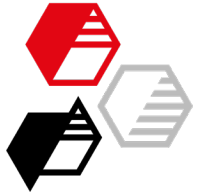


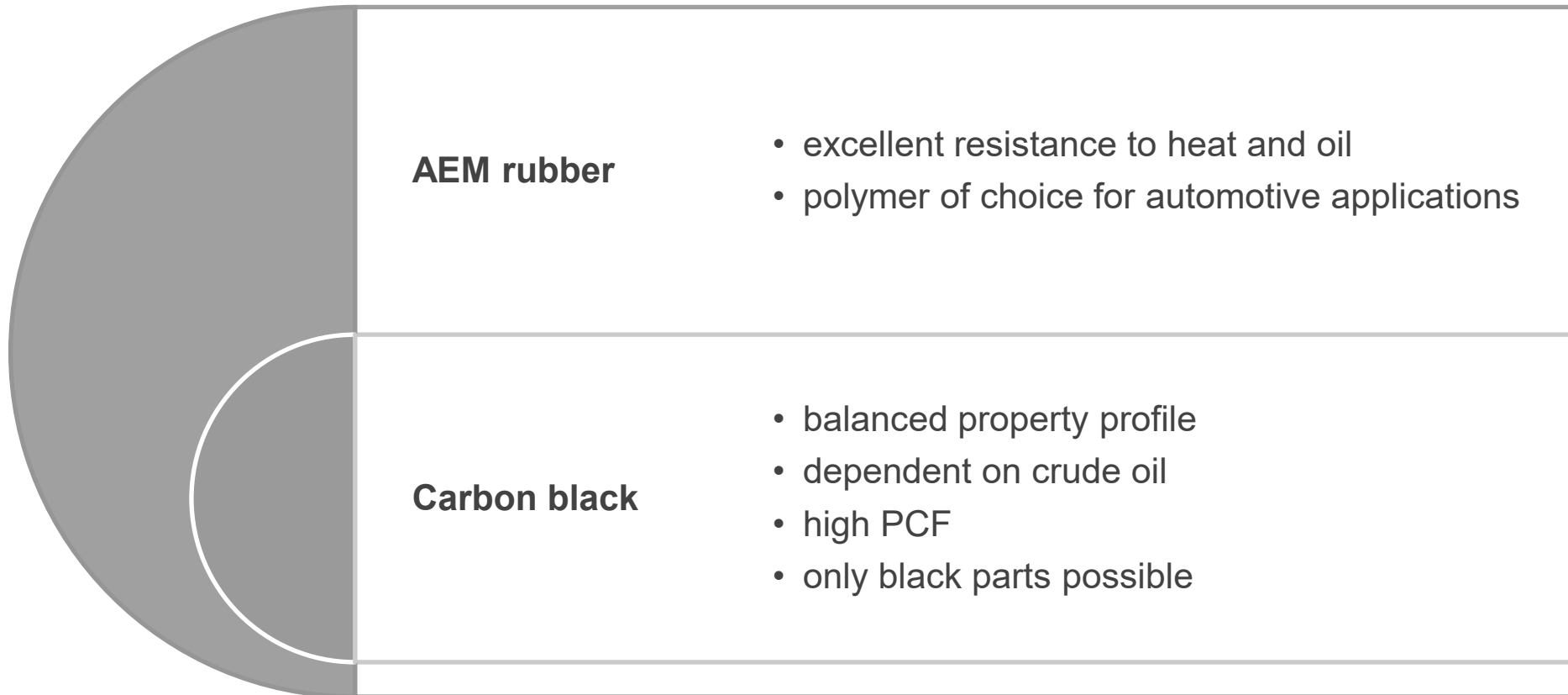
---

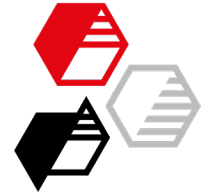
## Aktisil Q in AEM seals and gaskets



## Status quo

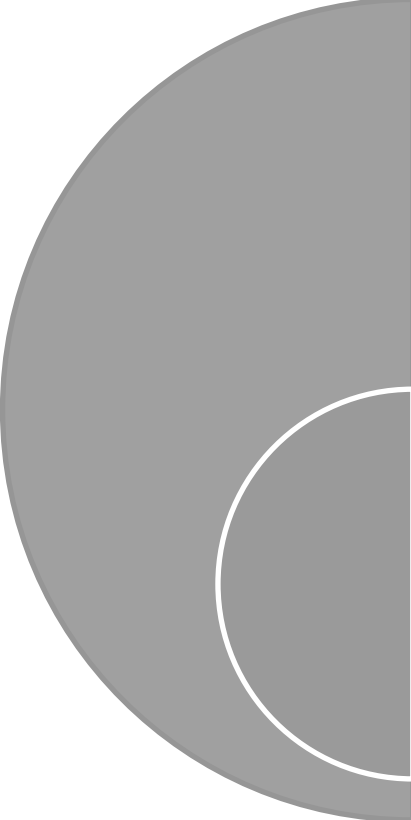
---





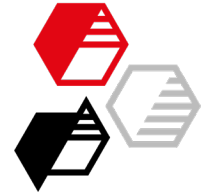
## Objective

---



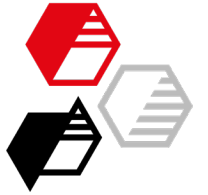
Is **Aktisil Q** a suitable replacement for carbon black in diamine cured AEM?

