

UV-Curable Acrylic Urethane Clearcoats for Automotive Applications

By Daniel B. Pourreau

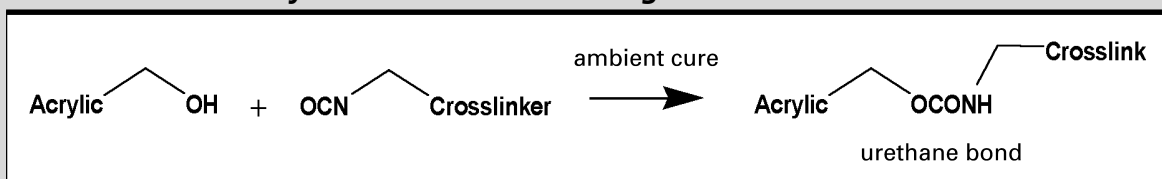
Acrylic urethane coatings are used in both automotive manufacturing and refinishing because of their versatility, durability, appearance, superior weatherability and acid-etch resistance compared to other resin systems. In automotive refinishing, the most common coating type is the two-component (2K) system, where an acrylic polyol solution is mixed with a poly-isocyanate just before it is applied to the vehicle. The coating then cures by a combination of solvent evaporation and chemical crosslinking to form a tough and durable film (Figure 1).

Automotive OEM clearcoats are also based on acrylic urethanes, but are obtained by crosslinking carbamate-functional acrylics with melamine resins. Two advantages of this chemistry are that the coating is single-component and the melamine crosslinker is less expensive and hazardous than the polyisocyanates used in automotive refinishing. One disadvantage is that the coatings must be baked.

UV-curable coatings are also one-component (1K) systems that cure by photoinitiated polymerization of the acrylated monomers and oligomers in

FIGURE 1

Conventional 2K acrylic-urethane crosslinking reaction



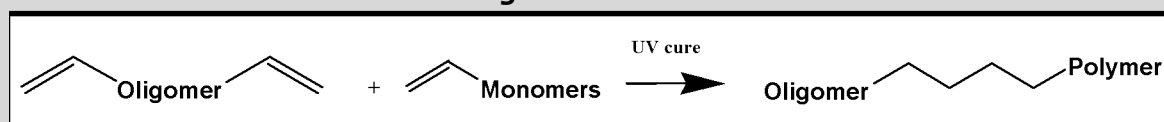
The cure speed and film properties can be tailored by varying the hardness (Tg) and functionality (EW or OH number) of the acrylic polyol, the isocyanate and solvents used, and by the addition of catalysts and activators. Heat is often applied to accelerate cure and solvent evaporation. However, compared to UV-curable coatings, 2K urethanes cure much more slowly, and have limited pot life and higher volatile organic compounds (VOCs).

the formulation (Figure 2). These typically do not contain VOCs and cure is instantaneous.

Compliance and productivity are key benefits of UV-curable coatings over solventborne 1K and 2K urethanes. However, because of the chemistry of UV-curable oligomers and the significant shrinkage that occurs during the curing process, UV-curable coatings are usually not as tough or weatherable as 2K urethanes. UV-curable urethane

FIGURE 2

Conventional UV-cured crosslinking reaction



oligomers, which comprise the majority of the formulation components, are usually prepared from polyether or polyester polyols. These resins are more susceptible to UV degradation and hydrolysis than acrylic polyols and thereby reduce the weatherability of UV coatings compared to acrylic urethane coatings.

