Photo-Latent catalyst for rapid cure of 2K-PUR coatings

Dr. Ziniu Yu

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Overview

- 2K-PUR coatings and current challenges
- What is a photo-latent catalyst and why would one be used
- BASF approach
- Performance overview
- Summary
2K-PUR coatings

- Good UV resistance with HDI
- Good gloss retention
- Good color stability

Coatings Market for 2K-PUR Global
~17,000 kT

- Car Parts
- 3C & Household
- Aerospace
- ACE
- Auto Refinish
- Auto OEM
- Furniture & Floor
- General Industry
- Wind Power

- Good UV resistance with HDI
- Good gloss retention
- Good color stability
Current technology and challenges

**Large objects**
- Low temperature processing
- Need to reduce cycle and storage times

**Heat sensitive substrates**

**Other Factors**
- Low VOC emission
- Tin catalysts like dibutyltin-dilaurate (DBTDL) have toxicological and environmental concerns.
RT Curing of 2K-PUR with UV-light triggered Catalyst

Non-latent Catalyst (e.g. DBTDL)
- Short Pot-life << 1 hr
- Fast curing requires thermal energy!
  - ~ 30 min @ 60 - 80 °C

Photo-Latent Metal Catalyst
- Longer Pot-life
- PL Catalyst low activity
- Me Cat
  - High catalytic activity at room temperature

2K-PUR Coating (+ catalyst)

Poly-NCO
Polyol
Other Photo Latent Catalysts: Photo-Latent Bases

Provide $pK_a$ Jump

The catalysts can be used as one-pack systems with long shelf life stability or as two-pack formulations with an extended working window, opening new possibilities for cross-linking mechanisms for the coating industry.
Why a photo-latent metal catalyst?

**Reduce energy consumption:**
- Room Temperature vs. 60-80°C
- Addresses the issue of heating very large objects, heat-sensitive parts, or heavy metal structures

**Increased throughput:**
- Short time to dust-free
- Short time to handling/moving of coated object
Why a photo-latent metal catalyst?

Reduce Paint Waste
- Cure on Demand
- Pot-life > 1 hour
- Increased flexibility in process timing

Increased Environmental Benefits
- Organotin-free
- Cold-cure
- End of life recycling

Cure-on-Demand enables better economics; Organotin-Free supports safer handling.
BASF photo-latent metal catalyst

- Physical properties:

<table>
<thead>
<tr>
<th>BASF Photo-Latent Metal Catalyst</th>
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<tbody>
<tr>
<td>Solids content</td>
</tr>
<tr>
<td>Butylacetate</td>
</tr>
<tr>
<td>Metal (non-tin)</td>
</tr>
<tr>
<td>Aspect</td>
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<tr>
<td>Shelf Life</td>
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</table>

- Good UV response and no photo sensitizer required for clear coat.
- AMES test: negative! \(\Rightarrow\) non-mutagenic
- TSCA listed
UV absorption of photo-latent metal catalyst

Catalyst was dissolved in Butyl Acetate for measurement.

- BASF Photo-Latent metal catalyst has strong UV absorption under 380 nm.
- Product can be triggered by medium pressure mercury lamp, metal doped lamp or even LED lamp.
## Formulation for study

<table>
<thead>
<tr>
<th>Component A</th>
<th>wt%</th>
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<tbody>
<tr>
<td>Acrylic Polyol</td>
<td>52.72</td>
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<tr>
<td>Leveling additive</td>
<td>0.60</td>
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<tr>
<td>Butyl Acetate</td>
<td>25.95</td>
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<table>
<thead>
<tr>
<th>Component B</th>
<th></th>
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</thead>
<tbody>
<tr>
<td>HDI based Polyisocyanate</td>
<td>20.65</td>
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<table>
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<tr>
<th>Catalyst</th>
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<tr>
<td>Photo-Latent Metal Catalyst/DBTDL</td>
<td>0.005-0.08</td>
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- **Formulation Characteristics**
  - 63% Solids
  - Initial Viscosity ~65 cP
  - Isocyanate Index=105
Pot life study

- If the catalyst levels are the same, 2K-PUR formulation with Photo-latent Catalyst had longer pot-life than DBTDL formulation.
- Formulations need higher loading of photo-latent catalyst to achieve the similar pot life.
Drying performance

In order to make a fair comparison, equal pot life formulations were selected for this study.

![Graph showing drying performance](image)

- **0.01 wt% DBTDL**
  - Tack-Free: > 24hrs
  - Dry Through: > 24hrs

- **0.08 wt% PL Catalyst No UV**
  - Tack Free: 8 hrs
  - Dry Through: 24 hrs

- **0.08 wt% PL Catalyst 3 J/cm²**
  - Tack Free: > 24hrs
  - Dry Through: 4 hrs
PDO (2,4-pentanedione) can significantly increase the pot-life of 2K-PUR formulations.

- Photo-latent catalyst provides “cure on demand” property even with PDO.
Pigmented 2K-PUR coatings

- 2K-PUR white (~45wt.% TiO2 on resin solids)
- Drying performance was evaluated by sand test

<table>
<thead>
<tr>
<th>Treatment</th>
<th>No Cat @RT</th>
<th>DBTL @RT (0.018 wt%)</th>
<th>PL Catalyst (0.045 wt%) @RT</th>
</tr>
</thead>
<tbody>
<tr>
<td>UV</td>
<td>No UV</td>
<td>~3J/cm² UV</td>
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</table>

DFT: ~50µm
Influence of UV activation

![Graph showing sand test drying time for different UV exposures.]

- **No Cat**
- **0**
- **~0.7**
- **~1.3**
- **~4**

*UV Exposure (J/cm²)*

- **Surface Cure**
- **Through Cure**

*Sand test drying time (hrs)*
Field trial

2K PUR clear coatings were applied on top of colored base coat.

1: 0.01 wt% DBTDL
2: 0.01 wt% DBTDL 3J/cm²
3: 0.08 wt% PL Catalyst No UV
4: 0.08 wt% PL Catalyst 3J/cm²

Apply Coating. DFT: 1.2 mil
Apply Cotton Ball after 1 hour
Peel off Cotton Ball

2K PUR clear coatings were applied on top of colored base coat.
Measuring NCO concentration with FTIR

0.08% PL Catalyst + UV

- For the formulation with PL catalyst, 25% of Isocyanate was reacted immediately after UV light exposure.
- Reaction rate of UV exposed formulation was much higher than the others at first hour.
Hardness development

![Graph showing the relationship between cure time and pendulum hardness for different catalyst concentrations.]

- **0.01 wt% DBTDL**
- **0.08 wt% PL Catalyst No UV**
- **0.08 wt% PL Catalyst 3J/cm2**
Summary

- BASF Photo Latent Metal Catalyst is designed for curing 2K-PUR coatings, offering:
  - Fast curing--- Increase in through-put
  - Longer pot life--- Reduced waste
  - Room temperature, UV instead of heat & fast curing---Cost savings, e.g. lower energy, reduced floor and storage space, ... 
  - Sn free---Healthier working environment

- BASF also offers Photo Latent Base Catalysts which can fit for different needs

- It exhibits high efficiency in both clear and pigmented coatings, including with difficult pigments for UV-curing systems, e.g. rutile-TiO₂, iron-oxides

- Add small addition of 2,4-pentanedione to 2K-PUR formula leads to extended pot-life without affecting the catalytic activity.
## Contact information

<table>
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<tr>
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