Markus Hallack*, **Tobias Unkelhäußer**, **Hans Görlitzer**, **Corey King** and **Rainer Lomölder**, Evonik Industries AG, discuss silane/urethane-hybrid crosslinkers for multifunctional, scratch resistant one and two pack wood coatings

The next step in wood coatings

Evonik has developed a new and versatile product family of crosslinkers/binders for high performance wood coatings. The innovative approach combines the benefits of silane chemistry with the performance of polyurethanes enabling excellent scratch resistance, while maintaining urethane properties in coatings.

3-Isocyanatopropyltrimethoxysilane (IPMS) is the core building block of the novel technology platform and responsible for a high freedom of design creating tailor-made binders and crosslinkers.

The resin concept also enables non-isocyanate (NISO) technology exhibiting and exceeding polyurethane performance. This technology can be realised generally in one and two component coating formulations.

Modern aliphatic 2K-polyurethane wood coatings are considered as today's benchmark to environmental etch, durability and are, in general, well-known for their excellent balance of flexibility and hardness. Furthermore, superb overall properties and good adhesion to wooden substrates are advantages, which helped the technology to set the benchmark in the wood coating industry in the last decades.

Here, especially the multilayer coatings, which are easy to use with their universal use in sanding or filling primer and top coat.

MULTILAYER MATTE CLEAR COATS NEED TO FULFIL PREMIUM REQUIREMENTS

The top clear coat or varnish layer of a wooden piece of furniture is the first defence barrier against various mechanical/physical and chemical impacts. Brushes and dust leaving micro scratches, aggressive chemicals like cleaners and suntan lotion causing swelling and coloured substances like red wine leading to discolouration (haze). The clear coat needs to look like new even after years.

The quality of clear coats has steadily improved but, nevertheless, there is still a need to significantly improve certain characteristics particularly the abrasion resistance. This trend is not just limited to market segment specific clear coats.

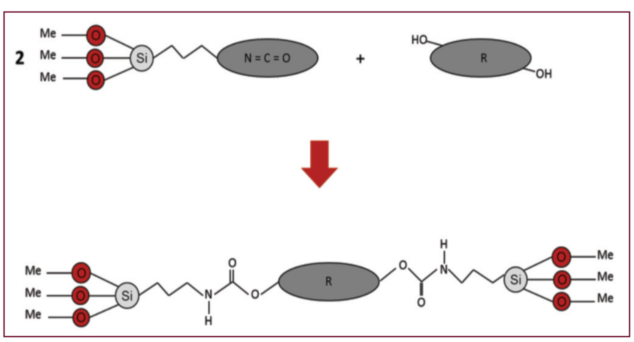
An appropriate way to gain reliable enhancements, in matters of increasing scratch resistance of clear coats and to satisfy the market needs and trends concerning a further integration of functions, is ensured by the use of silane/urethane-hybrid crosslinkers. As shown in **figure 1** IPMS can be reacted with any kind of (isocyanate) reactive groups (R-group) preferably with hydroxyl groups of diols, polyols or oligomeric diols to build an alkoxy-silane functional urethane linked non-isocyanate (NISO) crosslinker/binder.

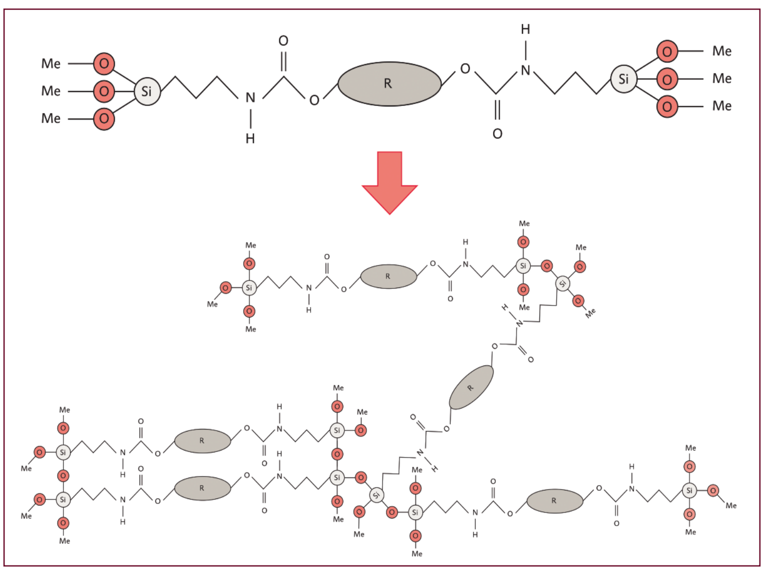
The choice of R-group will primarily determine the properties of the crosslinker or binder and, hence, will also influence significantly the attributes of the coating. For example the longer the backbone of the crosslinker or binder the more it acts as a flexibiliser in the coating. In contrast a branched and short R-group will result in a higher hardness.

