HMPSAs
Better Performance with NOVARES®

The application possibilities of aromatic hydrocarbon resins are multiple. They are established in EVA based hotmelts because of their tackifying and heat resistance improving properties. Furthermore they can improve the performance of HMPSAs on the basis of block copolymers - even with small amount.

Permanently tacky adhesives are called pressure sensitive adhesives. These may contain solvents, they may be UV-curable, used as water based polymer-dispersions or applied as hot melt pressure sensitive adhesives (HMPSAs). HMPSAs have multiply applications - e.g. for tapes, labels, in packaging, in medical products and for automotive applications.
Different mixtures and raw materials are used to define the application possibilities. Generally a HMPSA consists of polymer, resin, oil and antioxidant. Let's have a look at the correlation between SIS polymer and diverse resins in the following.

Major Components and their Effects

HMPSAs to a great extent consist of polymers and resins. With the current polymers used we are dealing with styrene block copolymers (SBC), belonging to the category of rubber polymers. SBC have a triblock structure with a polydiene rubber midblock like butadiene or isoprene and two styrene endblocks.
The thermoplastic, high cohesive styrene endblocks are connected through the elastic midblock. End- and midblock are not compatible, which is among others shown by two glass transition temperatures. Due to their viscoelastic properties these polymers can be well analyzed by using the dynamic mechanical analysis (DMA).

Illustration 1: Diagram of end- and midblock of a SIS-or SBS-molecule

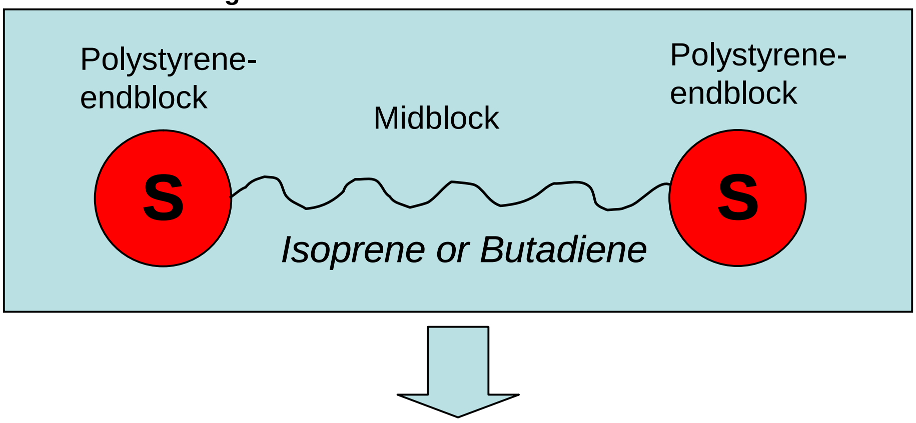
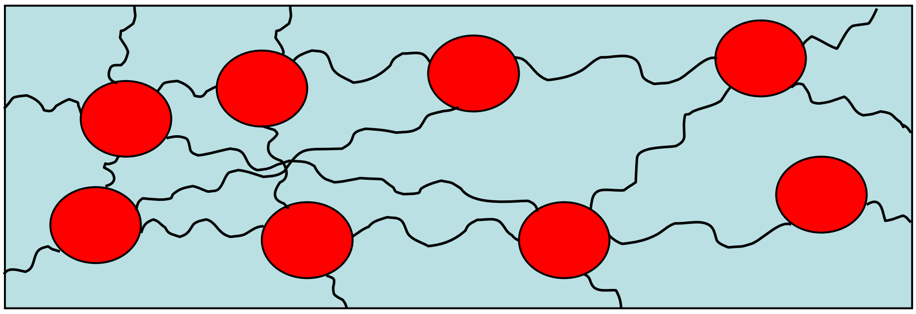


Illustration 2: Diagram of the resulting styrene-blockcopolymers



Important for the use of a resin in HMPSA based on SBC is its compatibility with the polymer. Aliphatic C5-resins are mostly in use with a softening point of 100°C. They do have interactions with the elastomer segments and improve the tackiness.
Aromatic C9-resins are compatible with the styrene endblock. These resins with a softening point (SP) > 150°C give an endblock reinforcement and increase the shear adhesion failure temperature (SAFT). Especially high melting resins like NOVARES TN 160 and NOVARES TN 170 are found more and more in heat resistant applications (ill. 3).

