



## Beyond Liquid: A Dive into Powder Coating Fundamentals and Future Trends



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# The ChemQuest Advantage: Navigating the intersection of strategy, markets, operations, and technology

## Four Pillars of Expertise

Deliver distinctive, thorough, actionable, confidential, and professional work and support our clients in every aspect of sustained, profitable growth, including:



**Business Strategy  
& Transformation**



**Technology  
Development**



**Operational &  
Manufacturing  
Efficiencies**



**M&A Advisory  
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**100%**

All of our work is proprietary, offering a full portfolio of services under NDA.

## Extensive Industry Relationships and Knowledge

Stakeholders across the value chain trust our thought leaders:

- **Team is more than 130 minds strong**, including ~ 48 Ph.D. chemists.
- **Senior personnel** each have a minimum of 25 years of experience in specialty chemicals and materials.
- **Extensive roster** includes former senior managers from major manufacturers, business owners, and senior technical managers.

## Our Mission is Enabling Our Clients to:

- **Build enterprises** that challenge established thinking and drive transformation.
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- **Unlock new and hidden insights**, empowering an organization's smart risk-taking, catalyzing innovation excellence and value creation.
- **Be successful** — because our success emanates from yours.

# Agenda



Overview of Powder Coatings and How They are Made

Powder Coatings vs. Liquid Coatings

Components of a Powder Coating Formulation

Areas of Active Research in Powder Coatings

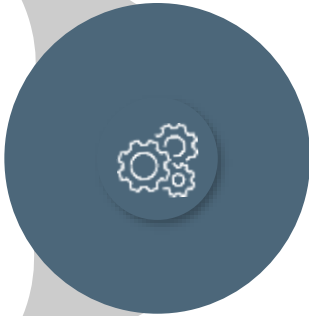


# What is a Powder Coating?

Powder coatings were first developed in Germany in the early 1950s.



Coating is applied as a dry, free-flowing powder using electrostatic spray equipment or a fluidized bed



Coated part is cured in an oven at relatively high temperatures (e.g., 190°C for 15 min)



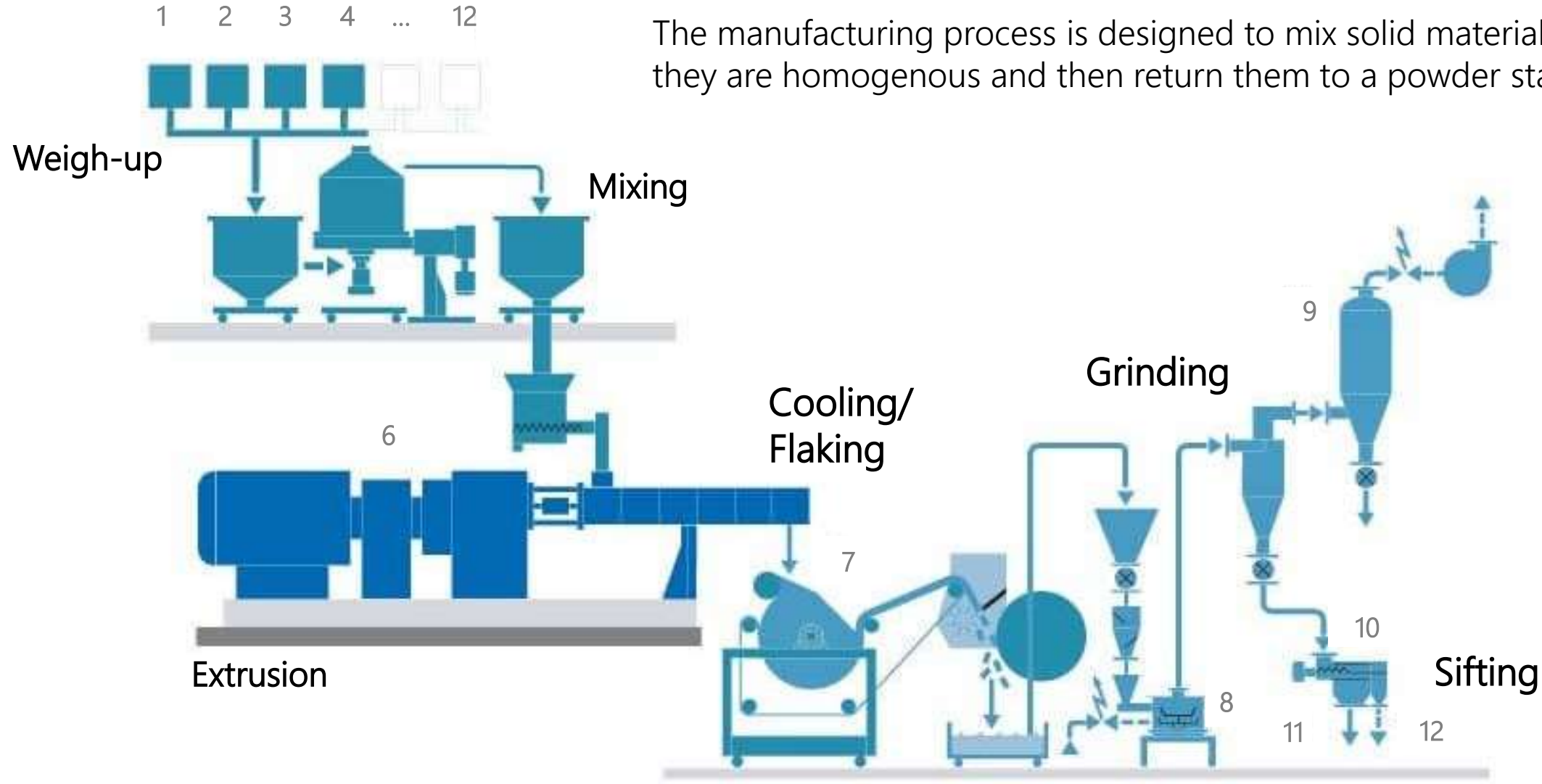
Industry growth is driven by unique combination of excellent performance and environmentally friendly profile