Reports of urethane prepolymers based on acrylic polyols are virtually non-existent and the author is aware of no such commercial products. This is in part because, unlike condensation polymers, the functionality of acrylic polyols cannot be limited to two or three. Consequently, treating conventional acrylic polyols with diisocyanates causes rapid crosslinking of the polymer chains and produces highly viscous or gelled products, which are not suitable for high solids coatings.¹

However, by using new acrylic polyols with all secondary OH functionality^{2,3} low-viscosity UV-curable acrylic urethane oligomers in high yield were prepared. These acrylated urethane acrylic oligomers were used to formulate tough, 1K UV-curable coatings for weatherable applications. These same acrylic polyols were also used to formulate 2K UV-curable acrylic urethane coatings by replacing a portion of the solvents and resins in conventional 2K urethane formulations with acrylated monomers. Both types of formulations were sprayed using conventional HVP equipment, UV-cured instantly to a tack-free state and, in the case of the dual-cure

system, by chemical crosslinking in the dark. The final coating appearance and durability were outstanding, rivaling the best commercial systems on the market today.

Replacing polyesters and polyethers in urethane oligomers with acrylics opens the door to the development of more durable UV-curable coatings for high-performance applications such as automotive topcoats. The synthesis of these new oligomers and their formulation in 1K clearcoats is described. This technology is also compared to the 2K UV formulations developed earlier.⁴

Experimental

Raw Materials

ACRYFLOW™ acrylic polyols were obtained from Lyondell Chemical Company. JONCRYL® 920 (acrylic polyol) was obtained from Johnson Polymer. Darocur® 4265 (photoinitiator) was obtained from Ciba Specialty Chemicals. UV monomers were obtained from Sartomer Company and used as received.

Attempted Preparation of an Acrylic Urethane Acrylate Oligomer with a Conventional High Solids Acrylic Polyol

An acrylic polyol (850 g, 80% solids in MAK) was charged into a 2-L glass resin kettle equipped with a stirrer, addition funnel, air inlet, and thermometer and heating mantle. Dibutyltin dilaurate (DBTDL, 0.88 grams) and 2,6-di-*t*-butyl-4-methylphenol (2.0 g, BHT) were added to the reactor and the reaction temperature increased to

40°C. Isophorone diisocyanate (125 g) was added to the reactor over a period of one hour under air sparge. The addition rate was controlled to keep the reaction temperature at 40°C. The reaction contents gelled after 89 grams of IPDI had been added.

Preparation of a Low Tg Acrylic-Polyester Urethane Acrylate Oligomer

Isophorone diisocyanate (IPDI) (400 g) and dibutyltin dilaurate catalyst (0.42 g) were charged into a 1-L resin kettle equipped with a stirrer, a nitrogen inlet, a thermometer and an addition funnel. Acrylic polyol (780 g) was gradually added as a 70% butyl acetate solution to the stirred reactor at 50°C over an hour and the reaction mixture stirred for an additional hour. Methyl ether hydroquinone (MEHQ, 3 g) was then added to the resulting prepolymer. Hydroxyethyl acrylate (HEA, 340 g) was gradually added to the reactor mixture over an hour at 50°C and the reaction mixture stirred for another two hours. The resulting product was a clear solution of acrylated resin. The reaction yield was quantitative.

Preparation of an Acrylic Urethane Acrylate Oligomer for UV-Curable Coatings

A quart sized round amber bottle was charged with 111.0 g of IPDI monomer and 0.8 g of DBTDL. To this bottle, 325 gram of acrylic polyol (80% solution in *n*-BuAc) diluted with 121 grams of *n*-BuAc was added in three parts one hour apart.

TABLE 1

Relative rate constants of the isocyanate reaction with primary OH groups

$$\text{OCN-R-NCO} \xrightarrow[k_1]{\text{HO-R}' } \text{OCN-R-NH-C(=O)-OR}' \xrightarrow[k_2]{\text{HO-R}'' } \text{''RO-C(=O)-NH-R-NH-C(=O)-OR}'$$

Isocyanate	k1	k2	k1/k2
TDI	400	33	12.1
MDI	320	110	2.9
IPDI	0.62	0.23	2.7
HDI	1	0.5	2.0
H12MDI	0.57	0.4	1.4

The bottle was rolled to mix the contents between each addition. Hydroxyethyl acrylate (66 g) was then added. The mixture was then placed in a 50°C oven for two hours then rolled overnight. The resulting mixture was a 70% solids solution of acrylic polyol-IPDI-HEA acrylate in n-BuAc with a Brookfield viscosity of 2,620 cps.

