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CASE STUDY

Naphthenic Chemistry Improves Elastic Attachment in Hygiene Products

Summary

Product type: Hydrotreated naphthenic process oil as plasticizer
Application: Elastic Attachment in Hygiene Products
Key benefits: High creep resistance | High shear strength | Enhanced softness | Greater flexibility | Low odor | Skin-friendly | Excellent aging stability

The Challenge

Hygiene products, such as baby diapers, feminine care and adult incontinence products must provide discreteness, comfort, a sense of security and maximum protection for an extended period of time. These products combine layers of absorbents, plastic films, and nonwoven liners with elastic materials to produce a snug, comfortable, and leak-proof fit. Specialty adhesives are used to bond these layers and to attach the elastic material to the film or liner. The adhesive must be skin friendly and provide a high-strength bond. The adhesive used to bond stretch panels must also be flexible so that it can move with the substrate. In addition to binding layers together, it must also prevent substrates from moving or sliding relative to one another under high elastic stress. The adhesive tends to slowly deform over time on exposure to high levels of stress; this is known as creep.

When dealing with elastic attachments, the general assumption that an adhesive will hold its position after application is no longer valid. Creep is the technical parameter that quantifies the deformation of the adhesive after its application. It characterizes how a material changes shape or flows under a load or stress. Manufacturers of hygiene products must test the suitability of an adhesive for their application by quantifying its creep property. The challenge is to find a suitable adhesive system with the right balance of the following essential properties:

- High creep resistance
- High shear strength
- High heat and cold resistance
- Excellent aging stability
- Excellent wet-strength

- Low odor
- High softness and flexibility
- Skin-friendliness
- Ease of handling

The Solution

Adhesives used in elastic attachment of hygiene products must match the chemistry of the plasticizer with the elastomer system to provide flexibility and creep resistance. High creep resistance provides comfort and flexibility, allowing the elastic to stretch and return to its shape again and again. Table 1 shows a typical formulation for the production of adhesives for hygiene applications. The formulation consists of a mixture of cycloaliphatic and aromatic hydrocarbon resins combined with a Styrene-Isoprene block copolymer (SIS) and an antioxidant. A clean specialty process-oil is added to the formulation which serves as a plasticizer and extender. The choice of the process oil greatly affects the performance of the hygiene adhesive. The oil must have good compatibility with the elastomer to optimize adhesive performance. Formulators can choose between naphthenic and paraffinic oils as plasticizers.

Function	Description	Weight %
Tackifier Resin - 1	Cycloaliphatic hydrocarbon resin	58.5
Tackifier Resin - 2	Aromatic hydrocarbon resin	5.0
Polymer (SIS Block copolymer)	Clear, Linear tri-block copolymer on styrene and isoprene	23.0
Antioxidant	Hindered Phenol - CAS Number 6683-19-8 Benzene propanoic acid, 3,5-bis(1,1-dimethylethyl)-4-hydroxy-,1,1'- [2,2-bis[[3-[3,5-bis(1,1-dimethylethyl)-4 hydroxyphenyl]-1-oxopropoxy]methyl]-1,3-propanediyl] ester	0.5
Plasticizer/Extender	Naphthenic to Paraffinic	13.0

Table 1: Typical adhesive formulation used in hygiene applications

Ergon, Inc. produces genuine naphthenic and paraffinic oils by distillation of virgin naphthenic crude followed by a modern, high pressure, severe hydro-treating process. Ergon's HyPrene process oils are designed for a variety of processing applications to exact specifications. HyPrene products have low pour points, good solvency power, low odor levels, excellent color and color stability characteristics. HyPrene Olympus L500 is a severely hydrotreated naphthenic process oil which shows resistance to discoloration by heat and ultraviolet light. It is recommended for use as a plasticizer in hygiene applications.

A study was conducted to compare the creep performance of adhesives formulated with a range of process oils with varying chemistries. The study evaluated and compared the performance of nine different process oils, including HyPrene Olympus L500, in otherwise identical adhesive formulations and test conditions. Table 2 shows the physical properties of oils used in the study which ranged from naphthenic to paraffinic. The study was performed by an independent third-party lab with blind samples.