Evaluation of results with reference to PSA S22 5106 Class 165.



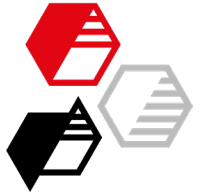
## Fillers and characteristics

|                    | Particle size           |                         | Oil absorption<br>[g/100g] | Specific surface area BET<br>[m <sup>2</sup> /100g] | Functionalization |
|--------------------|-------------------------|-------------------------|----------------------------|-----------------------------------------------------|-------------------|
|                    | d <sub>50</sub><br>[μm] | d <sub>97</sub><br>[μm] |                            |                                                     |                   |
| Carbon black N 550 | n.s.                    | n.s.                    | 121                        | 39                                                  | -                 |
| Aktisil Q          | 5                       | 18                      | 43                         | 6                                                   | methacrylic       |



## Formulation

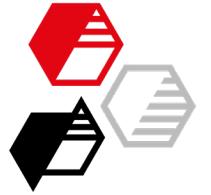
|                    | Carbon black N 550 |               | Aktisil Q          |               |
|--------------------|--------------------|---------------|--------------------|---------------|
|                    | Reference          | Polymer blend | Direct replacement | T810T         |
| Vamac Ultra IP     | 100                | 70            | 100                | 100           |
| Vamac VMX-3110     | -                  | 30            | -                  | -             |
| Luvomaxx CDPA      | 2                  | 2             | 2                  | 2             |
| Stearic acid       | 1.5                | 1.5           | 1.5                | 1.5           |
| Vanfre VAM         | 1.5                | 1.5           | 1.5                | 1.5           |
| Crodamide ER       | 1                  | 1             | 1                  | 1             |
| N 550              | 50                 | 50            | -                  | -             |
| <b>Aktisil Q</b>   | -                  | -             | <b>125</b>         | <b>125</b>    |
| AMEO               | -                  | -             | 0.63               | 0.63          |
| Rhenosin W 759     | 10                 | 10            | 20                 | -             |
| EDENOL T810T STAB  | -                  | -             | -                  | 20            |
| Diak No. 1         | 1.5                | 1.5           | 1.5                | 1.5           |
| Luvomaxx DBU DL 70 | 2.57               | 2.57          | 2.57               | 2.57          |
| <i>Total</i>       | <i>170.07</i>      | <i>170.07</i> | <i>255.70</i>      | <i>255.70</i> |



## Preparation and curing of the compound

---

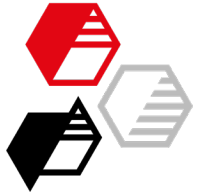
| Mixing               |                  |
|----------------------|------------------|
| Open mill            | Ø 150 x 300 mm   |
| Batch weight         | approx. 1 kg     |
| Temperature          | 50 °C            |
| Mixing time          | approx. 15 min.  |
|                      |                  |
| Curing and post-cure |                  |
| Curing               | 10 min. / 180 °C |
| Post-cure            | 4 h / 185 °C     |