Preparation of a Flexible Acrylic-Polyester Urethane Acrylate Oligomer for UV-Curable Coatings

A quart-sized round amber bottle was charged with 111.0 g of IPDI monomer and 0.8 g of DBTDL. To this bottle, 325 gram of acrylic polyol (80% solution in n-BuAc) further diluted with 174 grams of n-BuAc was added in three parts one hour apart. The bottle was rolled to mix the contents between each addition. Caprolactone acrylate (185 g) was then added. The mixture was then placed in a 50°C oven for two hours then rolled overnight. The resulting mixture was a 70% solids solution of acrylic polyol-IPDI-caprolactone acrylate in N-BuAc with a Brookfield viscosity of 1,941 cps.

Preparation of Acrylic Urethane Acrylate Oligomers for UV-Curable Coatings and Adhesives

A reactor was charged under air sparge with 100.0 g of IPDI monomer, 100 grams of diluent (n-BuAc or HDDA), 0.04 grams of MEHQ and 0.8 g of DBTDL. To this mixture was added three 146.67 aliquots of acrylic polyol (90% solution in n-BuAc or HDDA, hexanediol diacrylate) one hour apart. HEA (57 g) was added over 20 minutes. The mixture was then heated to 40°C and stirred for one hour. The resulting mixture was an 80% solids solution of acrylic polyol-IPDI-acrylate oligomer with a Brookfield viscosity of 3,900 cps (n-BuAc) or 38,800 cps (HDDA). The acrylic polyol acrylated oligomer solution in n-BuAc was stable indefinitely at room temperature whereas the HDDA solution gelled after approximately one week.

Preparation of UV-Curable Acrylic Urethane Clearcoats

The acrylated oligomers dissolved in acrylate monomers and treated with 4% by weight on total resin solids of photoinitiator. The resulting

formulations were reduced to spray viscosity with acetone and applied to steel panels coated with Bonderite 1000 and white base-coated steel and aluminum panels. Coatings were irradiated after a 30 minute flash-off period. Physical property tests were performed on the coated steel panels. Appearance tests were performed on the white base-coated steel panels. Weatherability tests were performed on the white base-coated aluminum panels.

UV Equipment and Cure

The panels were UV cured using a Fusion UV Model LC-6B Benchtop Conveyor equipped with a mercury vapor lamp ("H" bulb). The conveyor belt speed was set at 16ft/min. Actinometry was performed using a PowerPuck® from EIT Inc. All coatings were usually, in one pass, tack- and print-free, which corresponds to 1.65 J/cm², and were subjected to 3-11 more passes to ensure full cure. The number of passes required to cure the coatings was dependent on the Tg of the oligomers, the monomers used and the level of photoinitiator in the formulation.

TABLE 2

Physical properties of acrylated acrylic urethane oligomers and UV-cured coatings

Oligomer properties	Acrylic Polyol UHA	Acrylic Polyol UHA	Acrylic Polyol UHA	Acrylic Polyol UCA
Hydroxy acrylate	HEA	HEA	HEA	CA
Diluent	HDDA	n-BuAc	n-BuAc	n-BuAc
% Non volatile content	100%	80%	70%	70%
Viscosity, cps	38,800	3,900	2,620	1,941
Mn	800	3,057	2,081	3,442
Pd	26.4	8.3	8.0	18.8
Coating Properties, 3 mils wet on Bonderite® steel				
Photoinitiator	4%			
Koenig Hardness	28	18	109	17
Impact resistance				
Front	60	160	20	160
Reverse	<20	160	<20	160
MEK Rubs	69	20	90	60
% Crosshatch Adhesion	0	20	95	95

Results and Discussion

Preparation of Acrylated Acrylic Urethane Oligomers

Attempts to prepare acrylic urethane prepolymers with conventional acrylic polyols or with isocyanates other than IPDI, produced gels. This is attributed in part to the higher reactivity of conventional polyols that are usually based on HEA or methacrylate (HEMA). Primary OH groups react 2-4 times faster with isocyanates than secondary ones. In addition, isocyanates can have very different reactivities, even in the same molecule, see Table 1.

