Arkema Coating Resins

Welcome to the

2014 ACR Webinar Series!!

Invest one hour with us and we’ll help you grow your business with products and technology from Arkema Coating Resins

May 16, 2014
Today's Topic: Cementitious Coatings
Speaker: Mike Kaufman
Title: Sr. Application Development Leader
Our training goal

Give you the knowledge necessary to answer your customer’s questions concerning cementitious coatings with confidence

• Outline the basics of cement and concrete
• Describe some of the testing protocols
• Outline the characteristics of the different product classifications
• Highlight several Arkema products and describe their performance benefits
Agenda

- What is concrete and how is it made?
- The unique requirements of coatings for concrete
- Markets and Product Categories
- Paint formulating and testing basics
- ACR products for cementitious coatings
- Recap
Concrete Basics
Concrete is not a new invention

- Concrete has existed for thousands of years.
  - Archaeologist Heinrich Schliemann found concrete floors in the royal palace of Tiryns, Greece, c. 1400 BC.
  - The Assyrian Jerwan Aqueduct built c. 688 BC made use of fully waterproof concrete.
  - The Romans used concrete extensively from 300 BC to 476 AD.

- Roman concrete differed from modern concrete
  - It was made from quicklime, pozzolana and pumice aggregate.
  - Its widespread use in many structures, freed Roman construction from the restrictions of stone and brick and allowed for revolutionary new designs.
  - The knowledge of concrete production was lost in the west with the fall of the Roman empire.

- Modern concrete was made possible with the invention of portland cement by Joseph Aspdin in 1824.
Cement is the “glue” in concrete

- Cement is a basic ingredient of concrete.
- Concrete is formed when cement reacts with water and binds sand and gravel in a harden matrix.
Cement manufacturing is a multi-step process

- Common materials used to manufacture cement include limestone, shells, and chalk or marble combined with shale, clay, slate, blast furnace slag, silica sand, and iron ore.

- These ingredients, when heated at high temperatures form a rock-like substance called “clinker” that is ground into the fine powder that we commonly think of as cement.
Coating Concrete
Concrete structures must be protected from the "elements"

- Concrete is dimensionally stable but very porous
- It is susceptible to deterioration through the actions of water, air (oxygen and carbon dioxide) and salt(s)
- Carbon dioxide from air will react with the calcium hydroxide in concrete to form calcium carbonate, in a process called carbonation.

\[ Ca(OH)_2 + CO_2 \rightarrow CaCO_3 + H_2O \]
Steel reinforcement is it's Achilles' heel

Steel reinforcing rebar is employed in modern concrete structures to improve its tensile strength and ductility.

Steel rebar is susceptible to corrosion:

- The high alkalinity of the fresh concrete matrix protects the steel rebar from corrosion.
- Carbonation accelerates the rate of rebar corrosion by decreasing the alkalinity of the surrounding concrete matrix. Below a pH of 10, the steel's thin layer of surface passivation dissolves and corrosion is promoted.
- Water and oxygen can then corrode steel reinforcing rebar.
- The presence of salt(s) greatly accelerate the rate of corrosion.
Spalling accelerates the degradation of a structure

Corrosion of rebar causes cracking of the concrete matrix and leads to spalling
Coating concrete extends its service life

Numerous approaches are employed to reduce the rate of corrosion

- Positioning of the rebar within the concrete matrix to ensure there is an adequate concrete cover (if the reinforcement is too close to the surface, early failure due to corrosion may occur)
- Use of corrosion-resistant reinforcement such as uncoated, low carbon/chromium (micro composite), epoxy-coated, hot dip galvanized or stainless steel rebar
- Addition of corrosion inhibitors, such as calcium nitrite \([\text{Ca(NO}_2\text{)}_2]\), to the water mix before pouring concrete
- Application of a sealant coating some time after curing

The benefit of coating concrete is additive

- Can be employed in conjunction with other anti-corrosion measures
- Can be employed after concrete structure is in place
- Works by reducing the permeability of concrete surface to water, air and salt(s)
Cementitious Coatings Markets and Product Categories
Numerous market segments…