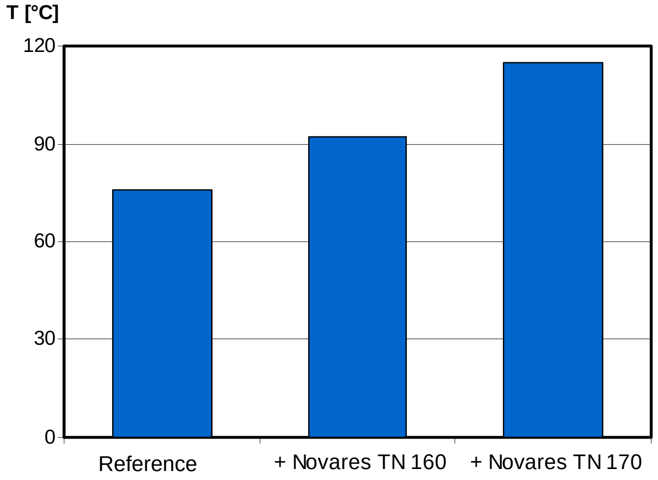


Illustration 3:
SAFT (Shear Adhesion Failure Temperature) by using 10% of high melting resins (HMPSA, SIS-based)

Technical Advantages

Aromatic hydrocarbon resins are not only in use for the heat resistance improvement but also special adhesive properties like shear strength, peel strength and tack adhesion are positively influenced by a partial replacement of C5-resins. By using aromatic hydrocarbon resins the shear resistance can become higher (ill. 4).
Especially NOVARES TN 170 improves this property by enforcing the polystyrene domains and the resulting enhancement of cohesion.

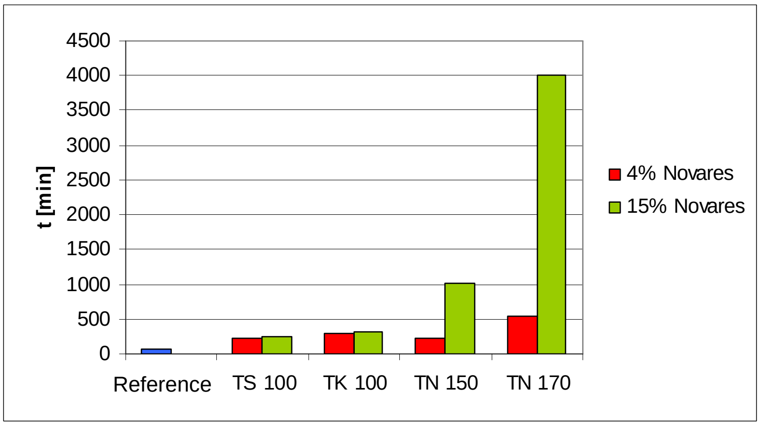


Illustration 4:
Shear Strength
of the HMPSA-formulations

Regarding the peel strength aromatic resins have also a positive influence (ill. 5). Especially NOVARES TN 150 improves the peel strength by up to 35%.