By using IPDI, a slow-reacting isocyanate with a reactivity ratio of 2.7, and new acrylic polyols with all-secondary OH functionality, low-viscosity acrylic aliphatic urethane prepolymers were produced by controlled addition of the polyols to IPDI monomer at ambient temperature. The reaction proceeded rapidly and in

quantitative yield. Low-viscosity acrylated acrylic urethane oligomers were obtained by adding of hydroxy-functional acrylates such as HEA or caprolactone acrylate (CA) to the acrylic urethane prepolymers. Oligomer and coating properties are listed in Table 2.

UV-curable coating formulations were obtained by adding 4% of a blend of bis-acylphosphine oxide/ ∞ -hydroxyketone photoinitiators. The urethane acrylate and caprolactone acrylate yielded soft films following UV irradiation, whereas the hydroxyethyl acrylate yielded a hard film with good adhesion to pretreated metal and good chemical resistance. The diluents had an effect on film properties. Acrylic polyol UHA in HDDA yielded a harder film with greater chemical resistance than acrylic polyol UHA in n-BuAc. However, its adhesion and impact resistance was reduced as was its storage stability.

Formulation of 1K UV-Curable Coatings

Solvent Selection

Traditional UV formulations do not contain solvents and are relatively viscous compared to solventborne formulations. This is due to the fact that acrylate monomers are relatively weak solvents for the acrylated oligomers resins in the formulation and the total amount of monomer in the formulation is kept low to reduce shrinkage and sag. High-coating viscosity makes conventional spray application difficult if not impossible. Hence, UV-curable coatings are usually applied by roll, curtain or vacuum techniques.

For spray application, it is preferable to include solvents in the formulation to help reduce the coating viscosity and improve sag resistance. This is especially important when coating 3-D objects with vertical surfaces. Clearly, fast solvents are

TABLE 3

Starting formulations and coating properties of UV-curable acrylic urethane coatings

Formulation Components	A	B	C	D	E	F	G	H
Acrylic Polyol UHA (70% in BuAc)	86	86	86	86				
Acrylic Polyol UHA (80% in BuAc)					75	75	75	75
IBOA		20			10	20		30
Isooctyl acrylate	10	20		30			20	
TMPTA		20	20		30			10
EO6 TMPTA	30			10		20	20	
Photoinitiator	4	4	4	4	4	4	4	4
Acetone	20	20	20	20	15	15	15	15
Total grams	150	150	150	150	134	134	134	134
Formulation constants								
% solids	69%	69%	69%	69%	78%	78%	78%	78%
grams VOC/liter	218	196	192	199	134	122	124	123
lbs VOC/gallon	1.82	1.63	1.61	1.66	1.12	1.02	1.04	1.03
% photoinitiator on TRS	4%	4%	4%	4%	4%	4%	4%	4%
Brookfield viscosity, cps	235	185	169	130	95	89	52	50
Coating Appearance, 3 mils wet on white basecoat								
60° Gloss	94	94	93	92	88	88	88	88
20° Gloss	87	87	87	86	80	80	80	81
DOI	60	50	70	60	90	90	90	100
Yellowness Index	5.1	4.1	6.5	2.3	2.5	2.5	3.1	3.1
Coating Properties, 3 mils wet on Bonderite® steel								
Dry film thickness, mils	2.1	2.2	2.2	2.2	2.4	2.5	2.3	2.3
Koenig Hardness, swings	112	121	135	84	90	37	14	80
Impact resistance, in.lbs								
Front	50	30	30	70	30	160	160	70
Reverse	10	10	10	60	10	100	100	40
MEK Double Rubs	200	200	200	200	200	200	200	200
Crosshatch Adhesion	0	0	0	0	0	20%	30%	0

preferable so that the flash-off time is relatively short and productivity is not significantly affected. In this study, n-Butyl acetate was chosen to prepare the acrylated oligomers and acetone to reduce the coating to spray viscosity. N-BuAc is non-HAP and acetone has the added advantage of being VOC exempt in the United States. Tail

solvents are not needed as the acrylate monomers help with flow and leveling.