	Viscosity, SUS @ 100°F	Viscosity, SUS @210°F	Refractive Index @ 20°C	Aniline Point, °F (°C)
Test Method	**ASTM D7279**	**ASTM D7279**	**ASTM D1218**	**ASTM D611**
HyPrene Olympus L500	507	55.6	1.4968	208 (97.8)
Prototype 1	517	57.0	1.4939	210 (98.9)
Prototype 2	536	60.2	1.4880	231 (110)
Prototype 3	552	63.0	1.4846	240 (115.6)
Control 1	467	54.5	1.4894	213 (100.6)
Control 2	532	68.4	1.4869	231 (110)
Paraffinic 1	540	66.9	1.4759	263 (128)
Paraffinic 2	590	67.0	1.4787	258 (125.6)
Paraffinic 3	582	68.4	1.4810	250 (121.1)

Table 2: Properties of various process oils used in the study

A creep test measures the ability of an adhesive to hold its position. The test was performed on strips of adhesive/stretched Lycra/fabric construct. The creep measurement recorded the elastic attachment bond failure length, as a percentage of the length of the strip (285 mm) when the initially stretched (energized) Lycra strand was in a relaxed state (released tension). Figure 1 shows the lengths used to calculate the creep value. The creep value was calculated using the following formula:

$$Creep\ Value = \frac{285 - Recovered\ Length}{285} \times 100$$

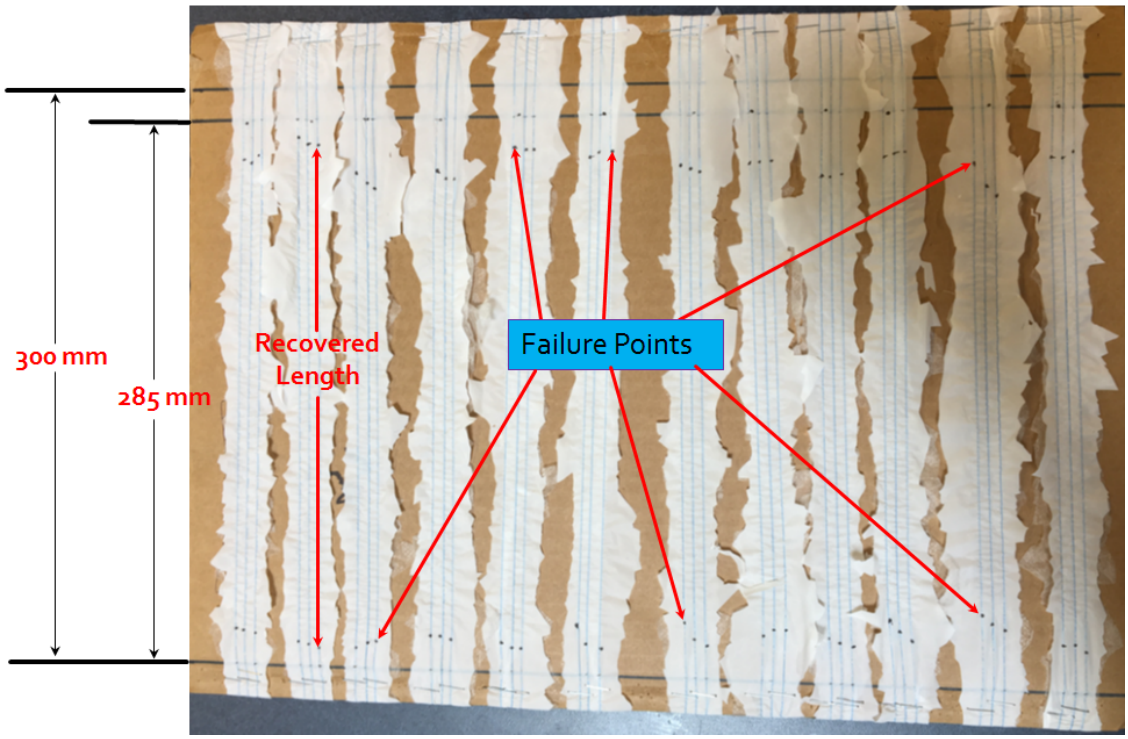

Figure 1: Calculating the creep value

Results

