Coatings Trends & Technologies SUMMIT

More than Just Wood: Low-Temperature-Cure Technology Opens Up a World of New Substrates for Powder Coatings

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Presentation Overview

The concept of low-temperature cure powder coatings has loomed since the dawn of powder coating technology. In recent years, novel technology has emerged that can be cured at ever-lower temperatures.

This presentation explores the following:

- Why Low-Temperature Cure?
- Heat-Sensitive Substrates
- Dealing with Conductivity
- Low-Temp Cure vs. Ultra-Low Bake
- Low-Temp Cure – Chemistries
- Ultra-Low Bake – Thermoset Chemistries
- UV-Curable Powder Coatings
- Future Trends

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 Services**

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.
- **Gain competitive advantage** through distinctive, targeted, and substantial improvements that sustain profitable growth.
- **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.

Technology Development

Design, formulate, test, accelerate, and scout innovative technology.

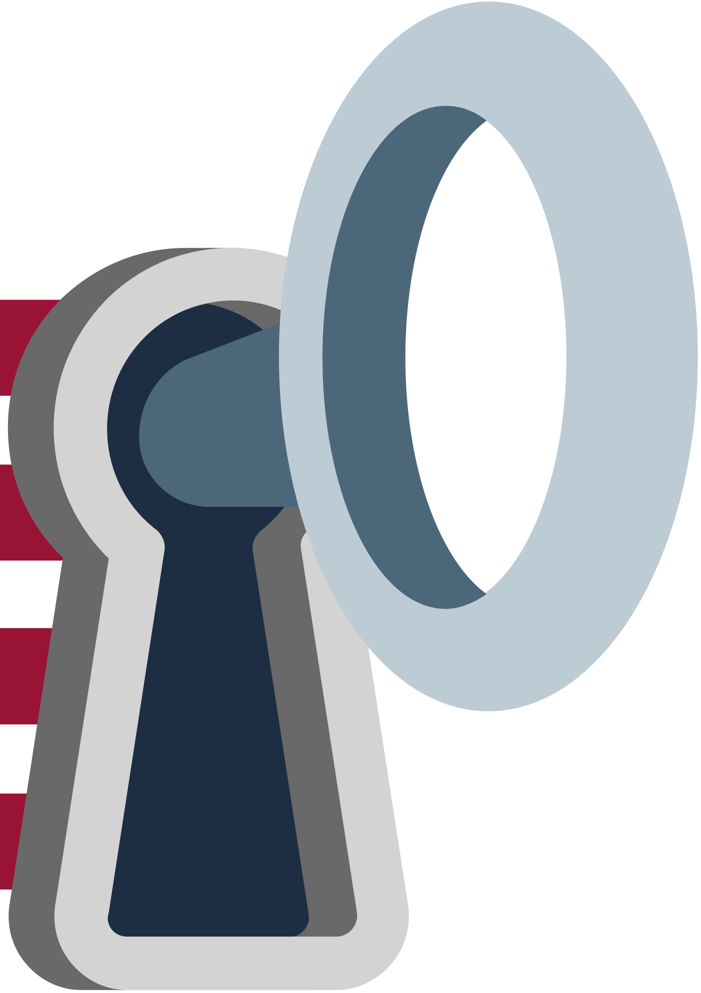
- For suppliers, manufacturers, and users
- Advanced lab facilities tailored to CASE R&D and polymer processing
- Services from molecular architecture to sophisticated application research
- Client-owned IP
- Education courses to enhance the capabilities and knowledge of your internal team

Powder Coating Benefits

- **No VOCs**
- **Non-Toxic**
  No heavy metals
- **Little or No Waste Stream**
- **Efficient**
  Collect and reuse overspray
- **High Performance**
- **Excellent Overall Economics**

Low-Temp Cure Opportunities

- Heat-Sensitive Substrates
- Pre-Assembled Parts
- Plastic Substrates
- Wood Substrates



Heat-Sensitive Substrates: Pre-Assembled Parts

Electrical Equipment
Motors, generators, switchgear

Pneumatic/Hydraulic Equipment
Door closers, jacks, shock absorbers, suspension parts