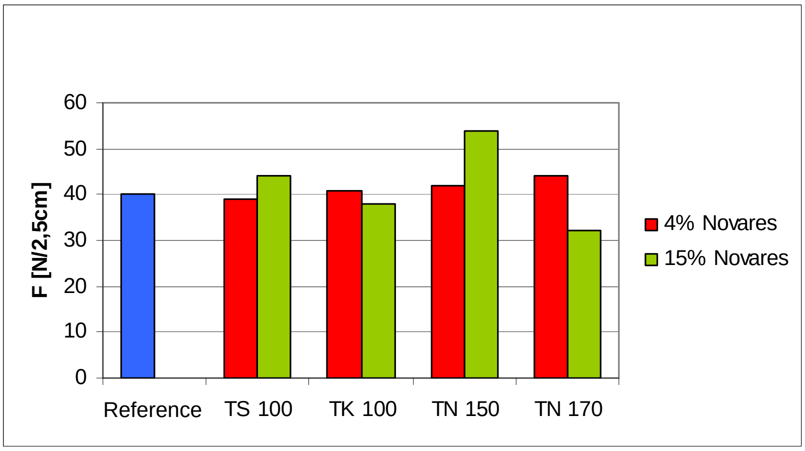


Illustration 5:
Peel Strength of the HMPSA-formulations (180° on steel)

Upon checking the surface tackiness it is shown that with partial exchange of the C5-resin with aromatic hydrocarbon resins an improvement of the tack becomes evident (ill. 6).

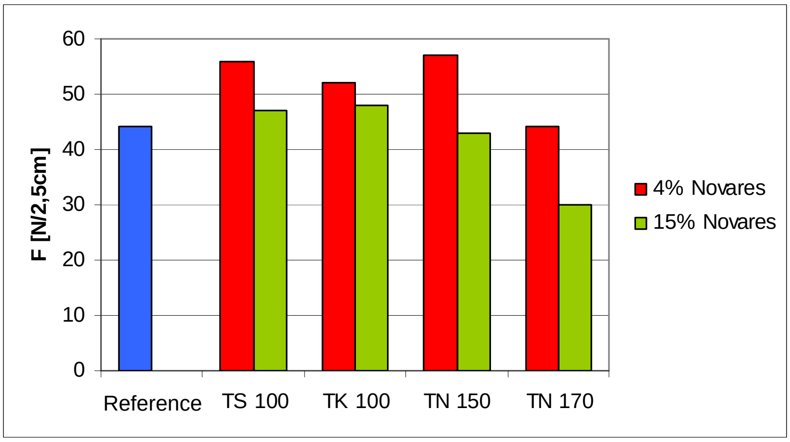


Illustration 6:
Tack Adhesion of the HMPSA-formulations (Quick Stick Test)

The influence of a resin on the midblock is defined by the glass transition temperature (Tg) and therefore by the softening point. It is also defined by its compatibility and therefore by its chemical composition. For this reason the different resins have to be regarded separately.

Due to the underlying raw material recipe NOVARES TN 170 shows the highest aromatic content as well as, high softening point, the highest Tg of approx. 120 °C. Consequently one can realize a considerable endblock reinforcement (improvement of cohesion) due to the excellent endblock compatibility, followed by the Tg increase of these endblocks. The system becomes stiffer and loses tack adhesion.

NOVARES TK 100 and NOVARES TS 100 are aliphatically modified resins with a Tg around 50 °C. Based on their higher aliphatic content an improved compatibility is shown with the midblock. The lower Tg entails a reduction of the Tg of the styrene domains so that better tack adhesion is measured in the investigated concentration range.

In adhesives with NOVARES TN 150 both effects are visible. At 4 % NOVARES TN 150 effectively associates with the midblock portion of the polymer and at a level of 15 % the resin associates and reinforces the endblock.

Testing conditions: SIS-based adhesives were formulated under inert gas at 180°C, afterwards solved in toluene and applied on PE-foil. After 24 h in a climatised room the tests were made according to the AFERA standards.

