Silane-modified adhesives and sealants

New polymers with a flexible backbone

Silane-modified polymers have long since made a name for themselves, having proved their worth in providing the most diverse industries with solutions to their adhesive and sealant problems. But a new class of silane-modified polymers is showing that there is still room for improvement. What makes them especially impressive is the variability of their polymer structure.

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In Europe silane-modified polymers have been used to formulate sealants since the late 1980s. The major advantage of this class of polymers is that they combine the outstanding properties of silicones with those of polyurethanes. Sealants based on silane-modified polymers have proved their worth in a host of different applications: from the construction sector to various industrial and transportation applications. These products have been successful on the market because of their special property profile. Adhesives and sealants, when made with silane-modified polymers, bond to the most diverse substrates without these having to be extensively pretreated. They cure without forming bubbles, can be overpainted, and possess a generally well-balanced property profile.

Yet, despite these advantages, there is still room for improvement. A new class of silane-modified polymers, as described below, is showing that this is indeed true. Thanks to their unique variability of the polymer backbone, developers can adapt the polymer to a large variety of applications and over a far broader range than at present.

High-molecular-weight PPGs

Most of the conventional silane-terminated polymers currently available on the market are based on a high-molecular-weight polypropylene glycol (PPG) backbone. Because of the availability of high-molecular-weight PPGs, the range of possible structures, chain lengths, and polarities is severely limited. The PPG backbone is terminated with silane groups, either directly (in SPEs) or via a urethane group (in SPURs) (Figure 1).

The SPE and SPUR polymers are cured under humid conditions and at room temperature, usually by using an appropriate catalyst. Generally, methanol is released during crosslinking.

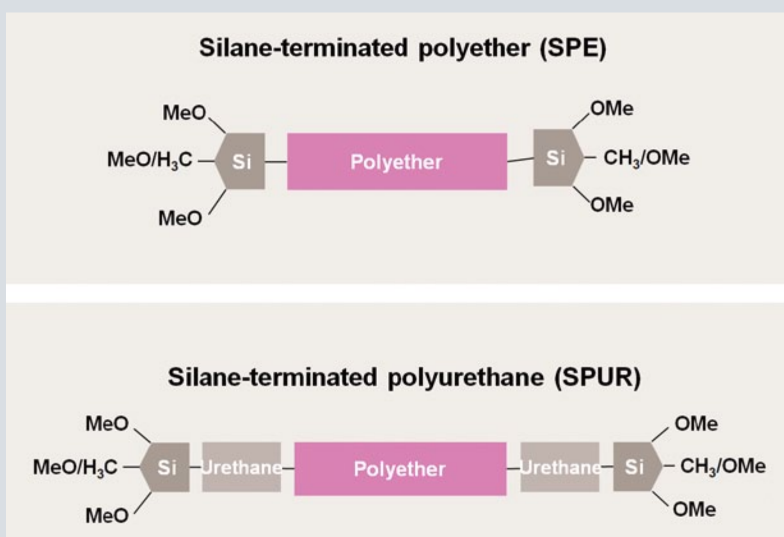


Figure 1: In currently available silane-terminated polymers, the polypropylene glycol (PPG) backbone is terminated with silane groups either directly (in SPEs) or via a urethane group (in SPURs).