Monomer Selection

Choosing acrylate monomer diluents can be confusing, with literally hundreds available. However, careful consideration of the intended application and the properties of the acrylated oligomer can significantly reduce the

number of viable options. The goal in this study was to develop weatherable coatings for spray application. To reduce potential respiratory and skin hazards, relatively non-volatile bulky monomers such as isobornyl and isooctyl acrylate, trimethylpropane triacrylate (TMPTA) and its alkoxyated derivatives were chosen. Although

TABLE 4

Starting formulations and coating properties of UV-curable acrylic-polyester urethane coatings

Formulation Components	I	J	K	L
Acrylic Polyol (70% in BuAc)	86	86	86	86
IBOA	40	20		20
TMPTA		20	20	
Adhesion promoter	5	5	5	5
Photoinitiator	4	4	4	4
Acetone	10	10	20	20
Total grams	145	145	135	135
Formulation constants				
% solids	75%	75%	66%	66%
grams VOC/liter	188	192	226	220
lbs VOC/gallon	1.57	1.61	1.88	1.83
% photoinitiator on TRS	4%	4%	4%	4%
Brookfield viscosity, cps	85	122	54	59
Coating Appearance, 3 mils wet on white basecoat				
60° Gloss	90	93	93	93
20° Gloss	85	86	86	86
DOI	90	90	90	90
Yellowness Index	3	6.84	9.21	3.33
Coating Properties, 3 mils wet on Bonderite® steel				
Dry fim thickness, mils	2.8	2.8	2.4	2.4
Koenig Hardness, swings	115	117	109	95
Impact resistance, in.lbs				
Front	30	40	40	160
Reverse	10	10	10	160
200 MEK Double Rubs	scratch	OK	OK	OK
Crosshatch Adhesion	100%	95%	95%	100%

weatherability data are not yet available on these latest formulations, there is confidence that they will weather as well as earlier 2K/UV-coating formulations.⁴

Table 3 lists several starting UV formulations and their coating properties. The formulations have VOC contents ranging from 120-200 grams VOC/liter and most can be sprayed with conventional spray equipment. These formulations were applied to pretreated and basecoated steel panels and UV cured to

yield glossy, solvent-resistant coatings with poor adhesion to pretreated steel. The coating hardness varied with the hardness of the acrylic backbone and the nature of the reactive diluents.

To improve the impact resistance and adhesion of these coatings, HEA was replaced with caprolactone acrylate in the oligomer synthesis. Polyesters such as caprolactone are known to improve the flexibility of 2K acrylic urethane coatings. A proprietary

adhesion promoter described by the manufacturer as a mono-functional acid ester was added (Table 4). Since acrylic polyol UCA, the caprolactone acrylate modified urethane prepolymer, gave a soft coating without acrylate diluents (Table 3), isobornyl acrylate (IBOA) and trimethylpropane triacrylate (TMPTA), two high-Tg monomers, were selected as the diluents.