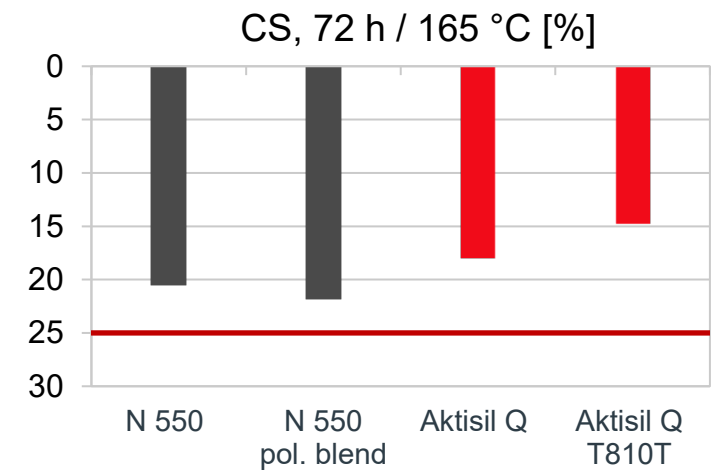
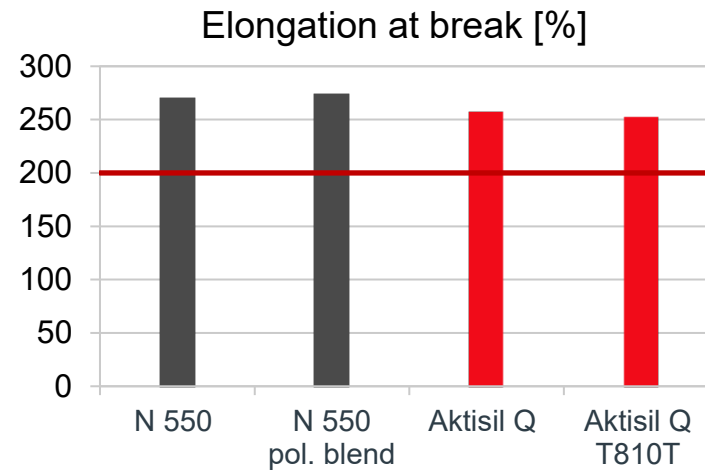
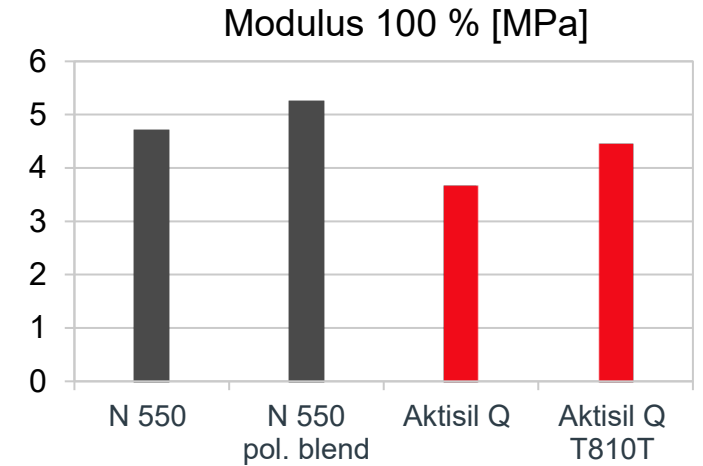
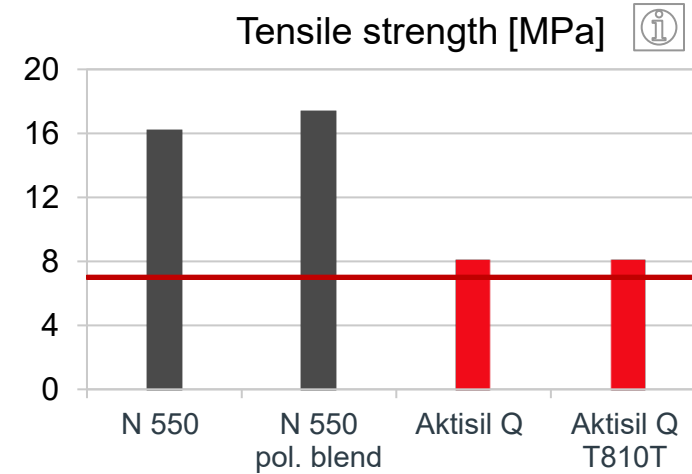
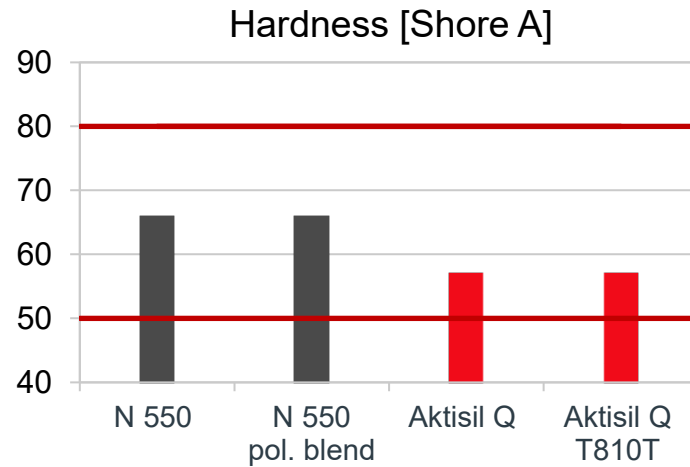
## Tests, standards, conditions

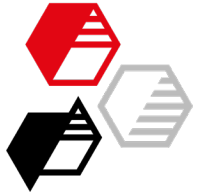
---

| Test                               | Standard              | Conditions                 |
|------------------------------------|-----------------------|----------------------------|
| Hardness                           | DIN ISO 7619-1        |                            |
| Tensile test                       | DIN 53 504, S2        |                            |
| Compression set                    | DIN ISO 815-1, Type B | 72 h / 165 °C / 25 % defl. |
| Storage in hot air                 | DIN 53 508            | 168 h / 165 °C             |
| Immersion in engine oil OS 206 304 | DIN ISO 1817          | 168 h / 165 °C             |