- **Non-Residential Building**
  - Industrial
  - Office & Commercial

- **Residential Building**
  - Exterior Broadwall
  - Driveways & Sidewalks
  - Flooring

- **Infrastructure**
  - Roads & Bridges
  - Parking Structures and Stadiums
With some end use applications

- Wall paints which improve performance and aesthetics on masonry/concrete surfaces
- Concrete stains that give high-end look to ordinary concrete patios
- “Wet look” in demand for driveway and sidewalk sealers
- Textured finishes refurbish “tired” concrete patios
- Cure & Seals ensure maximum compressive strength and protects from staining
- Concrete sealers also offer utility for infrastructure maintenance
Paint Formulating and Testing
# Paints are complex mixtures of raw materials

<table>
<thead>
<tr>
<th>Component</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Latex Polymer</td>
<td>Film Former</td>
</tr>
<tr>
<td>Coalescent</td>
<td>Plasticizer/ Open Time</td>
</tr>
<tr>
<td>Primary Pigments</td>
<td>Hiding Power</td>
</tr>
<tr>
<td>Extender Pigments</td>
<td>Control Gloss</td>
</tr>
<tr>
<td>Dispersants &amp; Surf.</td>
<td>Wetting</td>
</tr>
<tr>
<td>Defoamer</td>
<td>Eliminate Foam</td>
</tr>
<tr>
<td>Preservative/ Mildewcide</td>
<td>Prevent Microbials</td>
</tr>
<tr>
<td>Thickener/ Rheo. Mod.</td>
<td>Application</td>
</tr>
<tr>
<td>Misc. Additives</td>
<td>Anti-Mar, etc.</td>
</tr>
</tbody>
</table>
Pigments provide color and hiding

**Prime - Hiding and color**
- Titanium dioxide

**Functional - imparts specific properties**
- Zinc oxide: Used primarily in primers and exterior paints, it provides mildew resistance and stain blocking properties.
- Zinc Phosphate: Corrosion control

**Extender - flatness, sheen control, cost**
- Calcium Carbonate: Used in both interior and exterior paints, a general purpose, low cost, low hide pigment.
- Clay: Used mainly in interior paints, clay provides hiding power.
- Silica: Provides enhanced durability in exterior paints as well as scrub and abrasion resistance.
- Talc: A soft, general purpose extender pigment.
- Diatomaceous silica: Consisting of fossilized organisms, this form of silica is used to control sheen levels.
Binder holds the pigment together

Water-borne latex
- Acrylic
- Vinyl acetate/Versatate copolymers
- Styrene acrylic

Alkyds - not used on concrete due to saponification resulting in failure
Additives are critical to making a usable coating

Enhance numerous properties such as rheology, mildew resistance and other specific properties

- Rheology modifiers – HASE, HEUR, Cellulosic, HEURASE, ASE
- Preservatives and Mildewcides
- Dispersant and Surfactants
- Mar and Slip additives
- Coalescing solvent – aids in film formation
- Ethylene and propylene glycol – freeze thaw protection and open time extension
The proportion of raw materials affects quality

Higher quality coatings have more binder, less pigment and higher volume solids

- Gloss
  - Liquid
  - Binder
  - Pigment

- Quality Flat
  - Liquid
  - Binder
  - Pigment

- Low-cost Flat
  - Liquid
  - Binder
  - Pigment
Pigment volume concentration is a key metric

**Pigment Volume Concentration (PVC):**

\[
PVC = \frac{\text{volume of pigment}}{\text{volume of pigment + volume of binder solids}} \times 100\%
\]
PVC tells us about the nature of the paint film

**Critical Pigment Volume Concentration (CPVC)**

- CPVC marks the transition from a system in which the pigment is dispersed in a continuous binder matrix to one where there is insufficient binder to completely encapsulate all the pigments.
Coatings properties change dramatically at CPVC.
### Numerous paint properties affected by PVC

<table>
<thead>
<tr>
<th>Property</th>
<th>Low PVC</th>
<th>High PVC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stain Removal</td>
<td>Good</td>
<td>Poor</td>
</tr>
<tr>
<td>Scrub Resistance</td>
<td>Good</td>
<td>Poor</td>
</tr>
<tr>
<td>Dry Hiding</td>
<td>Fair</td>
<td>Good</td>
</tr>
<tr>
<td>Efflorescence Resistance</td>
<td>Good</td>
<td>Poor</td>
</tr>
<tr>
<td>Block Resistance</td>
<td>Poor</td>
<td>Good</td>
</tr>
<tr>
<td>Moisture Permeability</td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>Tensile Strength</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>Stain Resistance</td>
<td>Good</td>
<td>Poor</td>
</tr>
</tbody>
</table>
Paints are formulated over the entire PVC range.