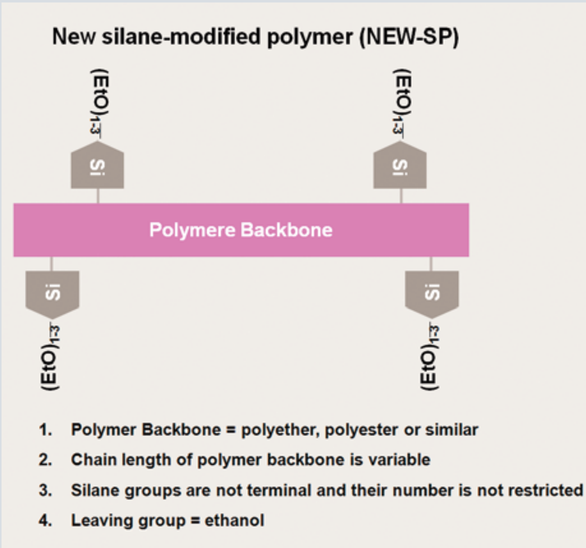


Figure 2: Schematic picture of the novel silane-modified polymer

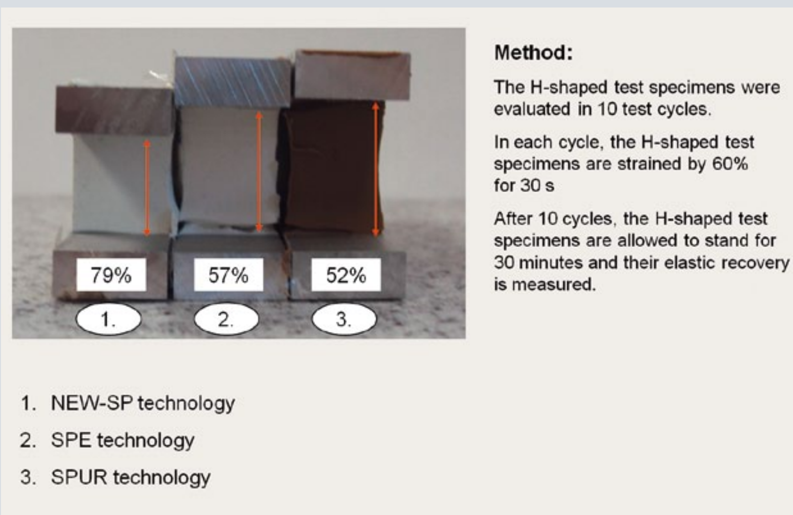


Figure 3: Comparison of elastic recovery for the various technologies

Additional functionalities

The recently developed silane-modified polymers – abbreviated NEW-SP – are produced in a special patent-protected process. This process allows additional functional groups to be incorporated into the polymer backbone modularly, thus producing polymers with entirely new physical properties. In addition, the molecular weight of the polymer backbone can be adjusted over a wide range.

Moreover, the silane functional groups are not incorporated in a terminal position, but are distributed over the polymer chain as side groups in a targeted manner. It is therefore possible to incorporate several crosslinking units into each molecule and, as a result, control the crosslinking density and polarity of the structures. These polymers are also cured under humid conditions, and usually by using a catalyst, at room temperature. Curing, however, does not release toxic methanol but ethanol exclusively (Figure 2).

Advantages of the NEW-SPs

The following three most important properties of the NEW-SPs are also an indication of how they can be used in an extremely broad range of applications in the construction, transportation, automotive, and other industries.

1. Improvement of elastic recovery

By changing the molecular structure, elastic recovery can significantly be improved, compared to commercially available products (Figure 3). The elastic recovery required by ISO 11600, which is greater than 70%, is easily achieved in the NEW-SPs without complex formulation elements. In addition, by employing the new technology, manufacturers can produce, for example, sealants for construction joints at an attractive cost-benefit ratio.

The above-mentioned targeted distribution of the silane units over the molecule can be used to explain the outstanding elastic recovery of the NEW-SPs. This distribution gives rise to a homogeneously linked network without free, unlinked polymer chains, thereby preventing the creep that frequently occurs in cured formulations based on SPE and SPUR technologies.

2. Complete curing in thick layers and area bonding

Other important criteria in moisture-curable polymers are the skin-formation time and through-cure of the products.

The skin-formation times for the NEW-SPs in their current state of development lie in the same range as those for commercially available materials based on the SPE and SPUR technologies. In principle, the speed of skin-formation can be adjusted with a good formulating knowledge. In regard to through-cure, however, the NEW-SPs are markedly superior to the conventional products.

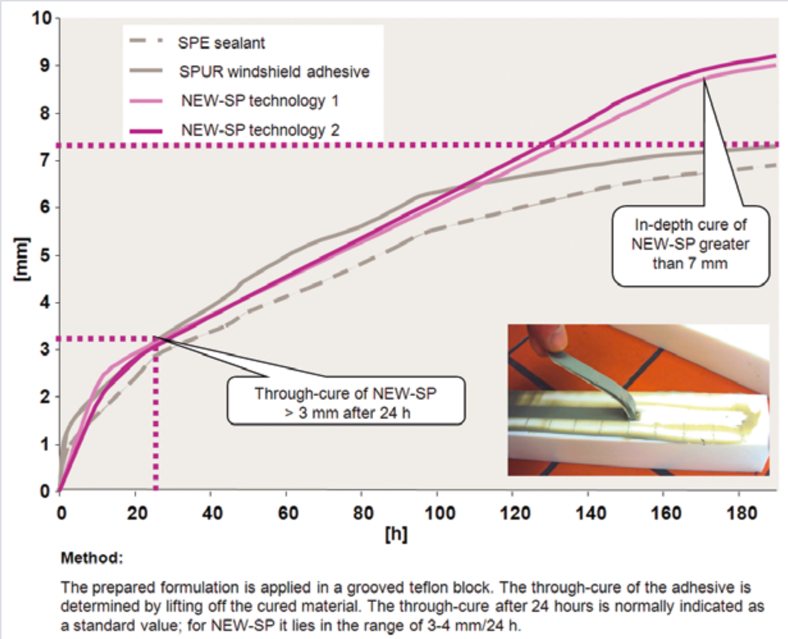
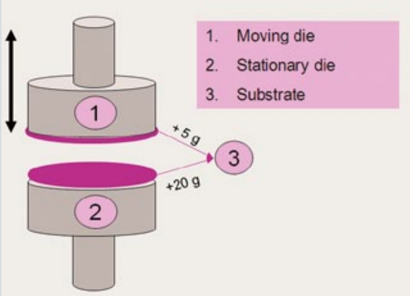