Metal/Plastic Assemblies

Gasketed Parts
Plumbing, taps, pumps, valves

Plastic Substrates

Substrate	Composition	HDT (0.46 MPa Load)	Powder Type
ABS	Acrylonitrile Butadiene Styrene	98°C	UV
Acetal Copoly	Polyoxymethylene (ethylene)	160°C	TS
Acrylic	Acrylic	95°C	UV
Nylon 6	Polyamide	160°C	TS
PC	Polycarbonate	140°C	TS/UV
PC/ABS	Polycarbonate/ABS Blend	80-100°C	UV
HDPE	High Density Polyethylene	85°C	UV
PET	Polyethylene Terephthalate	70°C	N/A
PMMA	Polymethylmethacrylate	105°C	UV
PP	Polypropylene	100°C	UV
PS	Polystyrene	95°C	UV
PVC	Polyvinyl Chloride	90°C	UV
Noryl GTX	Polyamide/polyphenylene ether	231°C	TS
PEEK	Polyetheretherketone	160°C	TS

Wood-Based Products

Substrate	Composition	Maximum Temperature	Powder Type
MDF	Medium-Density Engineered Board	135°C	TS/UV
HDF	High-Density Engineered Board	150°C	TS/UV
Wood Composites	Wood Pulp plus PVC & HDPE, LDPE	150°C	TS/UV
Closed-Grain Woods	Maple, Beech, Birch, Cherry, Poplar, Rubber Tree	140°C	TS/UV
Open-Grain Woods	Oak, Hickory, Ash	100°C	UV

Applying Powder to a "Non"-Conductive Surface

Thermal Spray (or plasma)
Thickness control

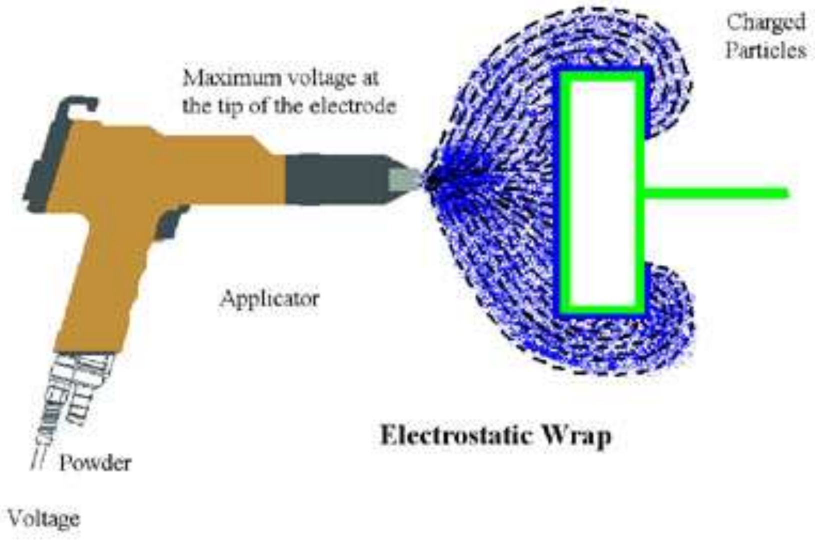
Preheat
Thermal losses

Conductive Primer
Solvent or waterborne?