Paint Types:
- High Gloss Enamel
- Gloss Trim
- Semigloss
- Interior Satin
- Exterior Sheen
- Exterior Flat
- Interior Flat

Pigment volume concentration:
- 15
- 25
- 35
- 45
- 55
- 65
- 75
Coatings used on concrete substrates:

- Vary in sheen from Gloss to Flat
  - Covers the PVC range
- Vary in VOC content
  - Texanol and Glycol impacted
- Will have varying strengths and weaknesses based on properties chosen by developer
  - Efflorescence and Alkali resistance two most important properties for concrete coatings
  - Tensile and Elongation important for Elastomeric coatings
- Can be applied either by brush, roller or spray gun
  - Rheology modifiers impacted
Concrete presents some unique demands on a coating

- **Highly Alkaline**
  - Fresh concrete substrates are extremely alkaline (pH > 12.5)
  - The surface of aged concrete has substantially less alkaline (pH ~8.5) due to carbonation

- **It can be an extremely porous material**
  - High permeable to water which may result in efflorescence and/or blistering
Key performance tests for cementitious coatings

- Efflorescence resistance
- Alkali resistance
- Water vapor permeability
Efflorescence is the migration of salts to the masonry surface

Three conditions must be satisfied for efflorescence to occur:

- There must be water-soluble salts present somewhere in the wall.
- There must be sufficient moisture in the wall to render the salts into a soluble solution.
- There must be a path for the soluble salts to migrate through to the surface where the moisture can evaporate, thus depositing the salts which then crystallize and cause efflorescence.
Concretes highly alkaline surface can degrade the binder

Hydrolysis of polymer backbone

\[
\begin{align*}
\text{CH}_3\text{C}=\text{O} & \quad \text{CH}_3\text{O} \quad \text{OH} & \quad \text{CH}_3\text{C}=\text{O} \\
\text{O} & \quad \text{O} & \quad \text{C} \quad \text{O} & \quad \text{C} \quad \text{O} \\
\text{CH}_3\quad \text{CH}_3 & \quad \text{CH}_3\quad \text{CH}_3 & \quad \text{CH}_3\quad \text{CH}_3 & \quad \text{CH}_3\quad \text{CH}_3
\end{align*}
\]

- OH \rightarrow OH \quad + \quad \text{CH}_3\text{C}=\text{O} \quad + \quad \text{CH}_3\text{OH}
There is no single standard method for evaluating efflorescence resistance

Efflorescence resistance

- Tombstone method
- Cleveland Humidity on Alkaline substrate
- ASTM C1400 - Standard Guide for Reduction of Efflorescence Potential in New Masonry Walls
- ASTM D7072 - Standard Practice for Evaluating Accelerated Efflorescence of Latex Coatings
- Numerous customer specific test methods
Nor for evaluating alkali resistance

**Alkali resistance**

- Alkaline soak
- Free film dissolution method
- ASTM D3643 - Standard Test Method for Acid Number of Certain Alkali-Soluble Resins
- Numerous customer specific test methods
Permeability testing conducted via ASTM protocols

**Permeability**

ACR Product Overview
ACR’s broad toolbox offers the most options for solving customer problems

- **Broapest technology platform**
  - NEOCAR® Acrylic polymers
  - Acrylic polymers
  - Styrene acrylic polymers
  - NEOCAR® polymers
  - Vinyl acrylic polymers
  - Vinyl acetate ethylene polymers
  - Styrene-butadiene polymers
Polymer composition can affect coating performance

- Vinyl Acrylics
- NEOCAR® LATEX
- NEOCAR® Acrylics
- Conventional Acrylics
- NEOCAR® Acrylics
What is NEOCAR® Technology?