# Powder Coating Manufacturing Process

The manufacturing process is designed to mix solid materials until they are homogenous and then return them to a powder state.



## Powder Coatings vs. Liquid Coatings

Powder coatings and liquid (solvent based) coatings each have their own advantages and should be used in the appropriate situations.

	Powder Coatings	Liquid Coatings (Solvent)
Application environment	Factory application only	Factory or field application
Cure temperature	Elevated temperature only	Ambient or elevated temperature
Substrate	Limited to substrates that can survive the cure temperature	Not limited by substrate
Sustainability	No VOCs; very little waste since overspray is captured and reused	Must use solvent (VOCs); significant waste due to overspray and pot life
Applied cost	Lower	Higher
Film thickness	Higher film build in one coat	Thinner films are possible
Other factors	<ul style="list-style-type: none"> <li>• High performance available in a single coating layer</li> <li>• Capable of wrinkle finishes and other types of textures</li> </ul>	<ul style="list-style-type: none"> <li>• Smoother coatings with better DOI are possible</li> <li>• Color options, including metallics and specialty pigments</li> </ul>



# Powder Coatings vs. Liquid Coatings

Powder coating formulations utilize similar raw materials as liquid coating formulations, except (almost) all the ingredients must be solid and grindable.

## Components

- ✓ **Binder**
  - Resins
  - Crosslinker
- ✓ **Pigments**
- ✓ **Mineral Fillers**
- ✓ **Additives**

## Philosophy of Formulating

- ✓ **Simplicity + Quality**
- ✓ **Binder selection gives 90% of the final properties**
- ✓ **Criteria**
  - Outdoor durability
  - Chemical resistance
  - Corrosion resistance
  - Mechanical performance
  - Aesthetics (color, gloss, surface profile)
  - Processability (manufacturing and application)
  - Economics

# Binder Selection Begins with the Exterior Durability Requirement

Level of exterior durability is generally the first filter for binder selection, as UV stability requirements limit the chemistries that can be utilized.



## Exterior Durable

- Fluoropolymer (20+ years)
- Acrylic (10 years)
- "Super-durable" (5 years)
- Polyurethane (1.5-5 years)
- Polyester (1.5-2 years)



## Interior Grade

- Epoxy
- Hybrid (epoxy-polyester)
- Acrylic hybrid (epoxy-acrylic)





# Epoxy

Often considered “functional coatings” since they are excellent for protecting substrates against chemicals/corrosion but lack UV stability



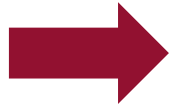
## Powder Coating Properties

- “Functional coatings”
- Excellent chemical resistance
- Excellent corrosion resistance: 3,000 hrs salt spray
- Poor UV stability: chalks very quickly
- Poor overbake resistance
- Moderate cost



## Epoxy/Polyester (Hybrid)

Robust coating for interior applications; offers good substrate protection and appearance at a low cost



### Powder Coating Properties

- 70/30, 60/40, 50/50 types
- Good chemical resistance
- Good corrosion resistance:  
1,000 hrs salt spray
- Fair UV stability; not intended for outdoor use
- Moderate overbake resistance
- Low cost



