Polyolefin Dispersions For Automotive Interior Applications

Tuesday, Feb 28, 2017

A. Chaudhary, P. Walia - The Dow Chemical Company, Midland, MI
S. Wakumoto – Colorado State University

Presentation Outline

Introduction

- BLUEWAVE™ Dispersion Technology
- Polyolefin Dispersions (PODs)

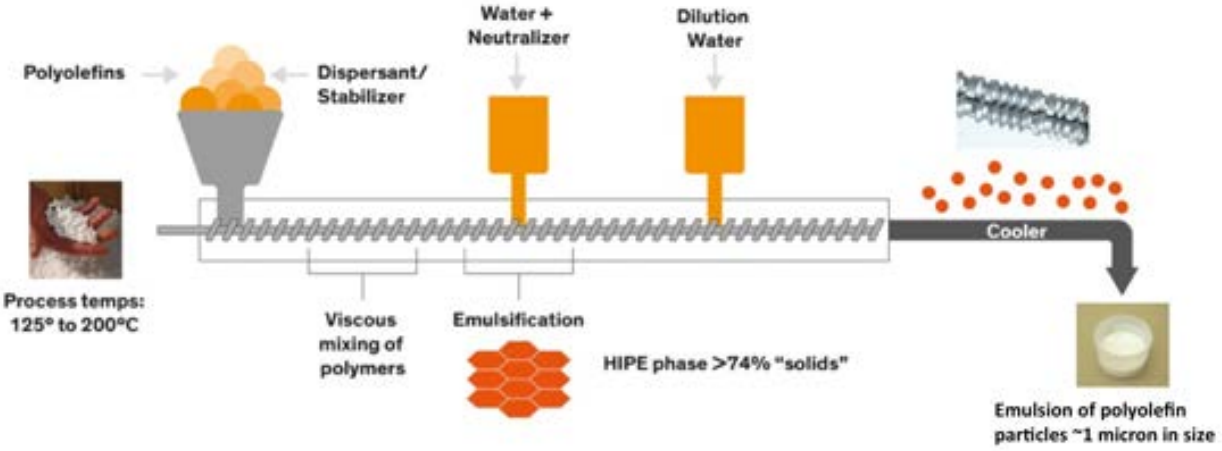
PODs for Automotive Applications

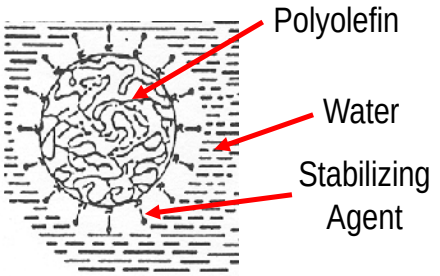
- Spray Skin Technology
- Value proposition
- Properties of PO skins
    - Physical properties/Thermal stability
    - Grain retention
    - Adhesion to polyurethane foam
- Use of PODs in alternative processes for making skin

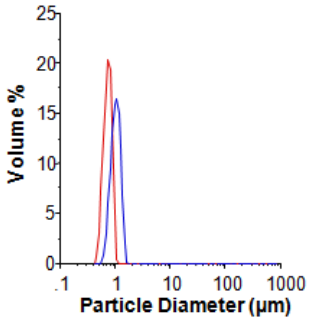
Summary

BLUEWAVE™ Technology

- Proprietary continuous emulsification process using high-shear mixing to create a solvent-free dispersion with submicron particles.
  - Solvent-free process
  - Effective with high viscosity polymers
  - Amenable to multiple polymer types
  - Low viscosity dispersion
  - Controlled particle size
  - Minimal surfactant
  - Polymer modification unnecessary
  - High Solids
- Polymer types
  - Polyolefin (HYPOD™, CANVERA™, ECOSMOOTH™),
  - Epoxy (Prosperse™), Ethylene vinyl acetate (ACCENT™)
  - Alkyd, polyester, silicone, urethane, acrylics and others