	Reference	**Modification 1**	**Modication 2**
C5 resin	50	46	35
C9 resin		4	15
SIS-Polymer	30	30	30
Soft Resin	10	10	10
Oil	9	9	9
AO	1	1	1

Table1:
HMPSA formulations

Resin	**SP**	**Chemistry**
NOVARES® TK 100	95- 105 °C	aromatic, aliphatically modified
NOVARES® TS 100	95- 105 °C	aromatic, aliphatically modified
NOVARES® TN 150	145- 155 °C	aromatic
NOVARES® TN 170	165- 175 °C	aromatic

Table 2:
Selected aromatic resins

Dynamic Mechanical Analysis (DMA)

The dynamic mechanical analysis is an excellent aid to determine the interactions between polymer and resin. The temperature sweeps reflect the compatibility of the resins, the influence on the glass transition temperature and the altered viscoelastic behaviour.

Former studies have shown that there is a correlation between the compatibility of the resin and the value of Tg as well as the positioning of the rubber plateau. The peak of tan δ is defined as the glass transition temperature. The area in which the storage modulus stays relatively constant is called rubber plateau.

Compatibility is identified by a pronounced shift of the tan δ peak temperature, associated with a depression in the storage modulus in the plateau. An incompatible system is confirmed by a minimal shift of the tan δ peak along with an increase in the storage modulus in the plateau [1].

This theory is demonstrated with the tested formulations (ill. 7-10).

The influence of the aromatic resins on the Tg is low in all formulations, as shown in the study [1], and is mainly exerted by the high melting resins. The interaction of NOVARES TN 150 with the midblock and the good application test results concerning peel strength and tack adhesion are confirmed by the comparatively high shift of the Tg. By using 4 % of NOVARES TN 150 the rubber plateau remains constant. In this case the endblock reinforcing properties and the positive influence on the midblock are shown. With the two aliphatically modified resins NOVARES TK 100 and NOVARES TS 100 a decrease of the rubber plateau is recognizable, especially for NOVARES TS 100, which is a sign of the better compatibility with the midblock.

The storage modulus G' at room temperature reflects the cohesion. NOVARES TN 170 has the highest and the aliphatically modified NOVARES TS 100 the lowest, as shown with the static shear test.

The Dahlquist criteria [2] defines that a good pressure sensitive adhesive has a storage modulus $G' \leq 3 \times 10^5$ Pa, at 25 °C and 1Hz. All tested formulations fulfil this requirement.

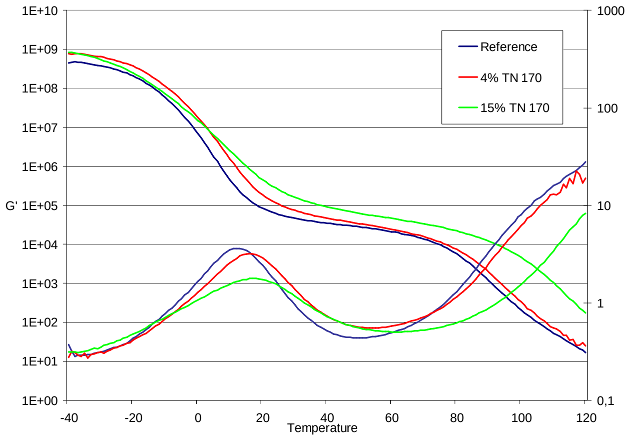


Illustration 7:
T-sweep of the reference and the HMPSA modified with NOVARES TN 170

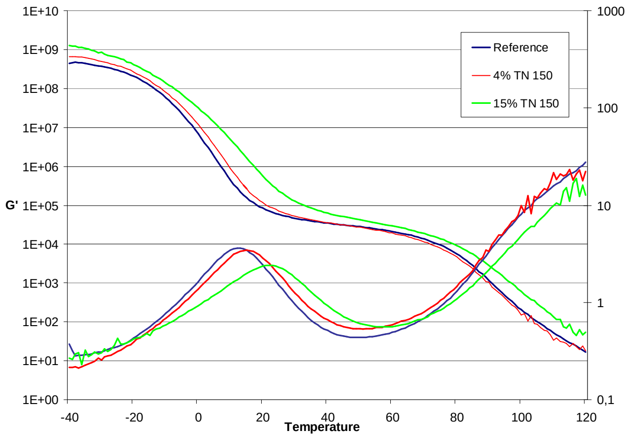


Illustration 8:
T-sweep of the reference and the HMPSA modified with NOVARES TN 150