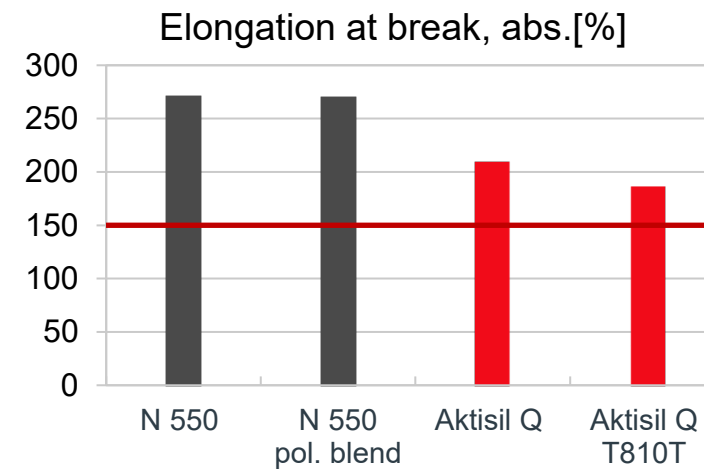
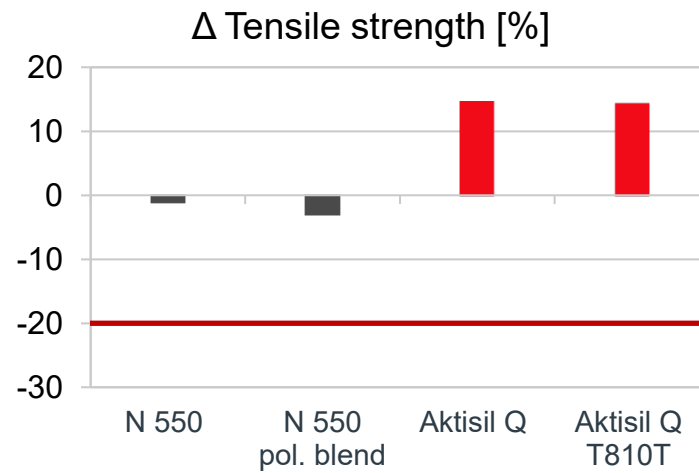
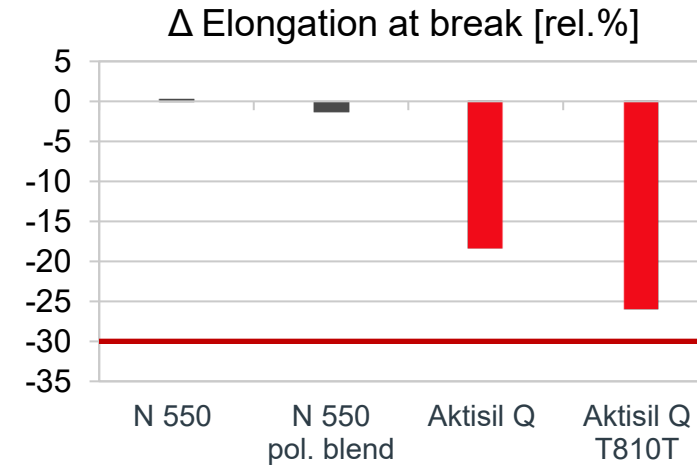
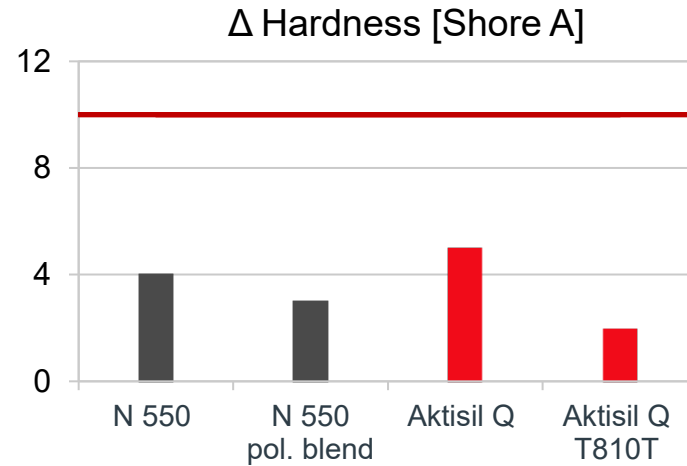