They are modified Acrylic or Vinyl Acetate containing latexes with the Neo Monomer via emulsion polymerization.

- NEOCAR Latex - VA/Neo
- NEOCAR Acrylic - Acrylic/Neo

What is Neo monomer

- Highly Branched Esters of Monocarboxylic Acid
- Extremely hydrophobic
  - Low oxygen content and water solubility
- Offers increased flexibility and elongation due to its low Tg
  - Neo Monomer (Tg, °C=-3 & 60) vs. Styrene (Tg, °C=100)
- UV transparent monomer that offers outstanding durability
- Benefits of Neo Monomers
  - Increased Hydrophobicity to impart in coatings
    - Exceptional water and alkali resistance
    - Improves chemical resistance
    - Exceptional flexibility and elongation
Decreasing polymer oxygen content - Increasing hydrophobicity

<table>
<thead>
<tr>
<th>Monomer</th>
<th>Formula</th>
<th>Mass</th>
<th>% Oxygen</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vinyl Acetate</td>
<td>C₄H₆O₂</td>
<td>86</td>
<td>37%</td>
</tr>
<tr>
<td>Methy Methacrylate</td>
<td>C₅H₈O₂</td>
<td>86</td>
<td>32%</td>
</tr>
<tr>
<td>Butyl Acrylate</td>
<td>C₇H₁₂O₂</td>
<td>128</td>
<td>25%</td>
</tr>
<tr>
<td>Neo Monomers</td>
<td>CₙHₘO₂</td>
<td>159-210</td>
<td>14-17%</td>
</tr>
<tr>
<td>Styrene</td>
<td>C₈H₈</td>
<td>104</td>
<td>0%</td>
</tr>
</tbody>
</table>
NEOCAR® Technology yields extremely hydrophobic polymers

- Styrene: ~0.01%
- Neo monomers
- 2-EHA
- BA

% Water Solubility vs. Tg, °C of homopolymers

- 0%
- 2%
- 4%
- 6%
- 8%
- 10%
- 12%
- 14%
- 16%

- 100
- 60
- -3
- -55
- -65
NEOCAR® Technology protects the polymer backbone
ACR offers a range of products to cover the entire spectrum of performance and cost

<table>
<thead>
<tr>
<th>Product</th>
<th>Chemistry</th>
<th>Total solids</th>
<th>T&lt;sub&gt;g&lt;/sub&gt; (°C)</th>
<th>Features</th>
</tr>
</thead>
<tbody>
<tr>
<td>NEOCAR® Latex 2300</td>
<td>Vinyl acetate/vinyl versatate</td>
<td>55</td>
<td>5</td>
<td>Interior/exterior masonry wall with excellent alkali and efflorescence resistance</td>
</tr>
<tr>
<td>NEOCAR® Latex 2535</td>
<td>Vinyl acetate/vinyl versatate</td>
<td>53.5</td>
<td>10</td>
<td>General purpose binder for high-film build coatings with wet adhesion</td>
</tr>
<tr>
<td>NEOCAR® Acrylic 820</td>
<td>Vinyl versatate/acrylic</td>
<td>45</td>
<td>20</td>
<td>Ultra-small particle size binder for water and blush resistance</td>
</tr>
<tr>
<td>NEOCAR® Acrylic 850</td>
<td>Vinyl versatate/acrylic</td>
<td>45</td>
<td>50</td>
<td>Ultra-small particle size binder with ambient cross-linking for coatings with block and chemical resistance</td>
</tr>
<tr>
<td>ENCOR® CL36</td>
<td>Acrylic</td>
<td>49</td>
<td>20</td>
<td>Suitable for primer and topcoats; efflorescence resistance over masonry</td>
</tr>
<tr>
<td>ENCOR® 651</td>
<td>Acrylic</td>
<td>65</td>
<td>12</td>
<td>Abrasion resistance coatings for athletic surfaces</td>
</tr>
<tr>
<td>ENCOR® 657</td>
<td>Acrylic</td>
<td>58</td>
<td>16</td>
<td>Cost effective high solids acrylic binder for masonry and wall coatings</td>
</tr>
<tr>
<td>ENCOR® 7325</td>
<td>Styrene acrylic</td>
<td>46</td>
<td>50</td>
<td>Concrete sealer</td>
</tr>
</tbody>
</table>