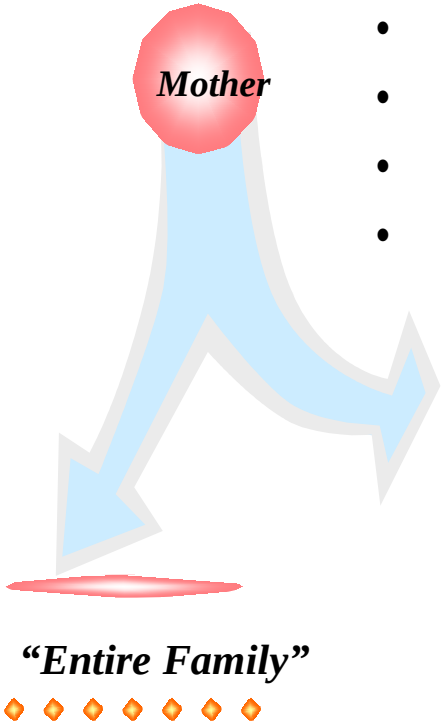


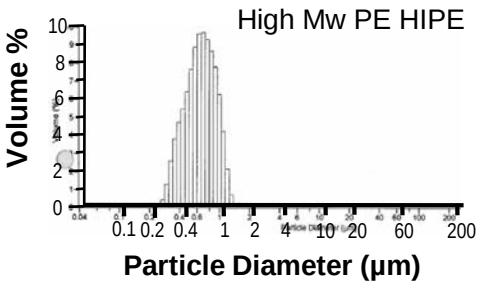


Droplet Formation Mechanism

Dow HIPE Process

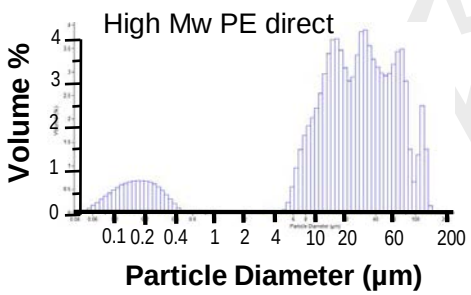
- Small size (<1 μm)
- Narrow distribution
- Very reproducible
- Relatively low shear

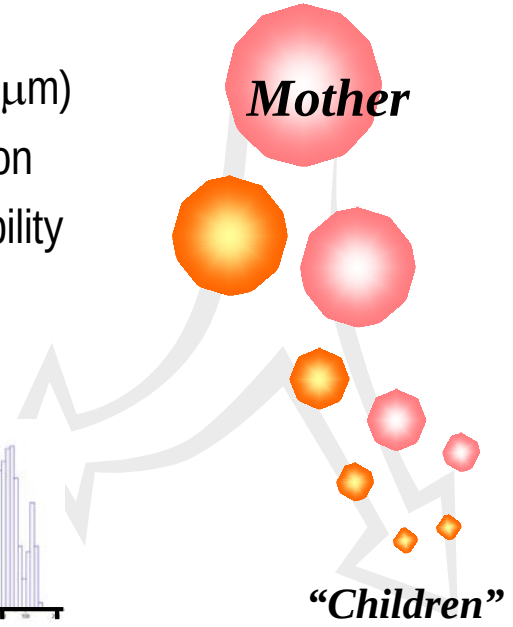




Direct Emulsification Process

- Large size (> 5 μm)
- Broad distribution
- Poor reproducibility
- High shear





$$d = \frac{\gamma}{\text{shear}} \cdot f\left[\frac{\eta_{dispersed}}{\eta_{continuous}}\right], \; f(T, t)$$

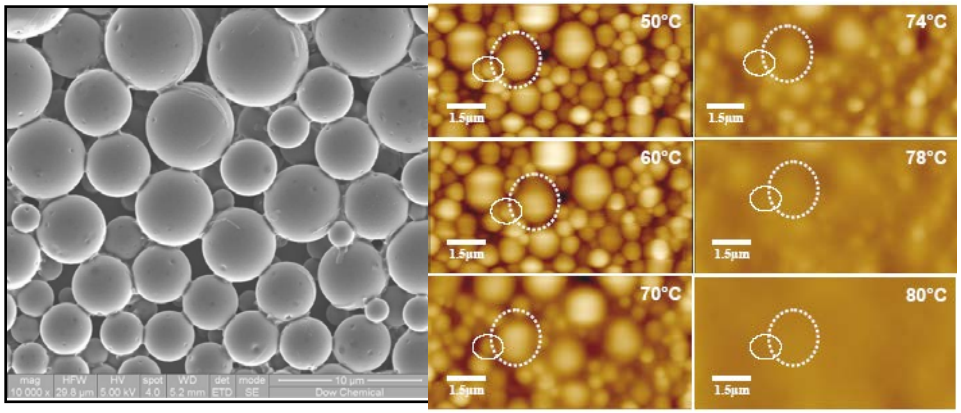
- IFT (formulation)
- Viscosity ratio (formulation)
- Shear (equipment)

JANSSEN and MEIJER J. Rheol. 37(4), July/Aug 1993 01486055/93/37(4)/597/12

Properties of Aqueous Dispersions

- Dispersion Properties
  - Average ~1.0 μm diameter
  - 30-55% solids in dispersion
  - Viscosity < 500 cps
- Material Properties
  - LDPE, HDPE, PP, Olefin elastomers, functional olefins (ex: -OH, -MAH)
  - Can vary properties (Tg, % crystallinity, Mw) to tailor application properties:
  - Toughness
  - Haptics
  - Moisture barrier
  - Adhesion to other substrates
- Dispersions provide a convenient form to utilize polyolefin elastomers and blends for different applications

