Effect of high molecular weight mineral oil on thermoplastic elastomers

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Mineral oil is a significant component of thermoplastic elastomers (TPE) that extends the rubber-like plastic and softens it for soft-touch applications. Clear, highly refined process oils allow color match and color stability for these TPEs. The higher the molecular weight (MW), the lower the volatility of these oils, which is important for higher temperature applications like automotive interiors. The industry standard TPE process oil Chevron ParaLux 6001 has the required properties to meet the automotive fogging requirements while allowing color match and color stability. A newly introduced, higher MW, clear oil; Renoil 1500-LV, has been compounded into a standard SEBS TPE formulation resulting in significantly reduced fogging.

1 TPEs and oil discussion

TPEs, akin to rubber, are plasticized by mineral oil, improving the softness of the article as more mineral oil is added. Various oils may be used depending on the final product application. Dark colored or black products may use a range of oils since color stability is not an issue. Colored TPEs, especially light colors, require a clear mineral oil that is UV stable to maintain that color over time. Applications with higher temperatures like automotive interiors, which can become very hot in the summer, have additional requirements related to the volatility of the oil. It is important that a compounded oil does not evaporate in normal use conditions.

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All figures and tables, unless otherwise stated, have been kindly provided by the authors.

The quality of the TPE will change as oil is removed and the soft plastic will become harder. Additionally, the evaporated oil condenses on the windshield of an automobile causing undesirable fogging.

Automotive companies require TPEs used in auto interiors to be stable within the full range of possible temperatures. Each auto maker sets standards for these soft touch TPE products and only a high MW oil can meet the standards. The unofficial standard process oil has been Chevron ParaLux 6001 which performs well. Renkert Oil has recently introduced Renoil 1500-LV which extends the Chevron ParaLux process oil line with a much higher MW while maintaining the highly UV stable, water-white color **(tab. 1, fig. 1).**

It is interesting to note that the flash point is not significantly different between the two oils. The flash point is a rough indication of volatility and the propensity to cause fogging in TPEs.

The gas chromatograph distillation curves in **figure 2** show that Renoil 1500-LV (red) has a significantly higher boiling point range than ParaLux 6001 (blue).

2 Compound description

Star Thermoplastic Alloys and Rubbers Inc. prepared standard PP/SEBS (polypropylene/styrene-ethylene butylene-styrene) thermoplastic elastomer samples using the two oils and also without oil. The formulations:

- Polypropylene
- Hydrogenated styrene butadiene copolymer
- Antioxidant package
- Extender oil (50 % or 0 %)

The clear polymer formulations were molded into sample plaques for testing.

3 Comparison of physical properties

To successfully identify any influence of the base polymers in the SEBS formulation on fogging, the samples were prepared as follows:

- A base sample with zero extender oil
- Standard ParaLux 6001 low fogging oil at 50 %
- New high MW Renoil 1500-LV extender oil at 50 %

Elongation at break and tensile strength were equivalent for the two oil extended samples **(fig. 3).** Equal weight percent of the higher viscosity/MW oil gave similar Shore A hardness compared to ParaLux 6001, but slightly more high MW oil may be utilized for equal softness.

- 50 % ParaLux 6001 — 66 Shore A
- 50 % Renoil 1500-LV — 69 Shore A
- 0 % extender oil — 97 Shore A

Three different test methods for fogging clearly showed the impact of the oils MW change and confirmed that the PP/SEBS polymer was a very small component of total fogging.

Tab. 1: Some properties of Renoil 1500-LV and Chevron ParaLux process oils

Oil	MW	Average carbon number	Viscosity at 100 °C cSt	Viscosity at 100 °F SUS	Flash point in °C
ParaLux 6001	528	38	12.0	538	277
Renoil 1500-LV	680	48	24.1	1,483	284

Higher MW process oil performs better in fogging (photometric):

- The base polymer is only a small component of fogging (0.8 %).
- Standard ParaLux oil adds about 7.8 %.
- Renoil 1500-LV reduces this impact by almost half to 4.4 %.