Conductivity into Plastic
Expensive to incorporate

In-mold Process
Tool is conductive

Conductive Solution
Easy, quick



Low-Bake Thermoset Chemistries

Epoxy

- Homopolymerized
- Latent catalyst
- 10 min @ 125°C

Polyester/Epoxy Hybrid

- High reactivity
- Lower T_g
- 10 min @ 130°C; 1 min @ 180°C

TGIC Polyester

- Exterior durable
- Good storage stability
- 10 min @ 140°C

HAA Polyester

- Limited low-cure capability
- 10 min @ 160°C

Polyester/Urethane

- Triazole-blocked isocyanate
- 15 min @ 160°C

GMA Acrylic

- High GMA (low EEW)
- Polyanhydride cure
- 15 min @ 140°C

Unsaturated Polyester

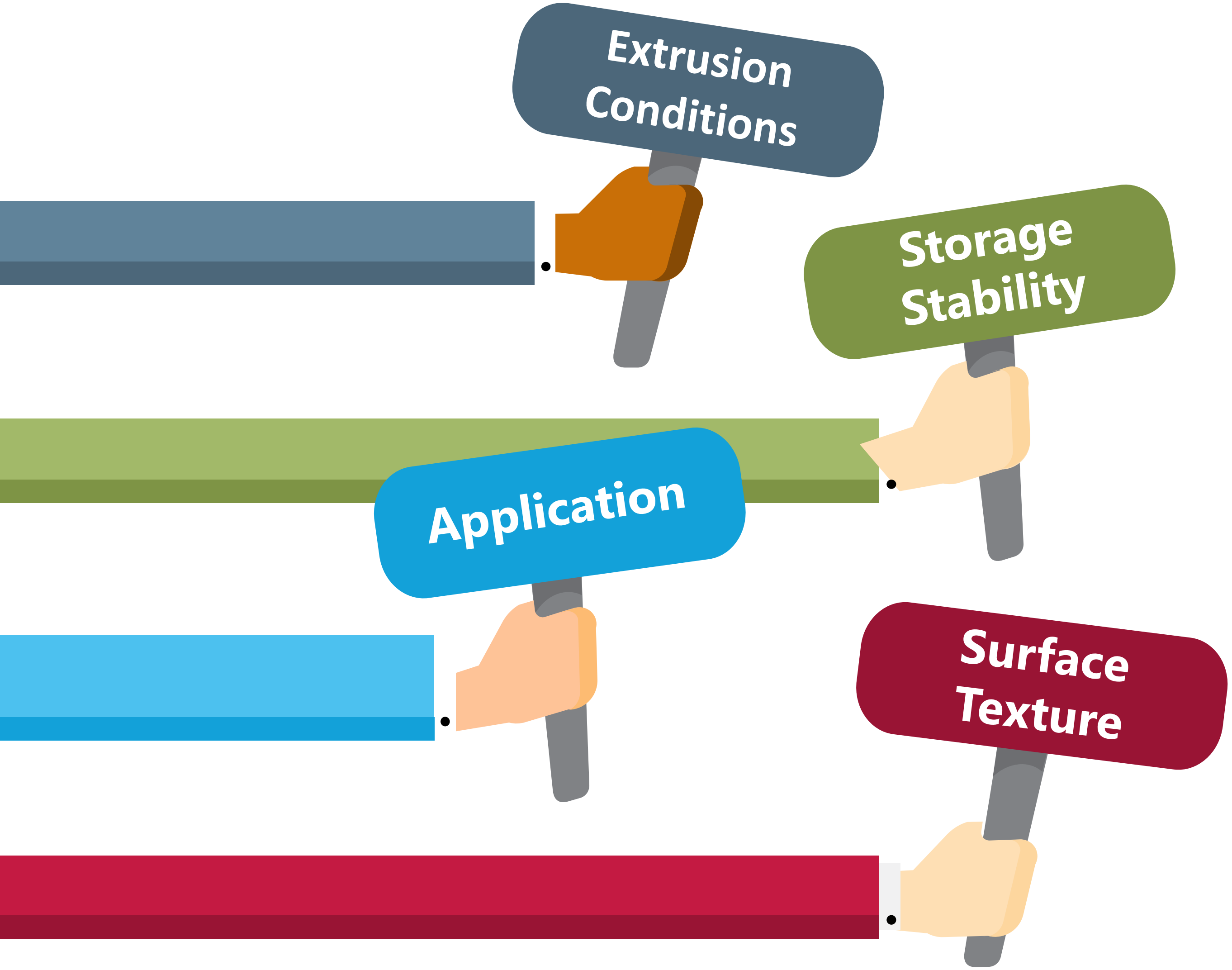
- Free radical (peroxide) cure
- Divinyl ether crosslinker
- 3 min @ 130°C

Ultra-Low-Bake Thermoset Chemistries: Bio-Based Polyester-Amide

Battelle Technology

- COOH functional
- Cure with TGIC or PT-910
- 85% bio-based COOH polyester-amide resin
- 135-180°C cure window
- Excellent smoothness
- Excellent impact resistance
- Excellent UV durability