A couple of trends are evident from these results. First, using TMPTA, a

TABLE 5

Optimized UV-curable coatings for weatherable applications

Formulation Components	M	N	O	P
UHA (70% in BuAc)	86.0		86.0	
UCA (70% in BuAc)		86.0		86.0
Isobornyl acrylate		20.0		20.0
Isooctyl acrylate	20.0		20.0	
Flow Aid	1.0	1.0	1.0	1.0
Adhesion promoter	5.0	5.0	5.0	5.0
Photoinitiator	3.0	3.0	3.0	3.0
Hydroxyphenyltriazine UV Screener (50% in acetone)	3.35	3.35	0.00	0.00
Benzylidene Malonate UV Screener (50% in acetone)	1.65	1.65	0.00	0.00
Acetone	17.5	17.5	20.0	20.0
Total grams	137.5	137.5	135.0	135.0
Formulation constants				
% solids	66%	66%	66%	66%
grams VOC/liter	219	215	224	220
lbs VOC/gallon	1.83	1.80	1.87	1.84
% photoinitiator on TRS	3%	3%	3%	3%
Brookfield viscosity, cps	36	130	34	103
Coating Appearance, 3 mils wet on white basecoat				
60° Gloss	94	93	94	93
20° Gloss	87	86	87	85
DOI	90	100	95	100
Yellowness Index	1.4	1.4	2.8	3.0
Coating Properties, 3 mils wet on Bonderite® steel				
Dry film thickness, mils	2.3	1.7	1.7	2.3
Koenig Hardness, swings	75	95	91	70
Impact resistance, in.lbs				
Front	30	160	120	160
Reverse	5	160	160	160
200 MEK Double Rubs	pass	pass	pass	pass
Crosshatch Adhesion	100%	100%	100%	100%

tri-functional acrylate monomer, negatively affected the coating's adhesion and color. Second, reducing the IBOA/oligomer ratio from 40% (Formulation I) to 25% (Formulation L) resulted in improvement in impact resistance and abrasion resistance

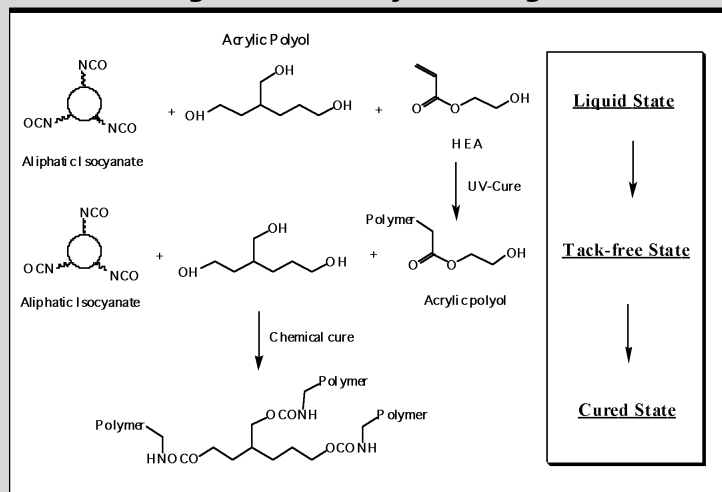
(MEK double rubs). The improvement in adhesion and flexibility was attributed to a reduction in shrinkage during the UV-cure process. The coating with less IBOA also showed improved scratch resistance when subjected to 200 MEK rubs. This was

attributed to an increase in the coating's crosslink density and a reduction in hardness as evidenced by the lower Koenig swing value.

Based on these results, optimized formulations were developed based on an all-acrylic urethane (UHA) oligomer

FIGURE 3

2K UV coatings without acrylated oligomers



and a caprolactone-modified acrylic urethane (UCA) resin (Table 5). A flow aid was added to improve gloss and DOI, and a hindered amine light stabilizer (HAL) and UV-screener package to two of the formulations. The two formulations without HAL and UV screeners yellowed slightly more

than the other two when UV cured but otherwise had identical properties.

Film thickness had an effect on impact resistance and surface hardness. The thicker the film, the softer it was and the lower its impact resistance. Overall, film properties were excellent for both formulations,

although the caprolactone-modified acrylic urethane has superior impact resistance and DOI. These formulations were sprayable at 66% solids and less than 1.9 lbs VOC/gallon.

These results also illustrate that using solvents in UV-curable formulations offers several benefits. First, the amount of acrylate monomer used can be substantially reduced while achieving spray viscosity. This has a positive effect on coating adhesion because UV-induced shrinkage is reduced and the solvents wet the surface. Second, the coating viscosity is reduced, which also has a positive effect on adhesion and appearance. Contrast, for example, the DOI (Distinctiveness of Image) values between the coatings in Tables 3 and 4. Third, coating sag resistance is improved because the solvent evaporates quickly before UV cure, leaving a semi-solid coating with little tendency to flow.