Gravimetric fogging results show similar 43 % reduction when using high molecular weight extender oil Renoil 1500-LV.

Oil mobility must have also been reduced because the flash point (a measure of volatility) is relatively similar yet the fogging was reduced over 40 % by the higher MW oil Renoil 1500-LV. This decreased mobility is expected as the higher MW naturally hinders the movement of the oil to the TPE surface.

4 Applications and potential effects

Soft touch TPE is used extensively in the automotive market. The color match, color stability and fogging requirements of auto interiors require a highly refined, high MW process oil like Chevron ParaLux 6001. Renoil 1500-LV is produced using the same hydroprocessing technology as ParaLux 6001 but has even higher MW as well as the clarity and stability required.

The automotive industry has indicated interest in even better fogging performance. Clearly Renoil 1500-LV provides a tool to achieve this target. It can also be used with polymers that have inherently higher volatility that impact fogging to remain compliant.

The reduced mobility of higher MW oil in TPE polymers may find application in medical or food contact materials. As the oil is more likely to remain in the polymer, even at higher temperatures, it will maintain the TPE properties and not negatively impact foods or medical uses. Renkert Oil has a USP version of this oil, Renoil 1700-W for these applications.

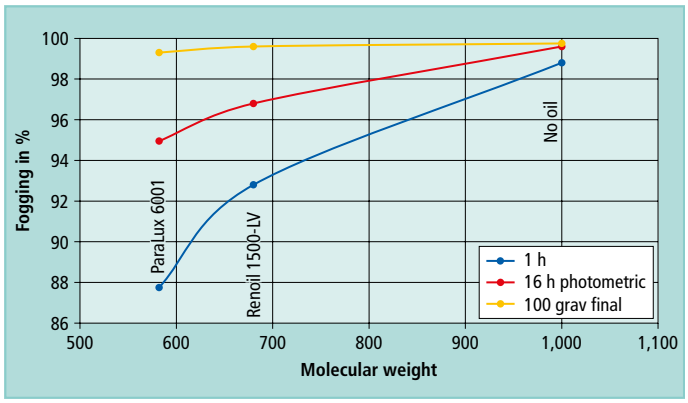

Fig. 1:
Impact of the MW oil on fogging behaviour

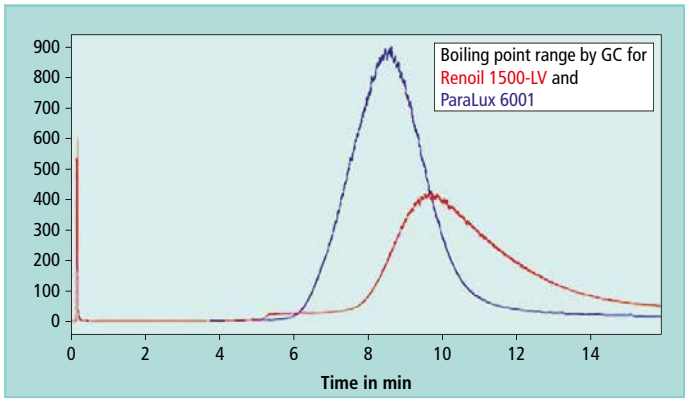

Fig. 2:
Boiling points for Renoil 1500-LV (red) and ParaLux 6001 (blue)

5 Summary

A direct comparison of the new Renoil 1500-LV and ParaLux 6001 in a standard TPE compound was performed.

Using the same level of mineral oil extension to SEBS compound, similar physical properties were obtained, but with significantly better fogging results.

The higher MW of Renoil 1500-LV naturally reduced the volatility and mobility of the process oil in the TPE.

Fig. 3: SEBS compounds with no oil extender and two highly refined process oils (ParaLux 6001 and Renoil 1500-LV) show very similar properties: elongation at break (a), tensile strength (b)