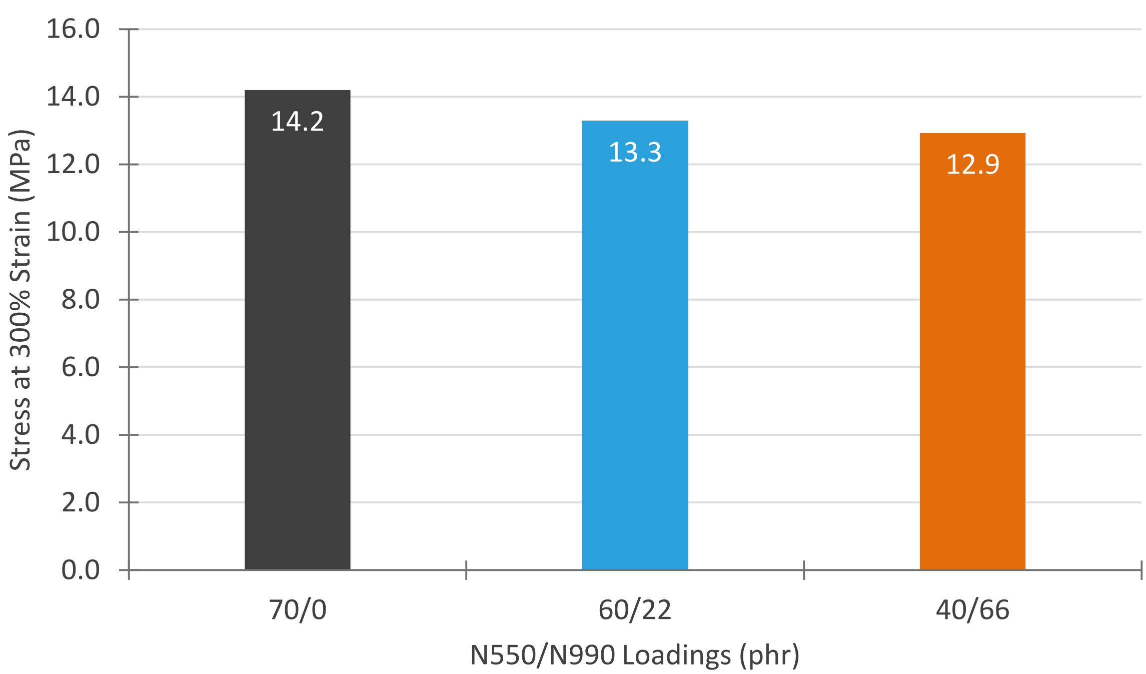

Figure 8. Stress at 300% strain of the compounds. A small decrease in 300% modulus was noted.

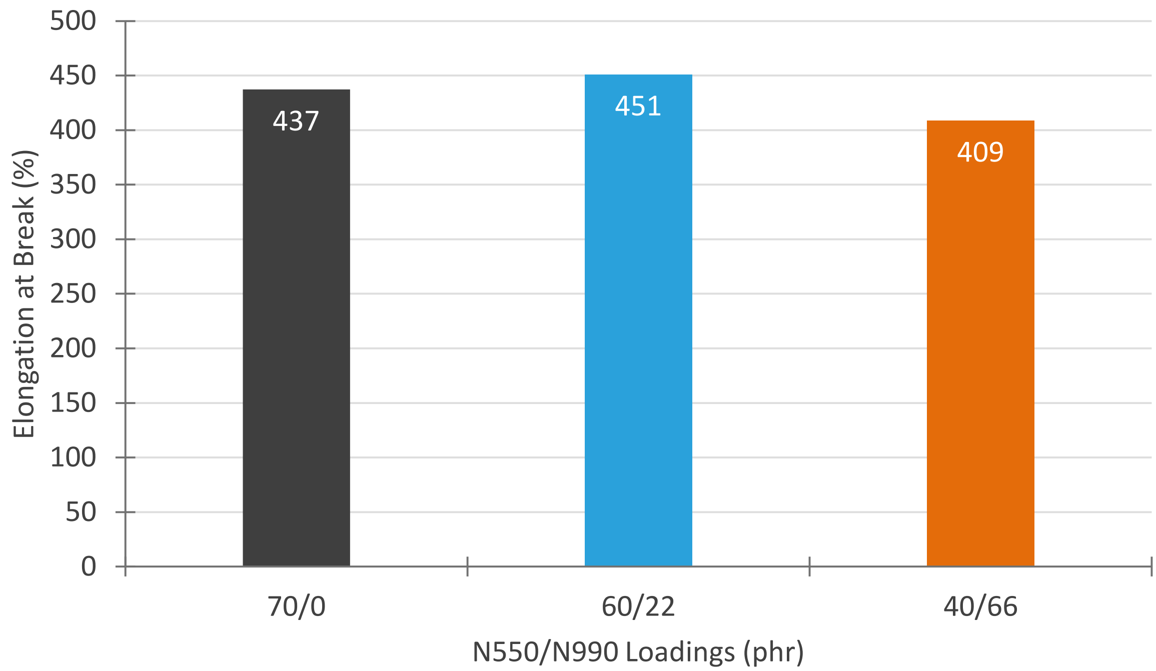

Figure 9. Median elongation at break of the compounds. A slight reduction in elongation was observed at higher loading levels.