



## How to formulate...UV curable metal coatings?

With photocure technology, metal coating users can find an interesting alternative to others standard technologies when they need a no-VOC and low energy consumption solution. Moreover, nowadays UV resins can compete with solvent-borne and water-borne coating performances.

In order to reach these performances, Sartomer is working continuously on improving its grades on each component, which compose a metal coating. Depending on the specifications needed, a metal coating formulation will be different from a single layer system to a dual layers system.

### SINGLE LAYER SYSTEM

For a single layer system, a photocurable formulation is composed of, at least, 3 components (+ photoinitiator system):

■ An **oligomer** chosen for its flexibility and adhesion to metal but for its good corrosion and scratch resistance too.

In this category, you will find low functionalised resins to reach a good adhesion such as:

- Polyester based resins :

	Viscosity (Pa.s)
<b>CN704</b>	2 @ 75°C
<b>CN710</b>	1.8 @ 60°C
<b>CN790</b>	2.7 @ 75°C

- Monofunctional epoxy acrylate:

- **CN131B** (Tg = 14°C), aromatic
- **CN152** (Tg = -14°C), aliphatic

When the application requires not only flexibility/adhesion but also very good corrosion and scratch resistance, it is recommended to switch to a difunctional .

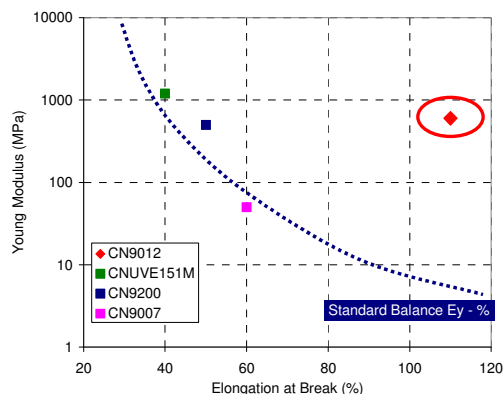
Suitable Urethane Acrylates are:

- **CN9012 (New!)**: Aliphatic Urethane acrylate with exceptional balance of mechanical properties.
- **CN9007**: Aromatic urethane acrylate with excellent flexibility
- **CN9200**: Aliphatic urethane acrylate with with good outdoor performances.
- **CN998B80, CN9278B80**: Trifunctional urethane acrylate used in combination with others urethane to improve the crosslinking.

Or also some specialty epoxy acrylates:

- **CN116**: fatty, low surface tension backbone, which gives a good water repellency
- **CNUVE151M**: good water and thermal resistance. Very high toughness.
- **CN2003EU**: high flexible version of **CNUVE151M** and lower viscosity.

All these grades are chosen for their well-balanced mechanical properties as shown in the results of tensile testing below.



This kind of test can reflect the needs in flexibility (Elongation) and Hardness (Young's Modulus).

Note: Sarbox® resins can also be considered as an alternative option to the other oligomer as acid oligomers. The intrinsic acidity of Sarbox® gives interesting performances in adhesion (see "adhesion promoter" section for explanation) and thermal resistance.



	Viscosity Pa.s	Acid value mg KOH/g	Features
<b>SB400</b>	30 @ 25°C	140	Diluted in 30% Methoxy Propanol Excellent for metal coating
<b>SB500E50</b>	3 @ 60°C	120	Diluted in 50% TMPEOTA Excellent for metal coating
<b>SB520E35</b>	7 @ 60°C	190	Diluted in 65% TMPEOTA Excellent for metal coating and inks

■ **A monomer** used as a diluent. Monofunctional monomer with high Tg is preferred in order to reach a better adhesion without surface tack:

	Viscosity @25°C mPa.s	Tg & Particularity
<b>SR506D</b>	10	Tg =70°C
<b>CD420</b>	5-10	Tg= 65°C
<b>SR531</b>	13	Tg= 35°C, no odour
<b>SR339C</b>	11	Tg=30°C, Xi free
<b>SR285</b>	6	Tg =10°C

■ **The third part of** a typical UV metal coating is probably the key element to obtain good performance : **the adhesion promoter**. This resins family is composed of acidic products. Their interest is to create a slight attack on the metal surface to improve then adhesion on this modified/oxidized surface.