Formulation of 2K UV-Curable Coatings

As previously reported,⁴ it is possible to develop dual-cure 2K UV coatings using conventional 2K urethane ingredients and acrylate monomers as reactive diluents. This has the potential of reducing the cost of dual-cure formulations by eliminating the need for acrylated oligomers. The acrylate monomers help reduce the viscosity of the polyol and isocyanate crosslinker and are polymerized with UV-light to achieve a solid state. Adding a hydroxy-functional acrylate monomer (such as HEA) provides a crosslinking mechanism between the UV-generated acrylic resin and the isocyanate crosslinker (Figure 3).

The final coating properties and cure speed are controlled by the formulation components, their relative amounts and their order of addition. Since neither the polyol nor the isocyanate crosslinker are

FIGURE 4

Effect of acrylate monomer selection and formulation on the hardness development of dual-cure coatings with 2K urethane components

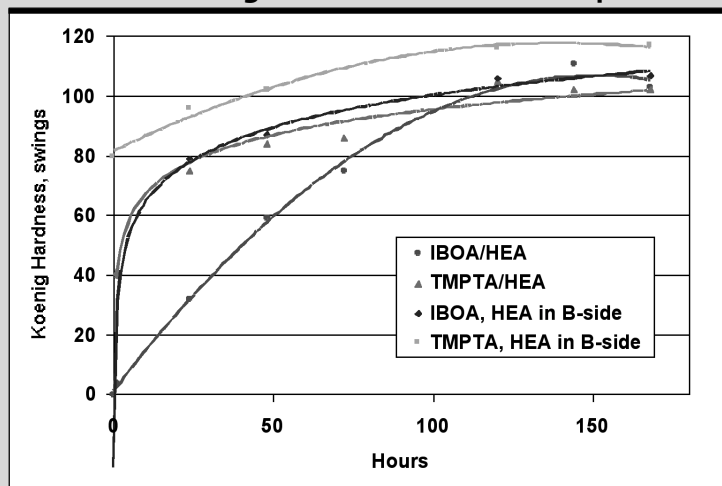


TABLE 6

Optimized UV-curable coatings for weatherable applications

A-side Componentss	2K UV	2K UV-2
Hard Acrylic Polyol (70% in n-BuAc)	16.1	10.7
Liquid Acrylic Polyol	3.75	7.5
IBOA	2.5	2.5
PO6-TMPTA	2.5	2.5
HEA	2.5	2.5
Adhesion Promoter	2.5	2.5
B-side components		
HDI Trimer (80% in acetone)	14.5	14.4
9% Photoinitiator (BAPO/AHK)	0.81	0.81
1% DBTDL (tin catalyst)	0.73	0.73
50% Hindered Amine Light Stabilizer (HALS) in acetone	1.1	1.1
50% Hydroxyphenyltriazine UV screener in acetone	1.1	1.1
Flow Modifier	0.5	0.5
Formulation Constants		
% solids	80	83
Viscosity, cps	<200	<200
VOC content lbs/gal (g/ml)	0.79(95)	0.55(66)
tack & print-free after UV cure	yes	yes
Film Properties after 7 days		
Film thickness (mil)	1.8	1.8
König Hardness	158	125
Direct Impact	150	160
Reverse Impact	140	160
Adhesion	5B	5B
MEK Rubs	200	200

involved in the UV-curing reaction, the acrylate monomers, acrylic polyol and isocyanate crosslinker must be carefully selected so that a tack-free state is achieved after UV cure.

With liquid (low Tg) acrylic polyols as the base polyol and HDI trimer as the isocyanate crosslinker, mono-functional acrylates such as IBOA (isobornyl acrylate) do not yield a tack-free state after UV cure, unless the HEA is pre-mixed with the isocyanate, as is illustrated in Figure 4. This, presumably, generates an acrylated polyisocyanate that can now be involved in the UV-curing process. Some tri-functional TMPTA is usually required to build enough molecular weight. However, the impact properties

of the final coatings suffer as is expected from the higher crosslink density (Figure 5).

