1K UV-A Automotive Refinish; Clear Coats and Primers

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Introducing Allnex!

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GLOBAL NETWORK, LOCAL SERVICE

DISCOVER OUR TECHNOLOGIES

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Crosslinkers
Powder Coating Resins
Solventborne – High Solids
Waterborne Resins
Urethane Specialties
UV Resins
Waterborne UV

16 Manufacturing Sites
13 Research & Development Centers
2 Joint Ventures

Allnex
All About Resins
Outline

• Changes in the automotive OEM and refinish markets
• Introduction of UV-A curable auto refinish
• Current products and innovation in the market
• Future outlook for the UV–A curable refinish market
• Conclusions
• References
• Questions
Changes in the Automotive OEM and Refinish Markets

- Major changes in polymers technologies used in coatings
  - NC lacquers were acceptable when the only color option was black
  - 2 K reactive primers, clear coats, water based “base coats”
  - Lower VOC and VHAPS

- Major changes in substrate technologies
  - Cold rolled steel
  - Engineered plastics
  - Aluminum
  - Composites
Introduction of UV–A Auto Refinish

• Early attempts to develop a UV refinish clear coat (2K) \(^1\)
  • UV Flash lamp (Xe lamp @ 480 nm) used in conjunction with BAPO PI
  • Polymer chemistry was dual cure (R-N=C=O; R-C=C & R-OH)
  • Cure took place with 10 to 20 flashes

• Patent application on a UV-A primer in 2001 (1K) \(^2\)
  • UV A lamp source was 250 W iron doped source filtering out UV B, UV C
  • Polymer chemistry was mono-cure (R-C=C)
  • Cure took place in several minutes leaving an uncured surface due to oxygen inhibition
  • Solvent wipe required

Photo provided by I-CAR
Introduction of UV–A Auto Refinish

- Automotive OEM technical paper on UV auto refinish clear coats
  - OEM evaluates UV cure clear coats
  - HALS and UVAs were formulated into these clear coats
  - OEM found that these systems embrittled to unacceptable levels under accelerated weathering

- 2003 Patent application by a paint company on UV–A (1K) CC
  - UVA/UVV & UV–A only curable
  - Polymer chemistry was mono-cure (R-C=C)
  - Cure times were 4 minutes with no surface inhibition
  - No gloss reduction or cracking was found when subjected to SAEJ1960
Introduction of UV–A Auto Refinish

• 2003 RADTECH report on use of UV–A cure primer systems in body shops
  • The following benefits were noted in the report: 1) time savings of 25 to 88 % on each job, 2) less preparation time, 3) use of disposable utensils is reduced, 4) less masking, 5) no flash times required between layers and 6) less waste over a 2K system
  • Report states the need for a UV–A clear coat

• 2005 OEM/Refinish paint company awarded the US Presidential Green Chemistry award for UV-cured auto finishing paint
Introduction of UV–A Auto Refinish

• 2006 patent application on dual cure UV clear coat spot repair
  • UV–A light source used for cure
  • Polymer chemistry was dual cure (R-N=C=O; R-C=C & R-OH)
  • After cure, the surface was easily polishable without defects

• 2006 patent filed by an auto OEM paint company on a UV–A primer that has a high pigmentation levels and extremely low oxygen inhibition
  • Uses a 400 W UV–A light that is held 10 to 30 cm away from the substrate
  • Chemistry is a mono-cure technology (R-C=C)
  • Cure time is 1-3 minutes at a thickness of 200 microns
  • Patent reports the ability to sand the primer after UV curing and the coating has had time to cool
Introduction of UV–A Auto Refinish

• Auto OEM technical paper on scratch performance of three UV cure automotive refinish clear coats
  • Three UV cure clear coats tested against a thermally cured acrylic/melamine/silane clear coat.
  • Car wash performance testing by the AMTEC-Kistler showed that two of the UV cure clear coats performed better than the acrylic/melamine/ silane clear coat.
Introduction of UV – A Auto Refinish

• Patent filed in 2007 that uses a structure to cure the UV paint.
• Patent publication filed in 2009 on a UV cure spot blender for clear coats.
  • Uses a UV–A 400 lamp to cure the UV clear coat.
  • Chemistry is based on 2K dual cure or 3K dual cure thiolene-based technology.
  • Clear coat technology is cured for 5 minutes at a distance of 10 inches.

Photo provided by I-CAR
Introduction of UV – A Auto Refinish

• OEM awarded the 2010 RADTECH Emerging Technology Award for the use of an in-line UV spot repair
  • The UV cure technology could possible reduce their cycle time by 50%
  • OEM evaluating the process to see if this technology will meet the durability specifications and test protocols.
  • Facilities would have to be modified to use the UV cure technology

Photo provided by I-CAR
### Current Products and Innovation in the Market

High throughput formulation screening \(^{12,13}\)

<table>
<thead>
<tr>
<th>Resin/ 50:50 blend</th>
<th>Reactive diluent</th>
<th>Photoinitiator/blend</th>
<th>[PI]</th>
<th>Irradiation time [sec]</th>
<th>Irradiation time [sec]</th>
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<tr>
<td>Delta</td>
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<td>Charlie</td>
<td></td>
<td>CGI 1870 #</td>
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<tr>
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<tr>
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<tr>
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<td>Hotel / Charlie</td>
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</tbody>
</table>

D-optimal design including 2nd order interactions:
~ 500 formulations and ~ 24,000 films (5 weeks of experimentation)