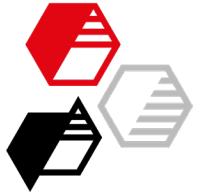
## Initial mechanical properties



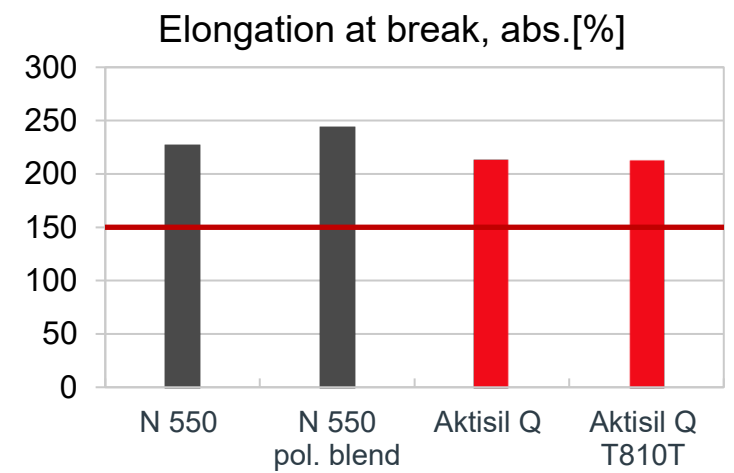
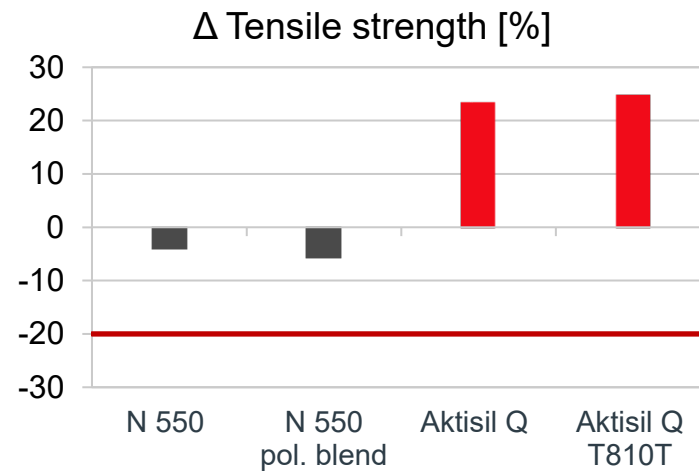
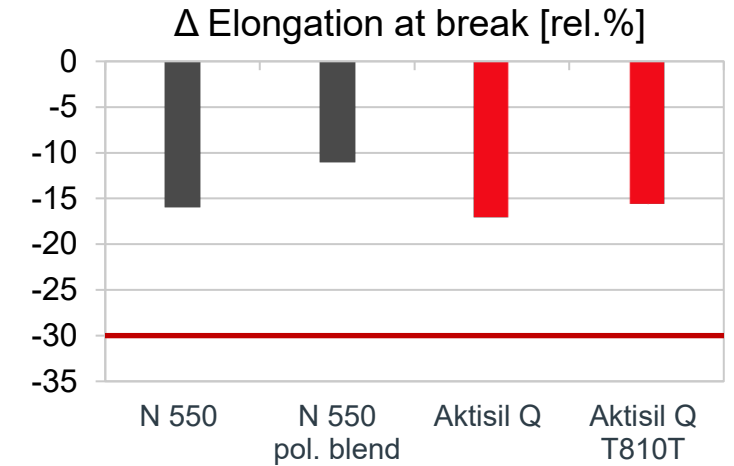
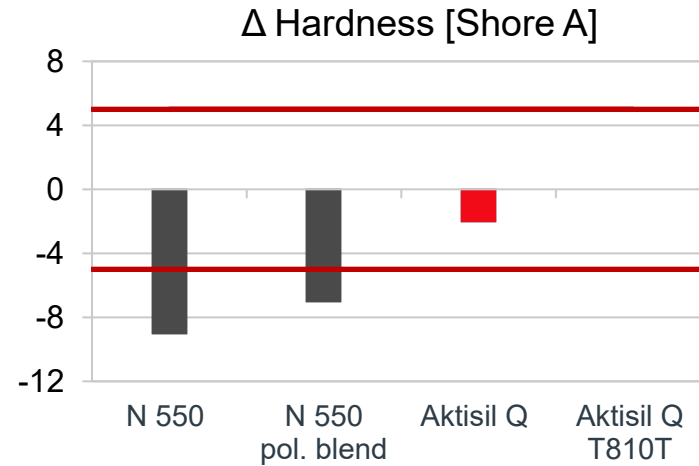
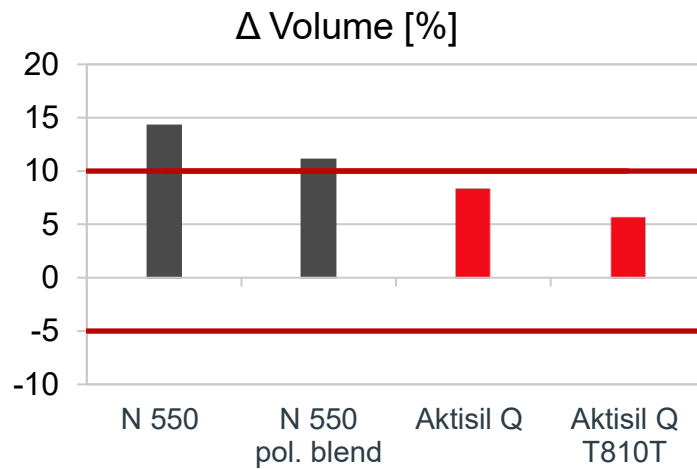