Nevertheless, this acidity could be a drawback as well. Indeed, in a humidity chamber or salt spray conditions, a high level of a promoter could diminish the performance of the photocurable coating. Hence, these adhesion promoters have been designed to get an improved water resistance versus standard acrylic acid or derivatives. As can be seen in the table below, several grades have been developed covering a broad range of acid value. A level of 3 to 10% is recommended in your formulation

	Viscosity @ 25°C mPa.s	Maximum acid value mg KOH/g
<b>SR9050</b>	23	200
<b>SR9051</b>	250	150
<b>SR9054 (New!)</b>	1900	300

**Note:** Contrary to quoted products, acrylic acid has high VOC level

■ **Other components** can be employed to reinforce protection to the metal (thermal, corrosion, chemical resistance). However, it is clear that adhesion and flexibility has to be monitored at the same time in order to find a good balance of properties: difunctional or trifunctional monomers or oligomers could damage the adhesion.

The most suitable resins that can be used to fine-tune your formulation are the following:

- **SR833S:** TCDDMDA. This is the ideal monomer to improve the water resistance and keep the same adhesion.
- **SR492:** TMP(PO)TA, because of the propoxylation moieties, an improved water resistance and an enhanced pigment wetting could be achieved.
- **CN922, CN890:** can be used at a low level to reduce the surface tack.

A starting point formulation can be drawn out of this table:

Category	Examples	1 <sup>st</sup> Option	2 <sup>nd</sup> Option
<b>Main oligomer</b>	<b>Soft polyester</b> CN704, CN131B...		
	<b>Difunctional Urethane</b> CN9012, CN9007	55 %	45 %
	<b>Trifunctional</b> CN9278B80, CN998B80... Sarbox		
<b>Monomers</b>	<b>SR506D, SR531, CD420</b>	35 %	35 %
<b>Adhesion promoter</b>	<b>SR9050, SR9054...</b>	6 %	6 %
<b>Photoinitiator</b>		4 %	4 %
<b>Others</b>	<b>SR833S, SR349...</b>	-	10 %





## MULTIPLE LAYERS SYSTEM

In a **Primer + Topcoat system**, the formulator will find some similarity to one layer system flexibility, good mechanical properties but there will be specific requirements for the primer and for the topcoat:

■ **Primer:** needs mechanical properties (flexibility, impact resistance...), adhesion to metal and corrosion resistance in a thin layer (4-10 µm). Hence, all the products mentioned before could be used except 3-functional urethane acrylates and some other multifunctional compounds, which probably reduce the adhesion on the metal substrates.

In order to avoid tack and to improve solvent resistance (in case of solvent topcoat), the formulator will prefer using the right oligomer(s) which gives enough flexibility/adhesion and toughness/solvent resistance.

The 1<sup>st</sup> formulation suggested could be used as a starting point.

■ **For Topcoat**, except adhesion on metal the requirements for this thicker layer are more or less similar. Di- and Tri-functional compounds can be accepted. Monofunctional monomers are still used for their dilution power. Obviously, an adhesion promoter is here useless.

Adhesion is may be not a difficulty but this topcoat layer has to fulfil other requirements: yellowing resistance, outdoor resistance (for buildings application for instance), and pigment compatibility or thermal resistance...

• The choice of monomers and oligomers for **Yellowing resistance** could be anticipated by the use of urethane acrylate and by our results of QUV test. Indeed, we recommend a selection of the following oligomers:

- **CN963B80**
- **CN9200**
- **CN965**

And monomers :

- **SR506D**
- **SR531**
- **CD536**

• **Outdoor resistance** can be monitored by different tests accelerated tests (Q-Sun,..). This allows a first selection of the most suitable structures for better stability. Then real outdoor

testing on the most promising products can be made.

As a first start, we can recommend:

- **CN9001:** excellent flexibility for a metal coating
- **CN963B88:** outstanding weatherability
- **CN981:** oligomer with best balance of mechanical properties.

An extensive Florida testing program has been initiated years ago. A lot of results are available and could be presented upon request.

• In a thin UV pigmented topcoat or thick EB pigmented topcoat, the **pigment wetting** could be an issue. With it's experience in UV inks market, Sartomer recommends different grades to improve ths compatibility:

On the monomer side, the choice will be between the functionality you need and the difficulty to maintain the stability of your pigmented coating:

	Functionality	Pigment wetting
<b>SR504</b>	1	+
<b>SR9003</b>	2	+++
<b>SR9020, SR492</b>	3	++

In case of pigmented systems and white pigment incorporation, oligomers with specific backbones have been developed to enhance the pigment affinity CN116, CN2505, CN2302 could be a first start.

Our experience in graphics application will allow us to recommend the most suitable products for the colour you need.

