A Winning Team for High-Solids 2K PUR Coatings

Combinations of HS polyester diols, HS acrylic polyols and VESTANAT® T 1890

IPDI trimer (VESTANAT® T 1890) exhibits many benefits in 2K clearcoats, especially for automotive refinish. Beside the well known positive influence on the balance of drying performance, pot-life and initial hardness, this crosslinker is able to compensate for the negative impact of a polyester modification on the final hardness and therefore opens an interesting option for higher-solids 2K PUR coatings.

Lightweight version of VW Golf modified with Evonik solutions and coated with high solid 2K PUR coating containing VESTANAT®T 1890

In today's coatings industry, acrylic 2K polyurethane (PUR) coatings set the benchmark for high performance, outstanding mechanical properties and appearance combined with excellent weatherability and environmental etch resistance. Due to increasingly stricter environmental regulations, the industry is forced to develop environmental friendly coatings, one option being HS 2K PUR coatings.

In addition to meeting regulatory standards, all high-solids formulations must also meet the requirements of the final applicators in order to be commercially successful. A major challenge is to balance the pot life of the wet paint and drying characteristics upon application while maintaining the hardness, chemical resistance and scratch resistance of the cured coating on a level expected from industry standard medium solid (MS) systems.

Figure 1

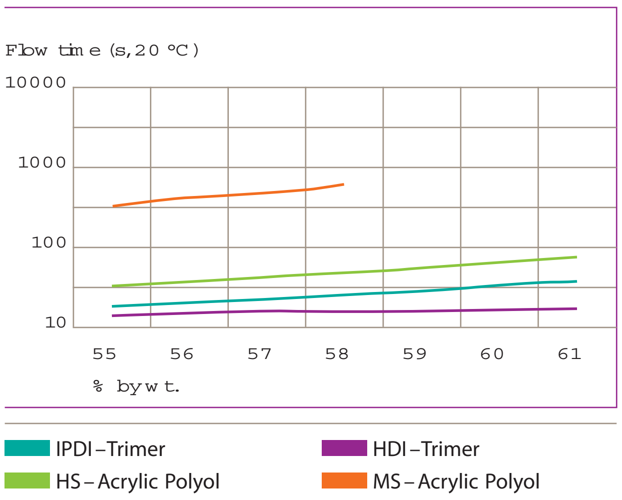


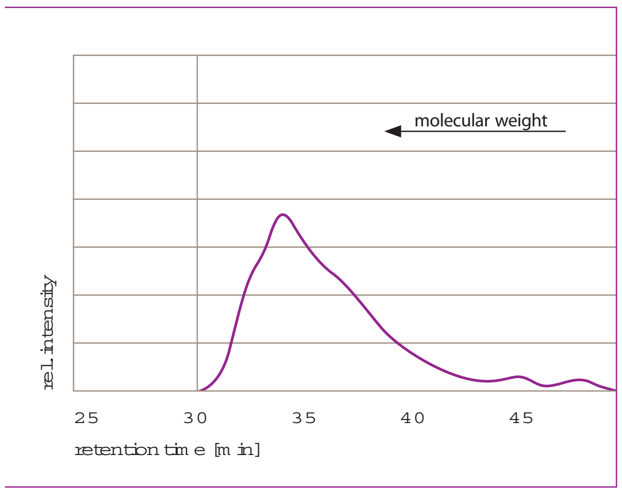
Figure 1: Viscosity profiles of acrylic polyols and polyisocyanates

The acrylic polyol determines the VOC content

A closer look at the relevant components of a 2K PUR coating reveals easily which component should be modified first: the acrylic polyol of a MS-system (MS-APO), representing approx. 2/3 of the organic binder moiety, exhibits @ 55 % solids a viscosity 25 times higher than the polyisocyanate crosslinkers (Figure 1). High-solid acrylic polyols (HS-APO) on the other hand, typically show a similar viscosity/solids profile compared to the polyisocyanates which are of relatively low molecular weight.