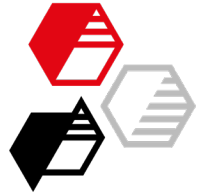
## Storage in hot air, 168 h / 165 °C





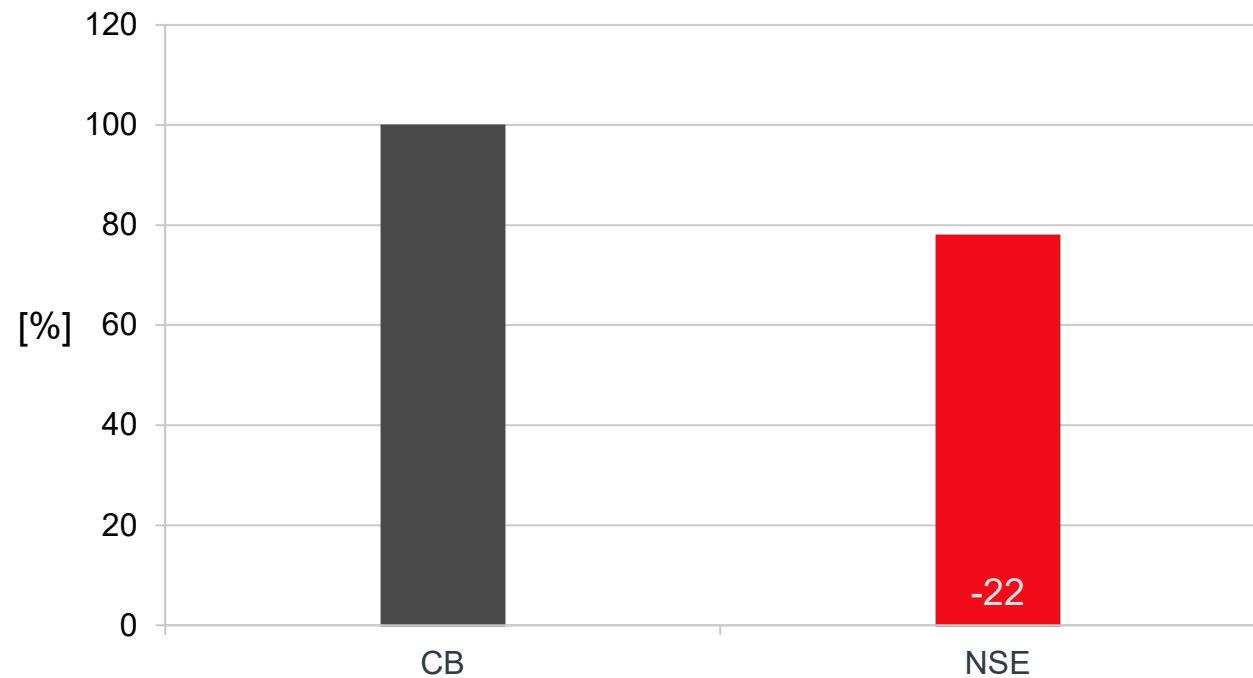
## Immersion in engine oil (OS 206 304), 168 h / 165 °C