# BASF, + Rahn
Current Products and Innovation in the UV-A Refinish Market

The larger the bubble shows the least amount of surface inhibition after UV cure.
Current Products and Innovation in the Market

Photo micrograph of a blend line for a commercially available UV – A curable clear coat over a black base coat
Current Products and Innovation in the Market
Concept of matching the Tg’s of traditional 2K clear coat technology with a 1K UV A cure clear coat\textsuperscript{14}

<table>
<thead>
<tr>
<th>Resin</th>
<th>°C</th>
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<tbody>
<tr>
<td>UA Resin A</td>
<td>10</td>
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<tr>
<td>UA Resin B</td>
<td>104</td>
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<tr>
<td>UA Blend 1</td>
<td>103</td>
</tr>
<tr>
<td>UA Blend 2</td>
<td>105</td>
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<td>UA Blend 3</td>
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<td>84</td>
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<td>UA Blend 5</td>
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<td>Commercial UV Refinish</td>
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<tr>
<td>Commercial 2K Refinish</td>
<td>62</td>
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</table>

1. \text{isocyanurate}
2. \text{allophanate}
Current Products and Innovation in the Market

Photo micrograph of a blend line for a commercially available **2K Clear Coat** over a black base coat

Photo micrograph of a blend line for a **UV – A Cure Clear Coat**
After matching Tg of a 2K Clear Coat over a black base coat
Current Products and Innovation in the Market

Photograph of a 1K UV-A primer and a 1K UV-A Clear Coat after 8 years of service in the NE US

Photograph of a 2K traditional primer and Clear Coat that was used as the standard for testing on the same vehicle
Future Outlook for the UV–A Curable Refinish Market

• Driving Change event in 2003 ¹⁵
  • Over 130 industry personnel attended
  • The future looked bright over 10 years ago

• RADTECH Transportation Focus Group & I-CAR
  • In 2007 RADTECH (industry trade organization) teamed up with I-CAR (auto refinish professional training organization) to develop a web based training module devoted to UV-A auto refinish
  • Since this launch over 900 professional body repair technicians have paid to take this unique training program

• The future of 1K UV–A cure is tied to the introduction of a 1K UV-A cure clear coat ¹⁶

[Photo provided by I-CAR]
Conclusions

• A significant amount of work has been done trying to develop the market for 1K UV-A Primers and Clear Coats
• When polymer technology went from NC lacquers to 2K reactive system, there was a lot of resistance to change
• The difficulty to repair was the major resistance to change from NC lacquers to a 2K reactive system
• In time better acceptance of the 1K UV-A Primers and Clear Coats will occur
References

2.) D. Fenn, et al., US 6,838,177 Mar. 27, 2003
5.) D. Maloney, RADTECH Report NOV/DEC 2003
9.) K. DeRegge, et al., US 7,704,564 Apr. 27, 2010
11.) Ford Motor Company, 2010 Emerging Technology Award, RADTECH 2010 Conference
12.) H. Bach, et al., RADTECH Europe, Nov. 2003
13.) S. Strazisar, et al., RADTECH Report, Nov. 2003
15.) RADTECH NA sponsored event; Driving Change, Sept. 2003
Thank you for your attention!

For more information, please visit us at www.allnex.com.

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Back Up Slides
Light Output Readings After UV A Cure Refinishing of PC

• 1993 Dodge Sundance
  • Readings at low audit settings
    • High beam 17,000 Candla
      • Prior value = 7,000 Candla
    • Low beam 7,000 Candla
      • Prior value = 3,000 Candla

Many military equipment / vehicles use polycarbonate as replacement for glass due to its performance for bullet resistance and light weight.
Military Applications
UV A Cure Battle Field Composite Repair

- KISS Principle
- Ballistic holes in composites
  - AK-47 or shrapnel
- Quick return to service
- Simple and quick process that returns the aircraft to service with eventual permanent repair at the depot
- Commercial air lines interested is this technique for remote location repair
**Basics of UV Curing**

**Curing of Coatings with electromagnetic radiation**

<table>
<thead>
<tr>
<th>Source</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>UV-C</td>
<td>100 - 280 nm&lt;br&gt;Imperative for the polymerization of printing inks and varnishes for a complete curing.</td>
</tr>
<tr>
<td>UV-B</td>
<td>280- 315 nm&lt;br&gt;Supports and maintains the triggered off reactions and ensures a better curing because of longer waves.</td>
</tr>
<tr>
<td>UV-A</td>
<td>315 - 380 nm&lt;br&gt;Responsible for the curing of very thick layers</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Electron beam</th>
<th>X- Rays</th>
<th>UV light</th>
<th>Visible light</th>
<th>IR</th>
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</thead>
<tbody>
<tr>
<td>&lt; 1 nm</td>
<td>&lt; 100 nm</td>
<td>&lt; 400 nm</td>
<td>&gt; 400 nm</td>
<td>&gt; 800 nm</td>
</tr>
</tbody>
</table>

Curing conditions: seconds/ milliseconds
Low Energy UV-A Lamps

Philips TL03

Promotor Car 250

Honle 250

Panacol 250

UV Process Supply 400

H&S Autoshot 400
Low Intensity Microwave Lamp

- Quantum Technologies
- Low powered lamps
- Current UV-A lamp assembly has a series of bulbs from 320 to 400 nm
- Bulbs can be made to desired wavelength output
NEW UV-A Light Sources
Automotive Refinish/Aerospace & Printing

- 1,200 W UVA Light
- H & S Auto Shot
- LED UVA
- Phoseon Technology