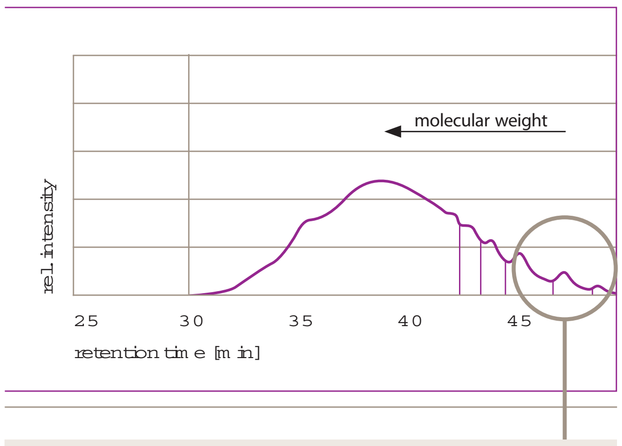
Lowering of the viscosity of the acrylic polyol is typically achieved by reducing the molecular weight of the resin. This effect can be demonstrated by size exclusion chromatography (SEC or GPC) of the corresponding compounds (Figure 2).

Figure 2.1



SEC Chromatogram of MS-Acrylic Polyol

Figure 2.2



SEC Chromatogram of HS-Acrylic Polyol

It is evident that at a comparable OH-content, the lower viscosity resin (lower molecular weight) not only contains a larger portion of low molecular weight molecules, but also – more important – exhibits a lower average OH-functionality per molecule. Also, such HS acrylic polyols contain a considerable amount of mono – or non-functional species that could act as plasticizers, leading to network failures.

As a result, 2K HS PUR coatings often exhibit poor drying characteristics. This inherent deficiency is often compensated by the use of higher catalyst levels resulting in very short pot lives.

VESTANAT® T 1890 (IPDI trimer) is compensating the loss of drying performance of HS systems

Another option to overcome this poor balance of pot life and drying characteristics is to employ a blending approach of different polyisocyanate crosslinker types that is well known from standard MS-systems: Compared to the pure HDI-trimer which is a liquid at room temperature, the IPDI-trimer is an amorphous solid (Tg approx. 70 °C) that contributes also to good physical drying of the applied paint. Such crosslinker blends are often used to optimize the balance between drying and pot life without dramatic changes in catalyst level. The question arises: Is this blending approach also applicable for HS systems?

In order to investigate the effect of polyisocyanate blending on the performance of a HS 2K system, we combined a HS acrylic polyol (Macrynal® SM 565) with various crosslinker compositions. All clearcoats were adjusted to the same VOC level (420 g/l) and to a similar pot life by varying the level of dibutyltin dilaurate (DBTDL) catalyst. The results listed in Table 1 demonstrate that the difference in spray viscosities (DIN cup 4 [s]) among all formulations was marginal but due to the lower reactivity of IPDI based polyisocyanates, a higher catalyst level had to be used in order to achieve an equal chemical reactivity as reflected by the pot life.

Also, in the cases of high-solids systems, the polyisocyanate blends led to improvements in initial hardness as well as a better drying of the wet film. Thus it was observed that the incorporation of IPDI-trimer optimized the improved properties of HS 2K clearcoats without negatively affecting the VOC content.

Table 1

HT 2500 LV/T 1890	100/0	70/30	50/50
Catalyst (% DBTDL)	0.0005	0.003	0.005
Gel-time [h]	9	9	10
Visc. DIN4-cup [s, 20°C]	20“	21“	21“
Hardness [König, sec] after 1d 3d 7d	tacky 93 162	22 113 171	22 92 146
Erichsen cupping [mm]	9.5	9.0	8.5
Dust dry time [min]	780	720	540
Touch dry time [min]	840	480	240

Table 1:Improved drying of a 2K HS clearcoat by using VESTANAT® T 1890 (IPDI trimer), amb. temp.cure

VESTANAT® T 1890 compensates the negative effect of HS polyesters on hardness

A further reduction of VOC via reduction of molecular weight of the acrylic polyol is very problematic because the proportion of molecules with mono-functionality increases to a very unfavorable level, resulting in poor chemical resistance. Alternatively, we investigated the use of bifunctional, low molecular weight polyester diols as co-polyols. An advantage of using polyester is that their functionality is not affected by the molecular weight. However, they generally have a negative influence upon the physical drying properties.