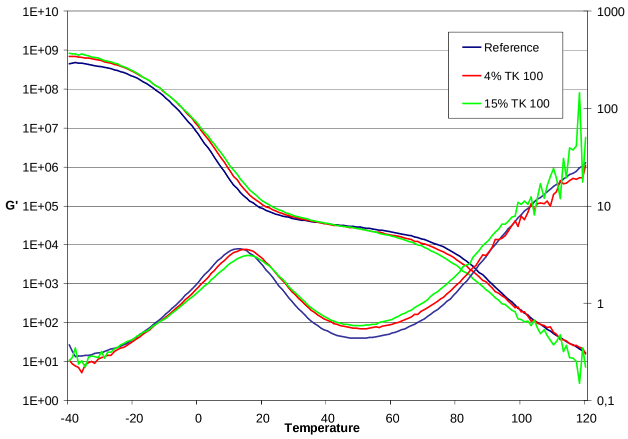


Illustration 9:
T-sweep of the reference and the HMPSA modified with NOVARES TK 100

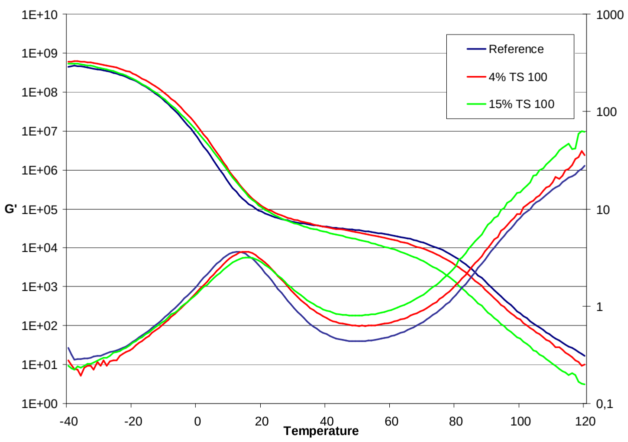


Illustration 10:
T-sweep of the reference and the HMPSA modified with NOVARES TS 100

Conclusions

Application tests of tackifying properties as well as dynamic mechanical analysis of HMPSA formulations have shown, that a partial replacement of aliphatic tackifier with aromatic hydrocarbon resins improves the adhesive properties. The amount to be replaced should be between a concentration area of 4 - 15%. Resins with a softening point > 150 °C like NOVARES TN 170 are an excellent choice for the endblock reinforcement and for the improvement of the heat stability of the hotmelt. Aliphatically modified resins, e.g. NOVARES TK 100 and NOVARES TS 100 with softening points around 100 °C improve the tack adhesion of the system. The aromatic resin NOVARES TN 150 has to be emphasized here – as a result of its raw material composition and balanced molecular weight distribution – it improves multiple properties like shear strength, peel strength and tack adhesion. This resin shows an optimal interaction with the styrene endblocks and the isoprene midblock.

[1] J.B.Class, S.G. Chu, “The viscoelastic Properties of Rubber-resin Blends. I. The Effect of Resin structure”, Journal of Applied Polymer science, Vol. 30, 1985, S.805-814
[2] C.A.Dahlquist, Proc. Nottingham Conf., Fundamentals and Practise, Mac Laren & Sons, London, 1966

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RÜTGERS CHEMICALS GmbH
Varziner Strasse 49, D–47138 Duisburg
Tel. +49 203-4296-02, Fax. +49 203-422551
E-mail: harze@ruetgers-chemcials.de