Ultra-Low-Temp Cure Caveats



Extrusion Conditions are Critical

- Short dwell time
- Cooler barrel temps

Storage Stability

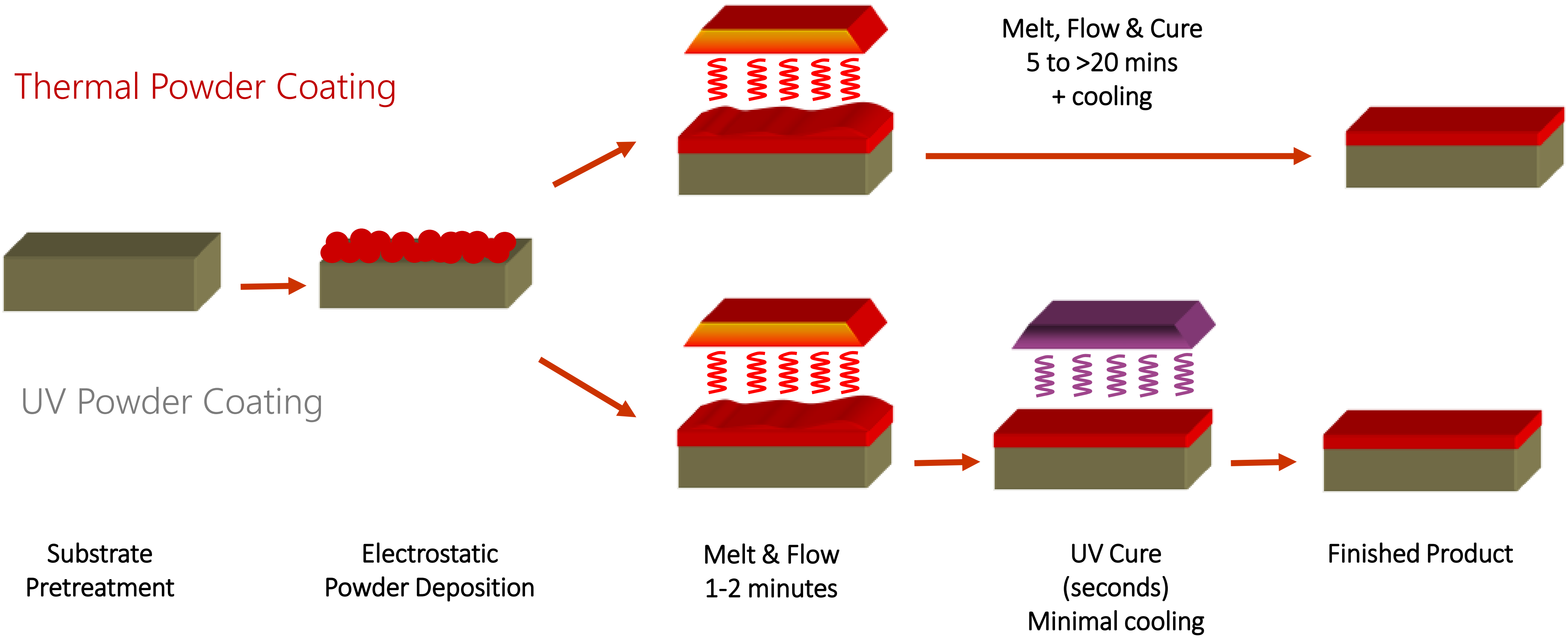
- May require reefer transportation
- Controlled storage temp and application system
- Shelf-life limitations

Application

Impact fusion

Smoothness?