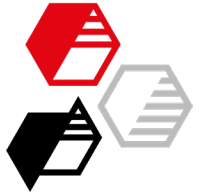




## An additional benefit...

Reduction of CO<sub>2</sub> eq. after replacing CB with NSE, volume based

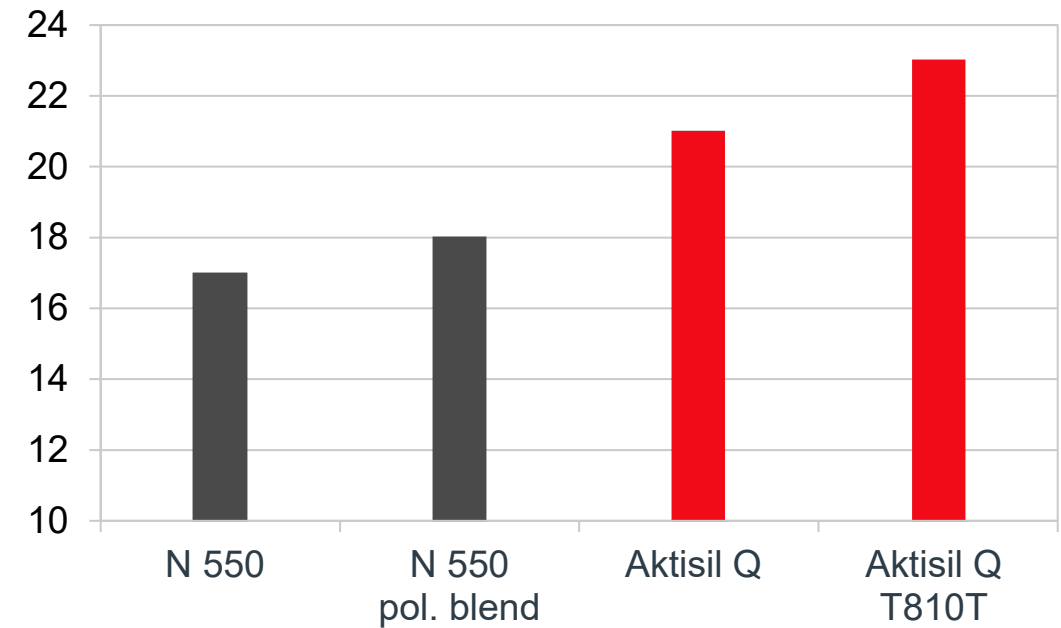


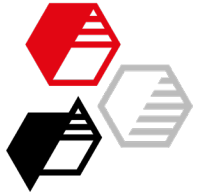


## Rating

|                           | Carbon black N 550 |           | Aktisil Q |           |
|---------------------------|--------------------|-----------|-----------|-----------|
|                           | -                  | pol.blend | -         | T810T     |
| <b>Initial properties</b> |                    |           |           |           |
| Hardness                  | ++                 | ++        | +         | +         |
| Tensile strength          | ++                 | ++        | +         | +         |
| Elongation at break       | ++                 | ++        | ++        | ++        |
| Modulus 100 %             | ++                 | ++        | +         | ++        |
| Compression set           | +                  | +         | +         | ++        |
| <b>Heat resistance</b>    |                    |           |           |           |
| Δ Hardness                | ++                 | ++        | ++        | ++        |
| Δ Tensile strength        | ++                 | ++        | ++        | ++        |
| Δ El. at break            | ++                 | ++        | +         | +         |
| El. at break, abs.        | ++                 | ++        | ++        | +         |
| <b>Oil resistance</b>     |                    |           |           |           |
| Δ Hardness                | --                 | --        | ++        | ++        |
| Δ Tensile strength        | +                  | +         | ++        | ++        |
| Δ El. at break            | +                  | +         | +         | +         |
| El. at break, abs.        | ++                 | ++        | ++        | ++        |
| Δ Volume                  | --                 | -         | +         | ++        |
| <b>Sum of +</b>           | <b>17</b>          | <b>18</b> | <b>21</b> | <b>23</b> |

Overall performance





## Conclusion

Carbon black N 550 leads to....



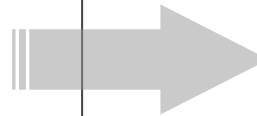
- excellent initial mechanical properties
- very good heat resistance

but also to



- insufficient resistance to engine oil
  - decrease of hardness
  - volume increase

Blending Vamac Ultra IP with a more oil-resistant polymer is not effective in meeting the standard.



Replacing N 550 with **Aktisil Q** leads to....



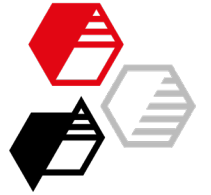
- good initial mechanical properties along with a good compression set
- good heat resistance
- markedly improved resistance to engine oil, esp.



- reduced hardness change
- reduced volume increase

Additional benefits:

- colored parts are possible
- positive costs aspects
- reduction of compound carbon footprint

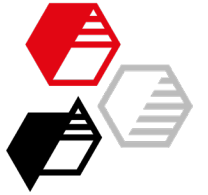


## We supply materials for good ideas!

HOFFMANN MINERAL GmbH  
Muenchener Straße 75  
DE-86633 Neuburg (Donau)

Phone: +49 8431 53-0  
Internet: [www.hoffmann-mineral.com](http://www.hoffmann-mineral.com)  
E-mail: [info@hoffmann-mineral.com](mailto:info@hoffmann-mineral.com)

Our applications engineering advice and the information contained in this memorandum are based on experience and are made to the best of our knowledge and belief, they must be regarded however as non-binding advice without guarantee. Working and employment conditions over which we have no control exclude any damage claim arising from the use of our data and recommendations. Furthermore we cannot assume any responsibility for patent infringements, which might result from the use of our information.