But due to the fact that by formulating with VESTANAT EP-M type crosslinkers urethane linkages are imparted, beneficial properties, which are known from aliphatic polyurethanes eg chemical resistance, good adhesion and excellent mechanical properties are provided.

Fig 1. Below: IPMS-based silane/urethane-hybrid crosslinker, containing urethane groups, terminated by tri-functional alkoxy-silane structures

Fig 2. Right: Hydrolysis/condensation reaction forming siloxane networks





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Component A
97.0% by wt Vestanat EP-MF 201
2.9% by wt Xylene
0.1% by wt Tego Glide 410

100%

Selected properties of the clear coat

- Touch-dry within one hour
- Outstanding scratch resistance
- Excellent chemical resistance

Fig 3. Above: Example of a clear coat formulation based on pure moisture curing binders for high end glossy scratch resistant formulations

Component A
65.0% by wt Synthalat A 1633[1] (Acrylic Polyol)
34.9% by wt Butyl acetate
0.1% by wt Tego Glide 410

Component B
VESTANAT EP-MF 201

Is there a fixed mixing ratio?

No, there is a free choice between 9:1 and 1:9 depending on the targeted coating performance

Fig 4. Above right: Example of a 2K clear coat formulation based on moisture curing binders and an acrylic resin
1. Supplier Synthopol Chemie

There are two possible reaction mechanisms how the illustrated IPMS-based crosslinkers can react via its alkoxy groups in coating systems. For ambient curing the reaction is a combination of hydrolysis and condensation to form siloxane linkages (Si-O-Si). The other crosslinking mechanism is a transesterification reaction, which occurs only if a hydroxyl-group, eg of an acrylic polyol, is present and at elevated temperatures. Each of the described mechanisms can be accelerated by using appropriate catalysts, which are numerously described in diverse publications[1,2].

This paper describes a performance analysis of coatings, which have been crosslinked at ambient temperatures, just by hydrolysation. On one hand by itself and on the other, as a hardener beside an hydroxyl functional acrylic resin to build an interpenetrated network, which is known as well from the epoxy-siloxane technology.

To analyse the impact of siloxane networks compared to standard 2K PU formulations, the following clear coat formulation was used as a standard to show the performance of the Vestanat EP-MF 201 as a single binder. The binder was formulated according to the following formula. The curing time is approximately 1hr at ambient temperature.

Vestanat EP-MF 201 is a solvent and isocyanate free, ready-to-use version of an alkoxy silane terminated crosslinker or binder requiring no other crosslinkers (ie poly-isocyanates).

It can be used for 1K moisture curing systems. The resulting coatings show outstanding scratch, stain and chemical resistance.

By combining the Vestanat EP-MF 201 with compatible polyols 2K formulations are obtained. The right mixing ratio between the two components should be determined. Due to an interpenetrated network, properties like scratch, stain and chemical resistance can be adjusted on demand. There is no need to add poly-isocyanate crosslinkers. The final coating is a NISO-system and – depending on the characteristics of the polyol – potentially low in VOC.

Figure 5 shows a technology comparison between 2K-PUR (left) and a 2K Vestanat EP-MF 201 based formulation (right). Both systems were applied on wood and were scratched using a modified crockmeter test. While many and very distinctive scratches occur on the unmodified 2K-PUR, the Vestanat EP-MF 201 based formulation resists the abrasive impacts keeping the shiny, initial appearance.

Besides the area of wood coatings there is also an attractive application when it comes to plastic coatings. Here the same properties will lead to scratch, stain and chemical resistant coatings. This product profile is essential for sporting goods or even in the automotive industry.

Silane/urethane-hybrid crosslinkers for multifunctional coatings

The backbone of the novel crosslinker technology is variable, which leads automatically to a high freedom of design for creating tailor-made crosslinkers with multifunctional functionalities in the future.

RESULTS

The Vestanat EP-M range is a family of silane/urethane-hybrid crosslinkers to generate multifunctional, scratch resistant coatings applicable on a variety of substrates. Due to specific modifications curing even at ambient temperature is possible. These crosslinkers and binders can be used in several application fields, ie also beyond wood coatings. This technology enables high performance NISO-coatings even exceeding PUR performance. But also 'traditional' 2K-PUR coatings can be improved significantly in scratch resistance by substitution of the isocyanate hardener.

Fig 5. Comparison of clear coats (applied on wood boards) after modified crockmeter scratch test / 2K-PUR (left) vs 2K-based Vestanat EP-MF 201 formulation (right) 50% wt of Vestanat EP-MF 201 were used in this formulation calculated on the acrylic binder

References
1. Lomölder, R; Görlitzer, H; Hallack, M; Unkelhäußer, T: Patent application EP 2 676 982, 2012.
2. Witucki, G: *Journal of Coatings Technology*, 1993, 57-60.