# Polyester

Good balance of properties; workhorse product for general exterior applications



## Powder Coating Properties

- TGIC vs. TGIC-free (HAA)
  - Toxicity
  - HAA drawbacks
    - Film thickness
    - Cure temperature
    - Overbake yellowing
- Exterior durable
  - Standard vs. "super-durable"
- Good balance of curing and physical properties
  - Flexible
  - Moderate chemical resistance
  - Overbake resistant
  - Low-temperature cure possible





# Polyurethane

Excellent appearance and chemical resistance, with good exterior durability



## Powder Coating Properties

- Appearance
  - Can be very smooth
  - One-shot matte possible
  - Wrinkle finish
- Exterior durable, including "super-durable"
- Anti-graffiti level of chemical resistance
- Excellent scratch resistance
- Cure temperature > 175°C



# GMA Acrylic

Excellent appearance and clarity with high level of exterior durability



## Powder Coating Properties

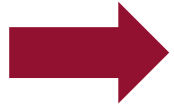
- Appearance
  - Excellent color and clarity
  - Very smooth coatings
- Highly weatherable
- Excellent chemical resistance
- Excellent scratch and chip resistance
- Incompatibility with polyesters
- Expensive





# Silicone and Fluoropolymers

Expensive but offer the ability to perform in specific applications



## Silicone

- Heat resistance > 425°C
- Highly incompatible with other chemistries



## Fluoropolymer

- Outstanding weatherability:  
20-50 years in Florida
- Very expensive



# Typical Binder Performance Properties

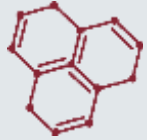
	Epoxy	Hybrid	Polyester	Polyurethane	Acrylic	Silicone	Fluoropolymer
Appearance	+	+	0	+	+++	0	-
Hardness	+++	+	0	+++	+++	-	-
Flexibility	+++	+++	+++	+	-	-	0
Weathering	-	-	+ / ++	+ / ++	+++	+	++++
Corrosion resistance	+++	++	+	++	+	-	0
Chemical resistance	+++	++	+	+++	++	0	+
Heat resistance	-	-	++	+	+	+++	++
Cost	0	+	0	-	---	--	----

+++ = Excellent; 0 = Moderate; --- = Negative



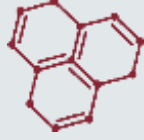
# Additives for Powder Coating Formulations

Powder coatings require a few additives specifically for issues related to the form of the applied product.



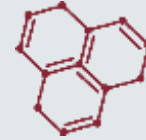
## Flow Agent

Aids the particles in flowing and fusing together at the required curing temperature



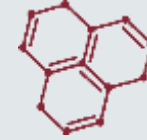
## Degassing Agent

Helps release air that can become trapped in the film as particles flow and fuse together



## Dry Flow

Improves fluidization during the application process



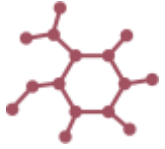
## Antioxidant

Reduces yellowing of the coating due to curing at elevated temperatures

Other common additives include waxes, pigment dispersants, catalysts, UV absorbers, and corrosion inhibitors.

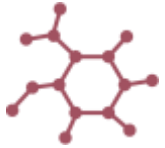


# Emerging Technologies



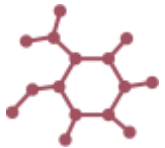
## Sustainability

- Use of recycled, renewable, and bio-based materials
- Elimination of materials of concern
  - PFAS, TGIC, etc.



## Low-Temperature Cure

- Thermal and/or UV cure
- Expand further into temperature-sensitive substrates
- Reduce energy costs

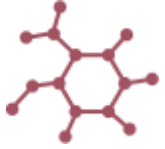


## Improved Corrosion Resistance

- Primers that perform over multiple types of metal substrates
- Improved edge coverage
- Dry-on-dry powder systems

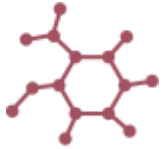


## Emerging Technologies (continued)



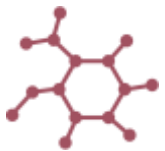
### Field-Applied Thermoplastics

- Field applied via flamespray application
- Corrosion resistance in a single coat
- Highly weatherable (acid, alkali, and UV resistant)



### Improved Architectural Topcoats

- Expanded color palette
- Environmentally friendly (LEED)



### Coatings for Electric Vehicles

- Thermal dissipation
- High dielectric strength
- Corrosion resistance







Thank You

Questions? Comments?

Feel free to reach out:

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