UV-A Curable Aerospace Topcoats

Todd Williams

Mike Gallagher

Alan Bushmire

Katrina Callen

Government Services

Mike Dvorchak

Chuck Gambino

Coatings, Adhesives, and Specialties
**Title:** UV-A Curable Aerospace Topcoats

**Performing Organization:** Bayer MaterialScience, 100 Bayer Road, Pittsburgh, PA, 15205-9741

**Abstract:**
ASETSDefense 2011: Sustainable Surface Engineering for Aerospace and Defense Workshop, February 7 - 10, 2011, New Orleans, LA. Sponsored by SERDP/ESTCP.
UV-A Coatings Characteristics

Advantages

- Faster cure
- Storage stable
- One component
- Low VOC

Challenges

- Limited raw materials
- Shadow areas
- Low gloss coatings

Drivers

- Dry-to-fly time
- Reduced Waste
- VOC
UV-A Coatings Site Applied

- Automotive refinish
- Headlight refinish
- Site applied flooring
- Aircraft stencils / small area repair
Previous Work – Stencil Coating

- Chuck Gambino formulated black UV curable stencil coating for aircraft ('07)

- Evaluated by CTIO
  - Reduce gloss
  - Increase flexibility
  - Match color (Deft)
### Weathering of UV-A Stencil Coatings on C-130

<table>
<thead>
<tr>
<th>Coating</th>
<th>ΔE 7 months</th>
<th>ΔE 14 months</th>
<th>Δ 60° Gloss 7 months</th>
<th>Δ 60° Gloss 14 months</th>
</tr>
</thead>
<tbody>
<tr>
<td>Black UV Stencil</td>
<td>1.56</td>
<td>0.87</td>
<td>(-5.2)</td>
<td>(-4.8)</td>
</tr>
<tr>
<td>2K Gray Fluorourethane (APC)</td>
<td>0.57</td>
<td>1.23</td>
<td>(-0.13)</td>
<td>0.00</td>
</tr>
</tbody>
</table>

- ΔE reduction in UV coatings most likely due to self cleaning – reduced film thickness over time
- Fluorourethane better with gloss retention
Critical Military Specs for Topcoat

- Closest coating from battery of comm. available coatings

<table>
<thead>
<tr>
<th>Test</th>
<th>MIL-PRF-85285 Spec.</th>
<th>Stencil Coating</th>
</tr>
</thead>
<tbody>
<tr>
<td>GE Impact Test</td>
<td>40%</td>
<td>2%</td>
</tr>
<tr>
<td>Chemical Resistance</td>
<td>Jet fuel, hydraulic fluid, and oil</td>
<td>Pass</td>
</tr>
<tr>
<td>Crosshatch / Wet tape Adhesion</td>
<td>≥4B</td>
<td>Pass</td>
</tr>
<tr>
<td>Gloss</td>
<td>85° ≤ 9  60° &lt; 5</td>
<td>85° - 39</td>
</tr>
<tr>
<td>Accelerated Weathering</td>
<td>ΔE &lt; 1 after 500 hrs.</td>
<td>0.9</td>
</tr>
<tr>
<td>Color</td>
<td>ΔE &lt; 1 from standard</td>
<td>3.4</td>
</tr>
</tbody>
</table>
## Expected UV Coatings Properties

<table>
<thead>
<tr>
<th>Test</th>
<th>MIL-PRF 85285 Specification</th>
<th>Typical UV Coating</th>
</tr>
</thead>
<tbody>
<tr>
<td>GE Impact Test</td>
<td>40%</td>
<td>--</td>
</tr>
<tr>
<td>Chemical Resistance</td>
<td>Jet fuel, hydraulic fluid, and motor oil</td>
<td>++</td>
</tr>
<tr>
<td>Dry Adhesion</td>
<td>≥ 4B</td>
<td>++</td>
</tr>
<tr>
<td>Gloss</td>
<td>85° ≤ 9</td>
<td>--</td>
</tr>
<tr>
<td>Weathering at 500 hrs</td>
<td>ΔE &lt; 1</td>
<td>++</td>
</tr>
<tr>
<td>Weathering at 500 hrs 85°</td>
<td>85° Gloss ≤ 9</td>
<td>++</td>
</tr>
<tr>
<td>Humidity Resistance</td>
<td>30 days 100% RH at 120 °F</td>
<td>++</td>
</tr>
<tr>
<td>Wet Adhesion</td>
<td>≥ 4A</td>
<td>++</td>
</tr>
<tr>
<td>Color</td>
<td>ΔE &lt; 1 from standard</td>
<td>--</td>
</tr>
</tbody>
</table>
UV Aerospace Team

ESTCP Principal Investigator
Glenn Baker

Program Management
Tom Naguy
Randy Straw (CTC)

