In step with green building trends in commercial and institutional architecture, Dow Coating Materials has developed ultra-low VOC acrylic-epoxy hybrid for concrete coatings that cures quickly, resists yellowing in the presence of natural light, and is tough enough to withstand aggressive cleaning regimens. The low-viscosity hybrid also offers excellent hot- and cold-tire pick-up resistance, and is compatible with applications at lower temperatures.

Green building design often includes energy saving strategies such as tightly sealed envelopes to reduce heating and cooling costs, as well as the increased use of natural lighting, aka day lighting, to reduce electrical lighting costs. These trends, coupled with an increased emphasis on indoor air quality and occupant health, are driving new goals for interior concrete floor and wall coatings, including robust UV resistance and ultra-low VOC emissions. Because they are very resistant to harsh cleaning agents and frequent cleanings, waterborne epoxy coating systems are commonly used in commercial and institutional space interiors. While these systems offer low VOC, they are generally slow curing, and often require a long wait period before being returned to service. In addition, standard epoxy-based systems are not inherently stable when exposed to UV light, thus limiting effectiveness in areas of abundant natural lighting and in exterior applications. Addressing an unmet need for ultra-low VOC concrete coating systems that cure quickly, resist yellowing in the presence of natural light, and are tough enough to withstand aggressive cleaning regimens, Dow Coating Materials has developed a Novel Waterborne Acrylic-Epoxy Hybrid (NAEH) Technology that combines the chemical resistance of epoxies and the UV protection of acrylics.

Currently, there are two types of epoxy systems most frequently used in concrete coating formulations. Type I systems are comprised of a neat liquid epoxy resin and a waterborne curing agent. Type I systems can be formulated to provide high hardness and resistance properties, and are more cost-effective for commercial applications; however, they also build hardness more slowly, which results in a longer return-to-service time.

Type II systems, utilizing pre-dispersed waterborne epoxy resins, are easy to use, since emulsification of the epoxy during the mixing step is not required, and deliver properties such as increased flexibility and faster hardness development through physical (lacquer) drying. However, these pre-dispersed epoxy systems often bring in significant levels of VOC solvents, as well as a higher cost profile, compared to Type I systems.

Coatings are utilized in a wide variety of applications, and on many different substrates in commercial architectural settings. Performance requirements will vary depending on the intended use and environment.
Novel Acrylic-Epoxy Hybrid (NAEH) Technology developed by Dow Coating Materials utilizes a waterborne amine hardener (Part B) and a hybrid acrylic-epoxy resin in which the epoxy functionality is housed inside the acrylic latex particle (Part A). In the wet state, the acrylic latex acts as a barrier between the amine and the epoxy. Parts A and B react when the formulated coating comes into contact with air and the water evaporates. Extensive testing demonstrates that this novel acrylic-hosted epoxy system offers a level of performance equal to conventional epoxy systems while offering longer pot life, faster cure time, greater UV resistance and ultra-low VOC. The novel system is delivered as a low-viscosity, easy-to-use, and cost-effective waterborne dispersion manufactured without added solvent.Benchmarked against commercially available concrete floor coatings, Novel Acrylic-Epoxy Hybrid (NAEH) Technology developed by Dow offers all the key properties required from concrete topcoats, such as durability, chemical resistance, and hot/cold tire pick-up resistance, as well as greater gloss stability under accelerated UV exposure without the use of UV stabilizers in the formulation.

**Type I WB epoxy system**
- Surfactants are used to aid in emulsifying the LER
- Diluents/solvent are often used to lower viscosity of LER
- Common technology for concrete flooring

**Type II WB epoxy system**
- Epoxy resin (most typically SER) is pre-dispersed
- Mixing is more easily controlled
- Common technology for concrete flooring and walls

**Test Results - Pot Life**
- NAEH-based coatings have a pot life of 4-10 hours compared to liquid epoxy systems (Type I) and waterborne epoxy dispersions (Type II), which typically exhibit a 2-3 hour pot life.

Viscosity isn’t always a good indicator of pot life in waterborne 2K coatings, as gelling of the coating doesn’t always occur. Gloss is a more common measurement of pot life in waterborne epoxy systems. As such, a significant decrease in gloss indicates compromised film formation and the end of pot life. Clear and pigmented NAEH-based coatings were tested and found to have at least four hours of pot life compared to approximately two to three hours for the Type I and Type II waterborne epoxy systems.