## In case, the tensile strength with Aktisil Q has to be increased

---

---

### Suggested measures

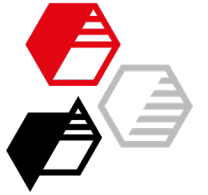
reduction of plasticizer content to 10 phr

less CB replacement with Aktisil Q

addition of ppt. silica along with increased silane dosage

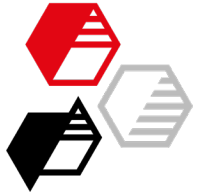
---





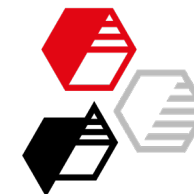
## Results in tabular form

|                                                                                |         | Carbon black N 550 |               | Aktisil Q    |       |
|--------------------------------------------------------------------------------|---------|--------------------|---------------|--------------|-------|
|                                                                                |         | Reference          | Polymer blend | Direct repl. | T810T |
| <b>Rheology</b>                                                                |         |                    |               |              |       |
| Mooney Viscosity, ML 1+4, 120 °C                                               | MU      | 33                 | 34            | 23           | 25    |
| Mooney Scorch, ML +5, 120 °C                                                   | min.    | 6.9                | 7.1           | 6.6          | 6.0   |
| Rotorless Curemeter, M <sub>min</sub> , 180 °C                                 | Nm      | 0.03               | 0.03          | 0.01         | 0.01  |
| Rotorless Curemeter, V <sub>max</sub> , 180 °C                                 | Nm/min. | 0.38               | 0.44          | 0.47         | 0.47  |
| Rotorless Curemeter, t <sub>90</sub> , 180 °C                                  | min.    | 2.6                | 2.4           | 2.5          | 2.6   |
| <b>Mechanical properties (cured 10 min. / 180 °C, post-cured 4 h / 185 °C)</b> |         |                    |               |              |       |
| Hardness                                                                       | Shore A | 66                 | 66            | 57           | 57    |
| Tensile strength                                                               | MPa     | 16                 | 17            | 8.1          | 8.1   |
| Elongation at break                                                            | %       | 270                | 274           | 257          | 252   |
| Modulus 100 %                                                                  | MPa     | 4.7                | 5.3           | 3.7          | 4.4   |
| Compression set 72 h / 165 °C / 25 %                                           | %       | 21                 | 22            | 18           | 15    |



## Results in tabular form

|                                              |         | Carbon black N 550 |               | Aktisil Q    |       |
|----------------------------------------------|---------|--------------------|---------------|--------------|-------|
|                                              |         | Reference          | Polymer blend | Direct repl. | T810T |
| <b>Resistance to hot air, 168 h / 165 °C</b> |         |                    |               |              |       |
| Hardness                                     | Shore A | 65                 | 67            | 62           | 59    |
| Tensile strength                             | MPa     | 16                 | 17            | 9.2          | 9.3   |
| Elongation at break                          | %       | 271                | 270           | 210          | 187   |
| Modulus 100 %                                | MPa     | 5.2                | 5.1           | 4.4          | 5.3   |
| Δ Hardness                                   | Shore A | +4                 | +3            | +5           | +2    |
| Δ Tensile strength                           | %       | -1                 | -3            | +15          | +14   |
| Δ Elongation at break                        | rel.%   | 0                  | -1            | -18          | -26   |
| Δ Modulus 100 %                              | %       | +10                | -2            | +21          | +19   |



## Results in tabular form

|                                                            |         | Carbon black N 550 |               | Aktisil Q    |       |
|------------------------------------------------------------|---------|--------------------|---------------|--------------|-------|
|                                                            |         | Reference          | Polymer blend | Direct repl. | T810T |
| <b>Resistance to engine oil OS 206 304, 168 h / 165 °C</b> |         |                    |               |              |       |
| Hardness                                                   | Shore A | 57                 | 59            | 55           | 57    |
| Tensile strength                                           | MPa     | 16                 | 16            | 9.9          | 10    |
| Elongation at break                                        | %       | 227                | 244           | 213          | 213   |
| Modulus 100 %                                              | MPa     | 5.6                | 5.8           | 4.5          | 5.0   |
| Δ Hardness                                                 | Shore A | -9                 | -7            | -2           | 0     |
| Δ Tensile strength                                         | %       | -4                 | -6            | +23          | +25   |
| Δ Elongation at break                                      | rel.%   | -16                | -11           | -17          | -16   |
| Δ Modulus 100 %                                            | %       | +19                | +11           | +24          | +12   |
| Δ Weight                                                   | %       | +9                 | +7            | +4           | +2    |
| Δ Volume                                                   | %       | +14                | +11           | +8           | +6    |