CTC
Matthew Campbell, CTC Project Manager
Anthony Kingera, Technical Support
Steve Finley, Technical Support

Principal Stakeholders
Ogden Air Logistics Center
Oklahoma City Air Logistics Center
Warner Robins Air Logistics Center
NAVAIR Depot Jacksonville
USCG Aircraft Repair and Supply Center

Subcontractor
Bayer Material Science/Deft

Presented at RadTech East 2010 by Matthew Campbell
Overall Approach

- Formulate coatings that meet MIL-PRF-85285
- Validate coating’s performance
- Demonstrate application and validate performance
  - Simple geometry parts
  - Aircraft markings
- Transition technology to end users
UV-A Light

- Currently using H & S Autoshot 1200W
- Dual heads allow cure 3 ft.$^2$
- Only UV-A and IR emitted
- Coating cures in minutes
- Currently no explosion proof light available
- Explosion proof light is feasible
Coating Formulation Project Goals

- Develop UV curable coatings formulations that meet MIL-PRF-85285

- Flat topcoats
  - 37038 international black
  - 36173 neutral gray
  - 36118 gunship gray

- Gloss white topcoats
  - 17925 Air Force white
  - 17860 Coast Guard white

<table>
<thead>
<tr>
<th>Critical Tests</th>
<th>85285 Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>GE Impact Test</td>
<td>40% or 60%</td>
</tr>
<tr>
<td>Chemical Resistance</td>
<td>Jet fuel, hydraulic fluid, and motor oil</td>
</tr>
<tr>
<td>Dry Adhesion</td>
<td>≥ 4B</td>
</tr>
<tr>
<td>Low Gloss</td>
<td>60° ≤ 9</td>
</tr>
<tr>
<td>Weathering at 500 hours</td>
<td>ΔE &lt; 1 at 500 hrs.</td>
</tr>
<tr>
<td></td>
<td>60°Gloss &lt;5 or &gt; 80</td>
</tr>
<tr>
<td>Humidity Resistance</td>
<td>30 days 100% RH at 120 °F</td>
</tr>
<tr>
<td>Wet Adhesion</td>
<td>≥ 4A</td>
</tr>
<tr>
<td>Color</td>
<td>ΔE &lt; 1 from standard</td>
</tr>
</tbody>
</table>
Deft Color Matching

- Color standard based on carbon black
- Black iron oxide ca. four units to light
- Deft identified a mixed oxides pigment closer to carbon black
- Deft also color matched two grays
  - 36118
  - 36173
- Color matched coatings evaluated by Battelle
# Properties of Color Matched Coatings
(Battelle’s Evaluation)

<table>
<thead>
<tr>
<th>Test</th>
<th>85285 Spec</th>
<th>37038 Black</th>
<th>36173 Gray</th>
<th>36118 Gray</th>
</tr>
</thead>
<tbody>
<tr>
<td>GE Impact Test</td>
<td>≥ 40%</td>
<td>40%</td>
<td>20%</td>
<td>10-20%</td>
</tr>
<tr>
<td>Dry / Wet Adhesion</td>
<td>≥ 4B / 4A</td>
<td>5B / 3A</td>
<td>3B / 2A</td>
<td>4B / 4A</td>
</tr>
<tr>
<td>Gloss</td>
<td>85° ≤ 9</td>
<td>12</td>
<td>10</td>
<td>8</td>
</tr>
<tr>
<td>Accelerated Weathering ΔE at 500hrs</td>
<td>&lt; 1.0</td>
<td>0.99</td>
<td>2.8</td>
<td>1.0</td>
</tr>
<tr>
<td>Color ΔE from Standard</td>
<td>&lt; 1</td>
<td>0.9</td>
<td>0.9</td>
<td>10.1</td>
</tr>
<tr>
<td>Initial Pencil Hardness</td>
<td>≥ 2B</td>
<td>2H to 3H</td>
<td>3H</td>
<td>H to 2H</td>
</tr>
<tr>
<td>Mobil Jet Oil</td>
<td>-2 pencils</td>
<td>-2 to -3</td>
<td>-3</td>
<td>-1 to -2</td>
</tr>
<tr>
<td>Hydraulic Fluid</td>
<td>-2 pencils</td>
<td>-1 to -3</td>
<td>-2</td>
<td>-1 to -3</td>
</tr>
<tr>
<td>JP-8 Jet Fuel</td>
<td>-2 pencils</td>
<td>-1 to -2</td>
<td>-6</td>
<td>-4 to -6</td>
</tr>
</tbody>
</table>
## Properties of Color Matched Coatings (Battelle’s Evaluation)