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2 The extent of pot life will depend on the specific formulation for any given coating.
Test Results - Early Drying & Cure

- NAEH-based coatings cut dry time by 50 percent under ambient temperatures, and can be used at lower temperatures (under 50°F), compared to liquid epoxy systems and waterborne epoxy dispersions.

Fast hardness development can translate to a rapid return-to-service, allowing a coated floor to be re-opened to foot traffic or for restocking after shorter downtimes. NAEH-based coatings were tested and measured alongside waterborne acrylic and epoxy dispersions for Konig hardness, dry-to-touch, and dry-through time. Clear and pigmented NAEH-based formulations ranked at or near the top in terms of Konig hardness, especially at low temperature and the dry-to-touch and dry-through time.

Typical drying/hardness properties of Type I and Type II coatings

<table>
<thead>
<tr>
<th></th>
<th>Konig hardness (7 days at room temperature, seconds)</th>
<th>Konig hardness (7 days at low temperature, seconds)</th>
<th>Dry-to-touch (hrs)</th>
<th>Dry-to-handle (hrs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NAEH</td>
<td>64</td>
<td>57</td>
<td>0.8</td>
<td>4.3</td>
</tr>
<tr>
<td>Type I</td>
<td>48</td>
<td>21</td>
<td>5.1</td>
<td>14.8</td>
</tr>
<tr>
<td>Type II</td>
<td>77</td>
<td>39</td>
<td>2.1</td>
<td>8.4</td>
</tr>
</tbody>
</table>

Test Results - Hot/Cold Tire Pick-up Resistance

- In both hot and cold tire pick-up resistance testing, NAEH-based coatings had no evidence of film compression and remained fully adhered to and intact on the concrete block.

Concrete floor coatings undergo stress tests, including hot and cold tire resistance tests. The hot tire resistance test is designed to simulate the situation where a car has been driven and then parked on a wet coated concrete surface, whereas the cold tire resistance test represents the same situation but where the tire is not at an elevated temperature due to heat being generated while driving on the road. In both hot and cold testing, NAEH-based coatings had no evidence of film compression and remained fully adhered to and intact on the concrete block. Neither of the two commercially available coatings (see figure below) showed evidence of film compression; however, both had small regions where the coating failed at the concrete block interface in the hot tire test. For black tire marking, all three coatings performed similarly.

Results of Hot Tire and Cold Tire Pick-Up Tests a

- Films were tested and rated on film compression, adhesion, and black tire marking.
Test Results - UV Exposure Resistance

- The acrylic component in NAEH-based coatings facilitates significantly improved UV durability, helping reduce the development of yellowing and loss of gloss caused by extended UV exposure.

Common epoxy systems typically degrade under exposure to UV radiation, exhibiting chalking and dramatic gloss reduction, and this result was found in accelerated UV exposure testing over concrete substrates. NAEH-based formulations, on the other hand, showed inherently better resistance to gloss change under UV radiation.4

CONCLUSION

Novel Acrylic-Epoxy Hybrid (NAEH) Technology developed by Dow Coating Materials performs very well in concrete enamel coatings across a range of critical properties. In comparison to other technologies and commercial waterborne epoxy concrete coatings, NAEH technology shows good or better overall performance. The new technology combines the overall excellent performance of waterborne epoxy and acrylic systems, while offering key advantages relative to commercially available products.

NAEH technology can be formulated into low coalescent or coalescent-free, ultra-low VOC coatings, thus enabling formulators to not just meet, but exceed, VOC regulations. Furthermore, the unique property balance brought by this new hybrid dispersion, including better resistance to UV, allows formulators to develop differentiated products aimed at environmentally conscious building standards, which are growing in prominence and importance.

Zhenwen Fu is a principal research scientist with Dow Coating Materials. His technical paper on Novel Acrylic-Epoxy Hybrid Technology for concrete wall and floor coatings earned first place in the Roon Awards competition held in conjunction with the 2014 American Coatings Conference.

4 Accelerated UV exposure testing was performed on pigmented coatings on metal panels. Coatings were cured for 7 days at 77°F/50% RH, then placed in a QUV-A (295-370nm, peak 340 nm, 0.68 W/M²) exposure chamber. Exposure was cyclical with 8 hours QUV-A exposure at about 60°C/4 hours condensation at about 50°C, and gloss was monitored as a function of the exposure time.