Clearcoats were formulated with 70/30 blends of acrylic polyol (Macrynal SM 565) and a HS polyester diol (Oxyester EP–HS 2272 from Evonik – Table 3: Formulation). The results listed in Table 2 clearly show the negative effect of the HS polyester: the coating crosslinked only with HDI trimer (VESTANAT® HT 2500 LV, left column) was not only characterized by a very low hardness after 1 day, but final hardness was far too low to be acceptable.

However, by using 50/50 blends of HDI trimer and VESTANAT® T 1890 (IPDI trimer) the negative effect of the HS polyester was compensated. By the use of the combination of HS-polyester diol and IPDI trimer the solid content of the original clearcoat formulation (Table 1) could be raised from 58 % to approx. 62 % by weight @ 20 sec. DIN cup 4, 20 °C!

37.5 % by wt. Macrynal® SM 565	1
11.4 % by wt. Oxyester EP–HS 2272	
2.4 % by wt. TEGOKAT® 218 (DBTDL) (1 % by wt. in butyl acetate)	3
0.1 % by wt. Pot life extender	
0.4 % by wt. Tego Flow® 300	2
9.9 % by wt. Butylacetate	
9.9 % by wt. Xylene	
11.7 % by wt. VESTANAT® HT 2500 LV	2
16.7 % by wt. VESTANAT® T 1890 L	2

1 Cytec
2 Evonik Degussa GmbH
3 Goldschmidt TIB GmbH

Table 2

HS APO/HS PES	7/3	7/3
HT 2500LV/T 1890	100/0	50/50
DBTL/PL-Extend. [%]	0.03/0.2	0.05/0.2
Gel-time [h]	12	11
Visc. DIN4-cup [s. 20 °]	20	20
Hardness 1d König [s] 7d	29 94	49 152
Cupping [mm]	10	9.5
Solids content [%]	61.5	61.8

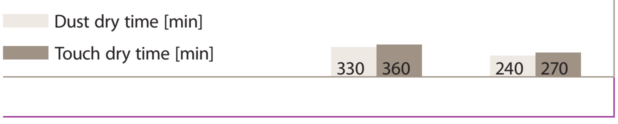


Table 2: Improvement of performance of a HS-polyester modification of an HS acrylic PUR clearcoat.

Table 3

	Traditional	HS-Acrylic	HS-Acrylic /HS-Polyester
HT 2500LV/T 1890	70/30	70/30	50/50
DBTDL/PL-Extend. [%]	0.01/–	0.03/–	0.05/0.2
Gel-time [h]	10	9	11
VOC at spray [20 sec. Din cup 4]	530	420	380
Hardness 1d König [s] 3d 7d	30 80 170	20 110 170	50 140 150

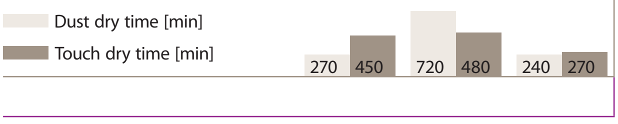


Table 3: Comparison of the latest development to MS – and HS-Systems, amb. temp. cure

The comparison of the performance of different CC formulations given in Table 3 clearly shows that the polyester-modified variant of a high-solid 2K acrylic PUR clearcoat performed equivalently to the traditional MS system while exhibiting a much lower VOC level.

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Summary

- The solid content of a 2K PUR coating is mainly determined by the characteristics of the polyol component
- The use of IPDI Trimer (VESTANAT® T 1890) has no significant effect on the VOC level of HS-formulations
- Especially in high solids systems, the use of IPDI Trimer (VESTANAT® T 1890) improves drying and development of initial hardness
- IPDI trimer is especially beneficial in polyester-modified HS 2K acrylic clearcoats to compensate for the lower hardness inherent in such systems