<table>
<thead>
<tr>
<th>Test</th>
<th>85285D Spec</th>
<th>37038 Black</th>
<th>36173 Gray</th>
<th>36118 Gray</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contrast Ratio</td>
<td>≥ 95%</td>
<td>Pass</td>
<td>Pass</td>
<td>Pass</td>
</tr>
<tr>
<td>MEK Resistance</td>
<td>&gt; 25 Double Rubs</td>
<td>Pass</td>
<td>Pass</td>
<td>Pass</td>
</tr>
<tr>
<td>Cold Flexibility</td>
<td>-51°C, 2” Mandrel</td>
<td>Pass</td>
<td>Pass</td>
<td>Pass</td>
</tr>
<tr>
<td>Heat Resistance</td>
<td>ΔE &lt; 1</td>
<td>0.2</td>
<td>0.9</td>
<td>0.30</td>
</tr>
<tr>
<td>Humidity Resistance</td>
<td>30 Days</td>
<td>Pass</td>
<td>Fail</td>
<td>Fail</td>
</tr>
</tbody>
</table>

- Qualified controls did not pass flexibility requirement (?)
- Results variability from coating’s cure energy requirements
- Black coating most successful
- Gray coatings least successful
Gloss White Coatings
Waterborne UV (UV-PUD) Coatings

**Typical Formulation**
- UV Curable PUD
- Photoinitiator
- Pigments
- Cosolvents
- Additives

**Typical Challenges**
- Application issues
  - Temperature
  - Humidity
- Water sensitivity
- Limited raw materials
# Gloss White Coatings Properties

<table>
<thead>
<tr>
<th>Test</th>
<th>Spec</th>
<th>Coating</th>
</tr>
</thead>
<tbody>
<tr>
<td>GE Impact Test</td>
<td>≥ 60%</td>
<td>60%</td>
</tr>
<tr>
<td>Dry / Wet Adhesion</td>
<td>≥ 4B / 4A</td>
<td>4B / 4A</td>
</tr>
<tr>
<td>Gloss</td>
<td>60° ≥ 90</td>
<td>80</td>
</tr>
<tr>
<td>Initial Pencil Hardness</td>
<td>≥ 2B</td>
<td>HB/F</td>
</tr>
<tr>
<td>Mobil Jet Oil</td>
<td>-2 pencils</td>
<td>-1</td>
</tr>
<tr>
<td>Hydraulic Fluid</td>
<td>-2 pencils</td>
<td>-1</td>
</tr>
<tr>
<td>JP-8 Jet Fuel</td>
<td>-2 pencils</td>
<td>-2</td>
</tr>
<tr>
<td>Humidity Resistance after 14 days ambient</td>
<td>30 days</td>
<td>No blisters</td>
</tr>
</tbody>
</table>
UV Aerospace Coatings Conclusions

- Flat coatings
  - Black coating close to meeting topcoat specification
  - Gray coatings need reformulation

- Gloss white coatings
  - Physical performance specs matched
  - Gloss is lower than desired

- Qualify to MIL-PRF-81352
  - Light footprint limited to touch up applications
  - Touch up specification
  - Lower gloss requirement ($60^\circ = 80$)
Acknowledgements

- ESTCP
- Bayer MaterialScience
  - Chuck Gambino
  - Mike Dvorchak
  - Mike Gallagher
  - Alan Bushmire
  - Kevin Elsken
  - Katrina Callen
- USAF
  - John Jusko
  - Glen Baker
  - Tom Naguy

- Concurrent Technologies Corporation
  - Matt Campbell
  - Randy Straw
  - Anthony Kingera
  - Steve Finley

- Deft Coatings
  - Randy Brady
  - Charles Keil
  - Haruji Sakugawa
  - Chuck Ray
Thanks for your attention!
The manner in which you use and the purpose to which you put and utilize our products, technical assistance and information (whether verbal, written or by way of production evaluations), including any suggested formulations and recommendations are beyond our control. Therefore, it is imperative that you test our products, technical assistance and information to determine to your own satisfaction whether they are suitable for your intended uses and applications. This application-specific analysis must at least include testing to determine suitability from a technical as well as health, safety, and environmental standpoint. Such testing has not necessarily been done by us. Unless we otherwise agree in writing, all products are sold strictly pursuant to the terms of our standard conditions of sale. All information and technical assistance is given without warranty or guarantee and is subject to change without notice. It is expressly understood and agreed that you assume and hereby expressly release us from all liability, in tort, contract or otherwise, incurred in connection with the use of our products, technical assistance, and information. Any statement or recommendation not contained herein is unauthorized and shall not bind us. Nothing herein shall be construed as a recommendation to use any product in conflict with patents covering any material or its use. No license is implied or in fact granted under the claims of any patent.