Replacing a portion of the liquid polyol with a high-Tg polyol was also effective in achieving a tack-free state immediately after UV cure. This approach is preferred over the use of TMPTA because the final coating has better impact resistance and flexibility. Formulations sprayable at 80% solids and above were achieved using acetone and acrylate monomers (Table 6). VOC contents were below 0.8 lbs/gal or 95 grams VOC/liter. Film appearance and physical properties were also excellent.

The cured 2K UV clearcoats were also subjected to accelerated

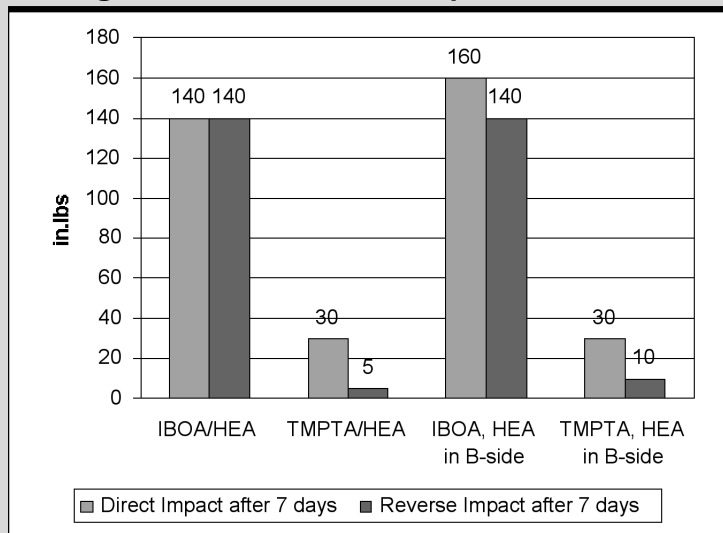
weathering tests under QUVB automotive conditions. After 3,300 hours of exposure, both coatings have retained over 80% of their 20° gloss (Figure 6).

Conclusions

By careful selection of raw materials and reaction conditions, low-viscosity, storage-stable acrylated acrylic urethane oligomers were prepared for the first time. These new acrylic urethane oligomers UV cure to form hard, chemically resistant coatings with excellent appearance and durability properties. Modification of the urethane prepolymers with caprolactone acrylate instead of HEA improved their impact resistance. These acrylated oligomers were used to formulate sprayable,

FIGURE 5

Effect of acrylate monomer selection and formulation on the impact resistance dual-cure coatings with 2K urethane components



low-VOC, UV-curable acrylic urethane clearcoats suitable for automotive topcoat applications.

Dual-cure, 2K acrylic urethane clearcoats were also developed by replacing a portion of the solvents and

resins in a conventional 2K urethane coating system with acrylate monomers. The monomers were selected to reduce the coating viscosity for conventional spray application and, when subjected to UV irradiation, to produce an acrylic

polyol, which then further reacted with the isocyanate crosslinker in the dark.

The benefits of these dual-cure coatings over their 1K analogs include potentially lower raw materials costs, VOCs and solvent content, improved storage stability, less reliance on UV to cure the coating, and an improved balance of film hardness and flexibility. The main disadvantages are ease of use, since the two components must be mixed prior to application and a limited pot life.

These new polymers and formulation approaches produce acrylic urethane clearcoats with “class A” appearance, the productivity of UV-curable technology, and durability properties that match or outperform conventional 2K urethane clearcoats and UV-curable coatings. These new coatings are expected to find use in the most demanding applications including automotive OEM and refinish clearcoats. ▀

Acknowledgments

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FIGURE 6

Gloss retention of dual-cure acrylic urethane clearcoats under accelerated weathering conditions (QUVB exposure 8/4 automotive cycle)