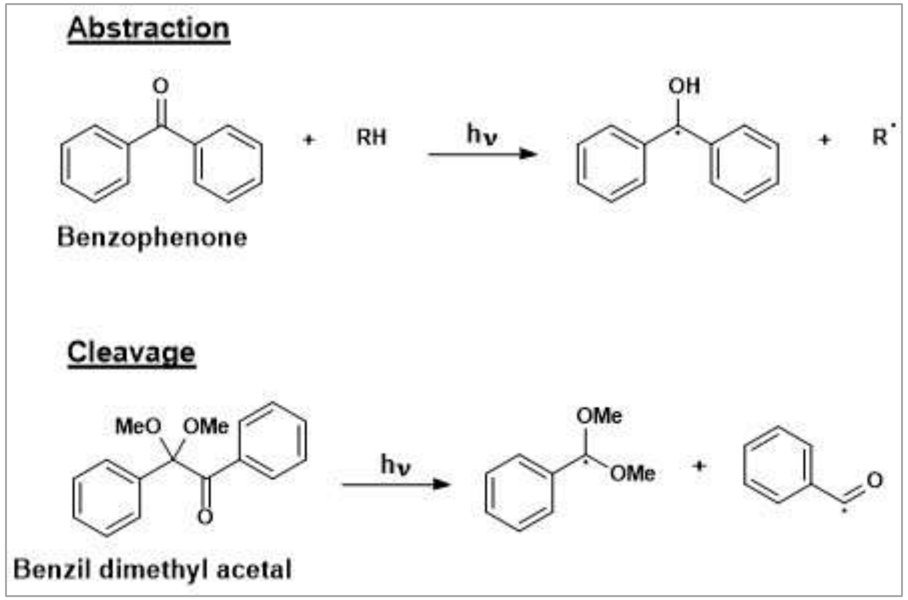
The UV Curing Process

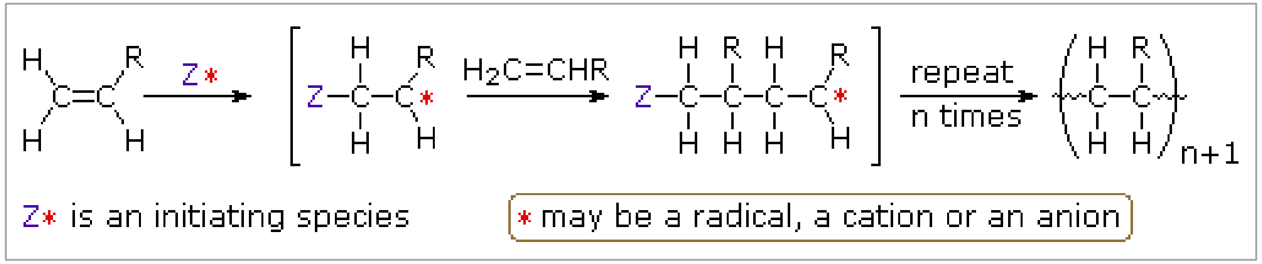


KEYLAND POLYMER UV POWDER Courtesy of Keyland Polymer

Free-Radical UV Cure

- Photoinitiator responds to UV energy, forming free radicals
- Chain-growth polymerization is initiated
- Can be inhibited by oxygen





Free Radical-Cured Binders

Acrylated/Methacrylated

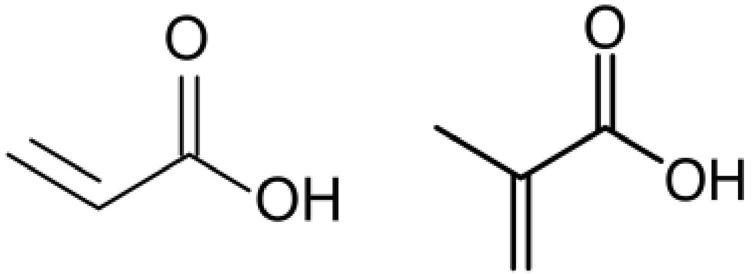
- Polyester
- Epoxy
- Urethane
- Homopolymerized

Unsaturated Polyester

- Maleate – vinyl ether copolymerization
- Divinyl ether crosslinker 73:27

Low T_g, Low Melt Viscosity

- Processing conditions
- Storage stability



Benefits of UV Cure

- Separates melt from cure
- Low processing temperature
- Smaller footprint
- Lower energy costs
- Shorter time
- Heat-sensitive substrates and assembled parts

Drawbacks of UV Cure

- Line-of-sight curing
- Pigment loading and film thickness limitations
- Limited selection of raw materials and chemistry
- Transportation and storage stability
- Capital expenditure
- Material cost

Powder Chemistries: UV Cure vs. Ultra-Low-Bake Thermoset

UV Cure

- Shorter time
- Small footprint
- Lowest energy use

Ultra-Low-Bake Thermoset

- Standard equipment
- All colors/thicknesses
- Low energy use
- More chemistries available

UV Cure

- Line of sight
- Cap ex
- Film thickness
- Physical storage stability

Ultra-Low-Bake Thermoset

- Manufacturing challenges
- Smoothness
- Limited temperature
- Chemical storage stability

Future Trends

More than just MDF

Composites, molded plastics

Real Michael Addition (malonate) Chemistry (allnex)

WO-2022236519 – Powder Coating Composition Blend

Low-Temp Cure Summary

- Low-temperature-cure (LTC) powders can significantly reduce energy costs.
- UV-cure powder coating technology is alive and well.
- Ultra-low-bake (ULB) powders open up a world of alternative substrates to the powder coating market.
- Novel technology is being introduced by raw material suppliers.
- Application to non-conductive substrates schemes are well-known and scalable.
- Powder coating producers are investing in the development and commercialization of LTC and ULB powder technologies.

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Thank You

Questions? Comments?

Feel free to reach out:

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