## Competitive products and suggested ACR alternatives

<table>
<thead>
<tr>
<th>Competitive Product</th>
<th>ACR Alternative</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Dow Chemical Company</td>
<td></td>
</tr>
<tr>
<td>Rhoplex 2500</td>
<td>ENCOR 657, NEOCAR Latex 2300</td>
</tr>
<tr>
<td>Rhoplex CS-4000</td>
<td></td>
</tr>
<tr>
<td>Rhoplex AC630</td>
<td>NEOCAR Acrylic 820</td>
</tr>
<tr>
<td>Rhoplex ML-100, 200, 300 or 400</td>
<td>NEOCAR Latex 2535</td>
</tr>
<tr>
<td>Rhoplex AC261</td>
<td>NEOCAR Acrylic 850</td>
</tr>
<tr>
<td>Rhoplex SS4</td>
<td>ENCOR 651</td>
</tr>
<tr>
<td><strong>BASF</strong></td>
<td></td>
</tr>
<tr>
<td>Acronol 296D</td>
<td>ENCOR 657, NEOCAR Latex 2300</td>
</tr>
</tbody>
</table>
NEOCAR® 2300
Vinyl Versatate-Containing Latex for Cost-Effective Architectural Coatings
NEOCAR® 2300 delivers superior cost/performance

Value Proposition

- Offers our customers the ability to formulate an extremely cost effective alkali resistant masonry paint

Product Overview

- Typical end use
  - Interior/exterior masonry wall coatings

- Features
  - Good interior/exterior durability
  - Water resistance
  - Good alkali and efflorescence resistance
  - Zero VOC capable
NEOCAR® 2300 offers superior durability

Scrub Resistance

<table>
<thead>
<tr>
<th>Material</th>
<th>Scrub Resistance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acronal 296D</td>
<td>100</td>
</tr>
<tr>
<td>NeoCAR 2300</td>
<td>500</td>
</tr>
<tr>
<td>ENCOR 657</td>
<td>200</td>
</tr>
<tr>
<td>ENCOR CL36</td>
<td>100</td>
</tr>
<tr>
<td>NeoCAR 2535</td>
<td>500</td>
</tr>
</tbody>
</table>

- Green: Contractor Flat
- Orange: Quality Flat
NEOCAR® 2535
Vinyl Versatate-Containing Latex for Cost-Effective Architectural Coatings
NEOCAR® 2535 delivers inherent film build

Value Proposition

- Offers our customers the ability to formulate an extremely cost effective exterior coating with inherent film build

Product Overview

Typical End Use Applications

- Exterior House Paint
  - Wood, masonry and cement fiberboard
- EIFS repaint

Features

- Inherent film build
- Good exterior durability
  - Grain crack and alkali resistance, color retention
- Zero VOC capable with non-VOC coalescing solvent
NEOCAR® 2535 has excellent alkali resistance

Commercial Acrylic(s)

NEOCAR Latex 2535
NEOCAR® Acrylic  820
High Performance Polymer for Clear Coatings and Sealers
NEOCAR® Acrylic 820 delivers superior blush resistance

Value Proposition

- Offers our customers superior blush resistance performance versus competitive acrylic and styrene acrylcs

Product Overview

- Typical End Use Applications
  - Architectural and Industrial usage
  - Surfaces requiring outstanding blush resistance
    - Wood decks, ceramic roof tiles and concrete patios
  - Masonry sealers
  - Clear sealers
  - Semi-transparent and solid color stains

- Features
  - Outstanding water and blush resistance
  - Zero VOC capable with non-VOC hydrophilic coalescing solvent
NEOCAR® Acrylic 820 has significantly lower water absorption.
NEOCAR® Acrylic 820 has significantly better blush resistance
NEOCAR® Acrylic 820 superior hydrophobicity yields water beading coatings
NEOCAR® Acrylic 820 exhibits excellent efflorescence resistance