Figure 2 shows the creep value of adhesives formulated with various process oils versus the aniline point of the oil. HyPrene Olympus L500 naphthenic process oil shows the best creep resistance with a low creep value of 13.6%. It has the lowest aniline point of the oils tested which indicates a high amount of solvency and compatibility with the elastomer system. The data shows that naphthenic plasticizers offer a distinct advantage in elastic attachment performance in an SIS block copolymer formulation. Adhesives in which paraffinic process oils were used as plasticizers exhibited less creep resistance with a creep value as high as 30%.

Figure 3 shows the creep value of adhesives formulated with various process oils versus the refractive index of the oil at 20°C. The downward sloping curve, fitted to the experimental data, shows that the creep resistance of the adhesive decreases with decreasing refractive index, reduced solvency, of the process oil. HyPrene Olympus L500 had the highest refractive index of all the oils tested in the study correlating with the best creep resistance.

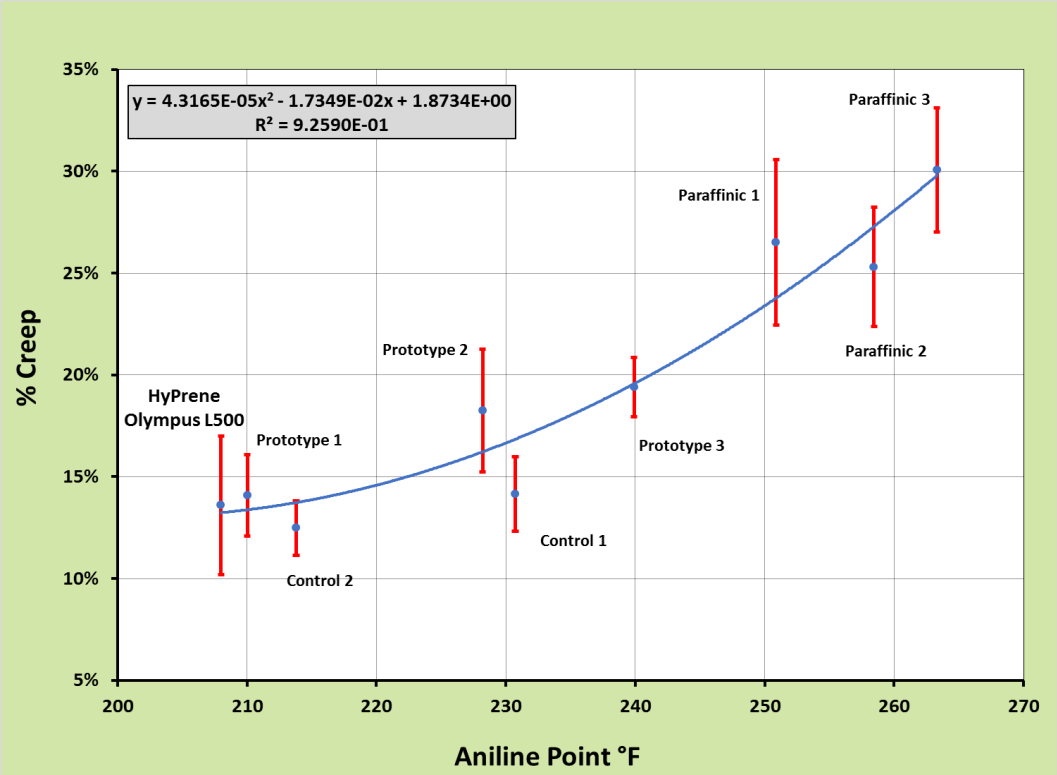

Figure 2: Creep value of adhesives formulated with various process oils versus the aniline point

