Powder Coating Consultants
Division of Ninan, Inc.
1529 Laurel Avenue
Bridgeport, CT 06604
Phone: (203) 366-7244
(800) 97 POWDER
Fax: (203) 367-5245
email: pcc@powdercoat.com
Website: www.powdercc.com

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White Paper

Questions and Answers Regarding Outdoor Durability of Powder Coating Systems and Chemistries

Question #1:
How do standard durable and super durable polyester & polyurethane powder coatings compare in outdoor weathering (UV resistance)?

Answer #1:

- We define three terms for outdoor durability:
  - **Standard outdoor durability**. Those products typically meet the gloss retention weathering resistance requirement of **AAMA 2603**.
  - **High outdoor durability** (often called super durability). Those products certainly meet the gloss retention weathering resistance requirement of **AAMA 2603**; some well formulated products may even meet the gloss retention weathering resistance requirement of **AAMA 2604.**
  - **Super high outdoor durability**. Those products certainly meet the gloss retention weathering resistance requirement of **AAMA 2604**; specially formulated products may even meet the gloss retention weathering resistance requirement of **AAMA 2605**.
  - For AAMA specifications see: http://www.saf.com/content.php?action=showPage&pid=63&cat_id=11.
- **Standard outdoor durable** polyester-TGIC and polyester-Primid based powder coatings lose about **20%** of their initial gloss within **28-36 months** of South Florida exposure.
- **Standard outdoor durable** emissive (E-cap blocked) polyester-polyurethane based powder coatings are slightly inferior on average; they lose about **20%** of their initial gloss within **20-28 months** of South Florida exposure.
- **Standard outdoor durable** non-emissive (uretdione type) polyester-polyurethane based powder coatings lose about **20%** of their initial gloss within **30 months** of South Florida exposure.
- **High outdoor durable** polyester-TGIC and polyester-Primid based powder coatings lose about **20%** of their initial gloss within **40-55 months** of South Florida exposure.
- **High outdoor durable** and emissive (E-cap blocked) polyester-polyurethane based powder coatings lose about **20%** of their initial gloss within **40-50 months** of South Florida exposure.

- **High outdoor durable** non-emissive (uretdione type) polyester-polyurethane based powder coatings lose **20%** of their initial gloss within **50-plus months** of South Florida exposure**.**
- **Super high outdoor durable** powder coatings containing Lumiflon resin in combination with high outdoor durable polyesters (TGIC cocktail or polyurethane type) may lose between **0 and 15%** of their initial gloss within **60 months** of South Florida exposure, depending on the amount of Lumiflon resin in such formulas. Higher Lumiflon content yield better outdoor durability; they are also much more expensive.
- All South Florida gloss loss data mentioned in "Answer #1" reflect typical average values; some powder coatings may perform somewhat better, or worse, than what is mentioned here. Color changes are not discussed in this answer.

Question #2**:**
What are the resin chemistry differences—in simple terms—used in standard, high outdoor durable, and super high outdoor durable powder coatings?

Answer #2:

- The type of polyester resins and their "chemical backbone" determine primarily how UV resistant and outdoor durable coatings made from them are. Polyester resins are the condensation products of organic dicarboxylic acids (contain two carboxyl groups per molecule) and glycols; their types and compositions in polyesters are called resin backbone. Mainly one type of acid, phthalic acid, determines outdoor durability. To obtain the highest outdoor durability, siliconized or fluorinated compounds (as polyesters, or other types) are commonly used (mainly in liquid industrial paints—fluorinated compounds sometimes also in powder coatings).
  - The backbone of **standard outdoor durable** polyester resins used in polyester-TGIC, polyester-Primid, emissive (E-cap blocked) and non-emissive polyester-polyurethane are based the lower cost terephthalic acid, or blend of all three phthalic acid isomers (see http://en.wikipedia.org/wiki/Phthalic_acid).
  - The backbone of **high outdoor durable** polyester resins used in polyester-TGIC, polyester-Primid, emissive (E-cap type) and non-emissive polyester-polyurethane are based on the more expensive isophthalic acid.
  - **Super high outdoor durable** resin combinations may contain **Lumiflon**[1] combined with isophthalic acid based polyesters. Lumiflon resins are fluoropolymer compounds. A combination of high outdoor durable isophthalic acid based polyesters (mainly as TGIC and non-emissive uretdione type polyester-polyurethane) with standard temperature (~ 90-120°C) extrudable **Kynar**[2] products can be used for formulating lower gloss (20-40 gloss) **super high outdoor durable** powder coatings.