Topcoat

NEOCAR Acrylic Sealer/Topcoat
NEOCAR® Acrylic 850
High Performance Polymer for Clear Coatings and Sealers
NEOCAR® Acrylic 850 delivers unparalleled performance

Value Proposition

- Offers our customers the ability to formulate coatings with the superior blush, chemical and block resistance

Product Overview

- Typical End Use Applications
  - Architectural and industrial usage
    - Surfaces requiring outstanding hardness, blush and chemical resistance
    - Garage floors, driveway pavers, tiles or concrete decks
  - Concrete sealers

- Features
  - Outstanding blush resistance
  - Excellent water and chemical resistance
  - Outstanding hot tire pick-up resistance
  - Capable of being formulated at 100 g/L VOC
NEOCAR® Acrylic 850 employs a unique ambient cure cross-linking mechanism.
This cross-linking yields films with excellent solvent resistance.
NEOCARA Acrylic 850 can enhance the appearance of stone pavers.
ENC O R® CL36
High Performance Polymer for Clear Coatings and Sealers
ENCOR® CL36 offers broad utility

Value Proposition

- Offers our customers the ability to formulate both primers and top coats for masonry substrates

Product Overview

- Typical End Use Applications
  - Barrier coatings

- Features
  - Excellent alkali and efflorescence resistance
  - Flat coatings
  - Good flexibility
ENCOR® 651
All-Acrylic High Solids Latex for Athletic Surface and Architectural Coatings
ENCOR® 651 for durable sport surfaces

Value Proposition

- Offers our customers the ability to formulate coatings for sport surfaces

Product Overview

- Typical End Use Applications
  - Block fillers
  - Barrier coatings
  - Athletic surfaces (i.e. tennis courts)

- Features
  - Excellent alkali resistance
  - Flat coatings
  - Good flexibility
ENCOR® 657
Versatile 100% Acrylic Latex for Interior, Exterior and Masonry Coatings
ENCOR® 657 is a low cost option for a 100% acrylic binder

Value Proposition

- Offers our customers the ability to formulate low cost, 100% acrylic masonry coatings

Product Overview

- Typical End Use Applications
  - Interior/exterior architectural paints
  - Exterior wood siding stains
  - Masonry paints and stains

- Features
  - Broad formulation latitude
  - Good balance of properties
    - Washability and Stain Resistance
  - Outstanding alkali resistance
  - Good color retention
ENCOR® 7325
Concrete Sealer
ENCOR® 7325 for cure and seal coatings

Value Proposition

- Offers our customers the ability to formulate cure and seal coatings for concrete floors

Product Overview

- Typical End Use Applications
  - Concrete sealers

- Features
  - Sealer for Interior and Exterior Concrete
  - Outstanding Water Resistance
  - Non-Yellowing
  - Passes ASTM C309 and C1315 for water retention
ENCOR® 7325 meets the performance requirements of ASTM C309

- Relevant test methods include ASTM C309, C156, D1308 and D1644
  - Application Rate: 200 ft²/gal

ASTM C309 test results

<table>
<thead>
<tr>
<th>Test results</th>
<th>Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water Retention, kg/m²</td>
<td>0.44</td>
</tr>
<tr>
<td>Drying Time to Touch, hours</td>
<td>~1.0</td>
</tr>
<tr>
<td>Nonvolatile Content, %</td>
<td>15.8</td>
</tr>
</tbody>
</table>
Today’s session was intended to provide you with a technical grounding in paint formulating and product selection for cementitious substrates.

Fresh concrete is a very alkaline surface and care must be exercised in the selection of raw materials and formulation of masonry coatings.

The three key performance tests of masonry coatings are water vapor permeability, efflorescence and alkali resistance.

ACR offers the broadest range of chemistries to the masonry paint market to meet a range of cost/performance requirements including:

- A variety of Acrylic latexes for use in broadwall and barrier coatings
- NEOCAR® technology to extend the performance capabilities of both vinyl acetate and acrylic-based latexes
Questions? Please contact the Account Team

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2014 ACR Webinar Series

Next Month’s Topic: Elastomeric Coatings

Speaker: John Dockery

Title: Technical Service Chemist

Friday June 20, 2014 @ 2:00pm ET
Thank You for Joining Us!!

See you in May!!