Figure 4: Through-cure behavior of the new silane-modified polymers compared with conventional formulations



Method

Measurement geometry: die, d: 100 mm
Initial gap / layer thickness t_0 1 mm
Movement speed: 25 mm/min

The indicated amount of the adhesive or sealant is applied on the substrate. A gap of 1mm is set as the initial value. Then the measurement is started. A force-time curve is recorded. The parameter determined is the maximum force attained, normalized over the surface area of the measurement geometry.

Initial tack

Plasticizer content	NEW-SP I	NEW-SP II
%	mN/mm²	
0	85	90
10	39	42

Commercial flooring adhesive
SPUR-based
Initial tack = 34 mN/mm²

Figure 5: Method for evaluation of initial tack

When the conventional SPEs and SPURs were used, the problem often arose of much slower through-curing of thick layers (from about 7 mm onward) due to poor penetration of water. This problem has now been solved, because the new NEW-SPs improve in-depth curing (Figure 4).

Laboratory tests have shown that the NEW-SPs can cure through to at least 9.5 mm, making it possible in the future to fill joints that are wider as well as deeper than at present. This improvement ensures a reliable through-cure of adhesive and sealant materials and thus contributes immensely to the quality and load capacity of the joint.

Bonding large surface areas will also be possible, because when the NEW-SP is used, complete crosslinking is ensured, and thus full end-strength is achieved. This has been a problem up to now, because the through-cure of the polymer did not extend to the middle of the bonded area, and therefore the joint was weakened by material that had not been fully cured.

3. Good initial tack for sophisticated assembly applications

In addition to the above-mentioned properties, it is possible, thanks to the highly variable polymer backbone, to improve the initial tack of the polymers.

In this case, it is important to bear in mind that the properties of the polymer backbone must be matched to the substrate to which it is to be bonded. This is done by skillfully modifying the polymer backbone to adjust crystallinity and polarity. The above-mentioned modular concept of the NEW-SPs opens up many different applications here. The new technology can be used in several applications: from adhesives for floorings, through to lightweight construction in the automotive and transportation industries, on to novel design elements in the building industry. In particular, the new polymers make it possible to bond and seal dissimilar materials, providing the end user of the adhesive or sealant formulations considerably greater freedom of design. To evaluate the initial tack of the NEW-SPs, formulations for applications in the area of flooring adhesives were used. The NEW-SPs have been used in relevant formulations to be compared with a commercially available SPUR-based system (Figure 5). The tests showed that initial tack that is about 20 percent higher is attainable.

The laboratory studies also indicated that formulating adhesives and sealants with high initial tack and resulting good tensile strength of the cured polymer is in principle easily possible. Strengths exceeding 3N/mm² are attainable in appropriate formulations.

Summary

In the new silane-modified polymers presented here, the particularly flexible variability of the polymer backbone makes it possible to adjust initial tack, elastic recovery, and through-cure to satisfy the various requirements placed on adhesives and sealants for construction, transportation, automotive, and industrial applications.

For example, the excellent through-cure behavior and high initial tack of the new polymers are suited to meet the demand for reduced cycle times and improved productivity in automotive and transportation applications.

The same holds for the growing need to bond dissimilar materials. The NEW-SPs make this easy to do, opening up a new dimension in design freedom for lightweight construction and, for example, modern, energy-efficient living. Metal-plastic and metal-FRP combinations can be achieved, as can the bonding of metals with hydrophilic mineral substrates.

Finally, formulated adhesives and sealants using the new polymers are distinguished by improved strengths of the order of those attained by polyurethane adhesives and sealants today. ■

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