[1] See http://www.lumiflon.com/what_us/index.html and http://www.lumiflonusa.com/specifications_powder_grade.php for more details.
[2] See http://en.wikipedia.org/wiki/Polyvinylidene_fluoride for more details.

Question #3:
Are all **high outdoor durable** powder coatings created the same?

Answer #3:
- Apart from using polyester resins containing isophthalic acid in their backbones, outdoor durability depends also on formulating tricks, such as using primarily **inorganic pigments** and **correct fillers** (e.g. Barium Sulfate or Wollastonite, and no Calcium Carbonate—the latter causes chalking). Powders with low pigment and filler loading generally show somewhat better outdoor durability; very low gloss powders finishes *appear* to be better performing in outdoor durability (when not chalking) because loss of gloss differences are harder to see.

Question #4:
What affects weathering and UV performance?

Answer #4:
- As mentioned in "Answer #3," the choice of pigments and fillers affect outdoor durability; e.g. **iron oxide pigments** are natural UV absorbers. Inorganic pigments show virtually no color fading (color change) after years of outdoor exposure.
- The **stoichiometric** ratios of resins and curatives have to be correct for best results.
- **Extrusion conditions** can influence outdoor durability, e.g. lower extruder RPM and higher extrusion temperature result in improved pigment and filler wet-out; poor pigment and filler wet-out can cause premature chalking.
- A **full** (100%) **cure** is necessary. Undercured coatings are more susceptible to chemical and environmental attacks and degradation.
- Some formulators are using **UV absorber** additives (in combination with **antioxidants**); this is most beneficial when formulating transparent or clear high outdoor durable coatings.
- Extended Florida weathering has shown that the degradation of coating finishes is often caused by mold attacks, which occurs more frequently in warm and humid environments. Using **biocide**[3] additives in powder coatings has become more common for formulating **high outdoor durable** powder coatings.

Question #5:
How can transfer efficiencies be improved?

Answer #5:
- Adding 0.2 to 0.5% **Barium Titanate** into formulas, especially highly filled powders, improves transfer efficiency. Powders with low pigment and filler content transfer better than highly filled powders because they have higher **dielectric constants**[4].

[3] See http://en.wikipedia.org/wiki/Biocide for more details.
[4] See http://en.wikipedia.org/wiki/Dielectric and http://hyperphysics.phy-astr.gsu.edu/hbase/Tables/diel.html for more details.

Question #6:
List accelerated weathering test methods and explanations of each.

Answer #6:

- **Accelerated weathering**[5] operates *ALWAYS* with a near UV (300-340 nanometer) light source exposure combined with a wet cycle (water sprinkle). UV radiation only cycles are **not** called accelerated weathering; they are usually used for testing light fastness properties of textiles. See also *Powder Coating, The Complete Finisher's Handbook* (PCI Powder Bible), second edition, Chapter 18, pages 248-249 (Weathering).

Bruno Fawer, B.Sc., MBA

[5] For more information about accelerated weathering, visit the following websites:
http://www.ptli.com/weathering.asp, http://www.q-lab.com/QUV.html,
http://www.aztest.com/accelerated.html
http://www.astm.org/Standards/D4798.htm
http://weather-ometer.com/en/products/laboratory_weathering_testing/index.shtml
http://www.ptli.com/testlopedia/tests/QUV-D4329.asp