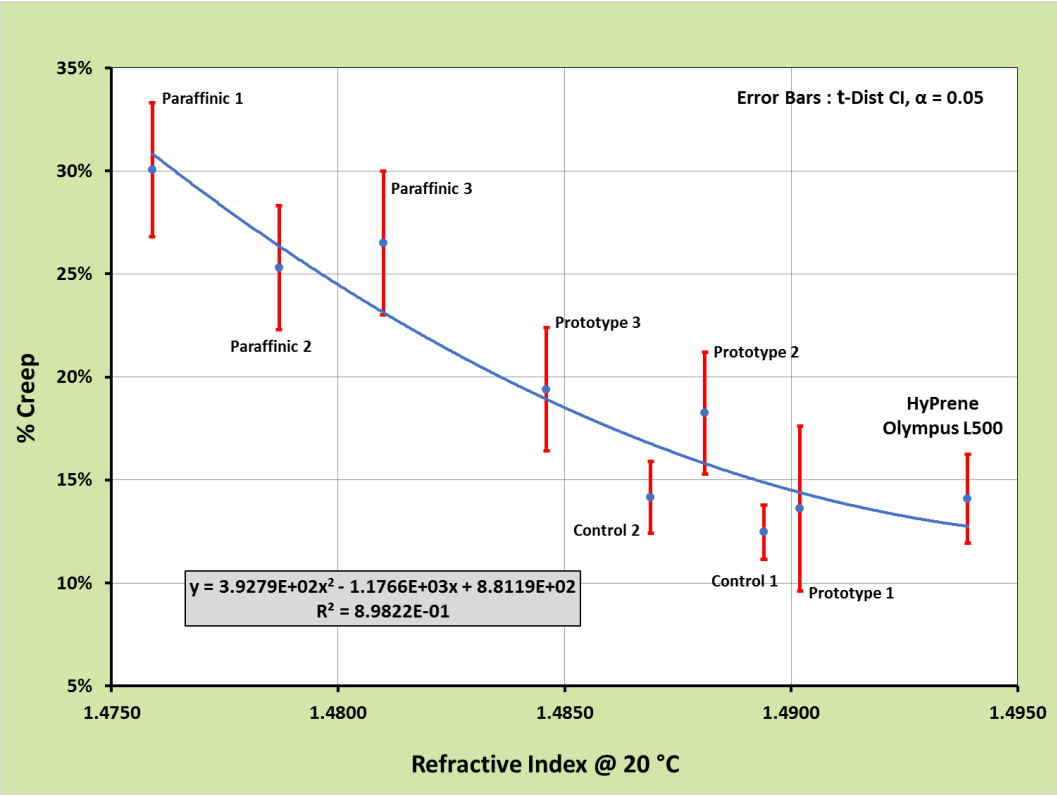

Figure 3: Creep value of adhesives formulated with various process oils versus the refractive index

Conclusion

In hygiene elastic attachment applications, creep resistance of adhesives is critical, as adhesives must withstand the shear forces on the bond due to the stretched Lycra strand and the lamination bond. The elastic band adhesive can be optimized by choosing naphthenic process oil chemistry. Creep tests show that improved creep performance correlates well with higher refractive index and lower aniline point of the process oil, indicating that greater solvency in the process oil improves adhesive performance.

Naphthenic process oils improve performance by plasticizing the styrene end blocks. The aromatic and naphthenic molecules, in the process oil, associate with the styrene end block domains providing additional softening. In addition, the aromatic and naphthenic rings contribute to the structural entanglement which results in physical crosslinking. Naphthenic process oils, therefore, add greater elasticity to the adhesive compound, as compared to iso- and n-paraffins.

HyPrene Olympus L500 is a severely hydrotreated naphthenic process oil which can be used as a plasticizer in adhesive formulations to improve creep resistance in elastic attachments of hygiene products. It helps achieve bonds with high shear strength and excellent aging stability. HyPrene Olympus L500 offers clear advantages over paraffinic process oils when used in formulating adhesives for hygiene applications including enhanced softness and greater flexibility. It has low odor and is skin-friendly which makes it ideal for use in hygiene products.

References:

https://www.adhesivesmag.com/articles/91373-avoiding-creep