Film Formation – Hot Stage Microscopy



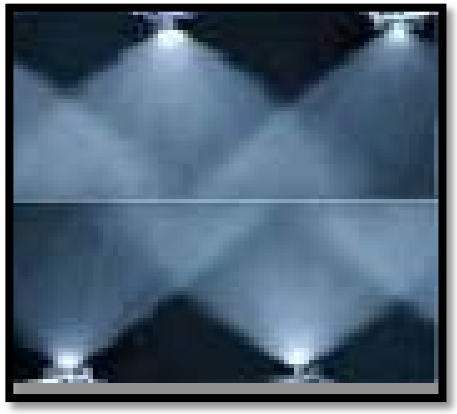
Suitable for Industrial Applications with Cure Cycle, Semi-crystalline polyolefin dispersion, Tm ~70 °C

- Polyolefin Dispersion Applications
  - Paper Coatings
  - Hot Melt Adhesives
  - Pressure Sensitive Adhesives
  - Health & Hygiene
  - Plastic Coatings
  - Gaskets for Metal Closures
  - Carpet Backing
  - Hair care

Aqueous Dispersion Application Methods

Stable Liquid Dispersions

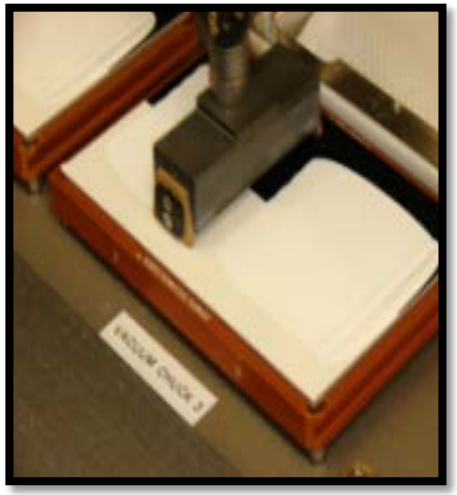
Spray Application



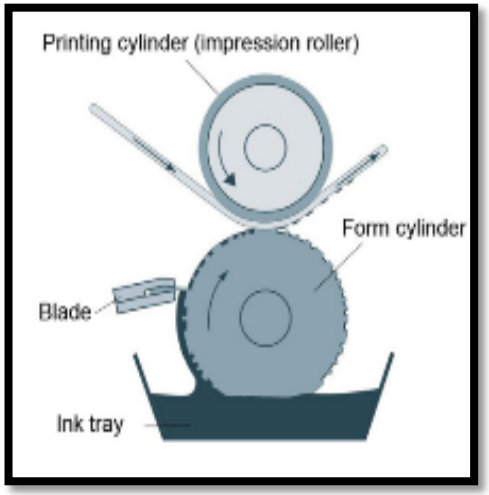
Dipping

Spray Dried Powders

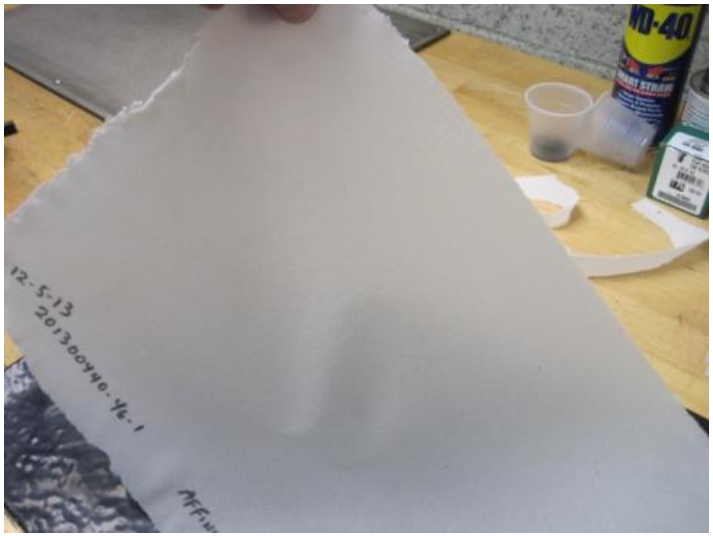
Draw Downs



Rotogravure & Inkjet



Spray Skin Technology



- Skins are formed via spray drying on tools heated to 60-95 °C
  - Technology has been trialed at lab scale and on instrument panel (IP) tools
- Dispersion can be sprayed with existing spray equipment or on a low capital paint line
  - No mixing & curing requirements
- Skins have good haptics (feel), grain replication, scratch & mar
- Technology is early stage and requires development

Value Proposition for Spray Skin

- Potential advantages over incumbent material.
  - Weight Savings
    - Lower density (~0.88 g/cc) compared to PU and PVC
    - Potential of thin gauging
  - Simplified Process
    - No mixing & curing steps (less expensive equipment)
    - Low tooling requirements (~ 80°C process) – longer drying time is the potential drawback
  - Lower VOCs compared to PU and PVC
  - Recyclability
    - Scrap & overspray can be captured
    - Can enable an all olefin instrument panel construction
  - Aesthetics
    - Enable unique design (e.g. two tone color, overmolding)

Materials Used

- Polymers

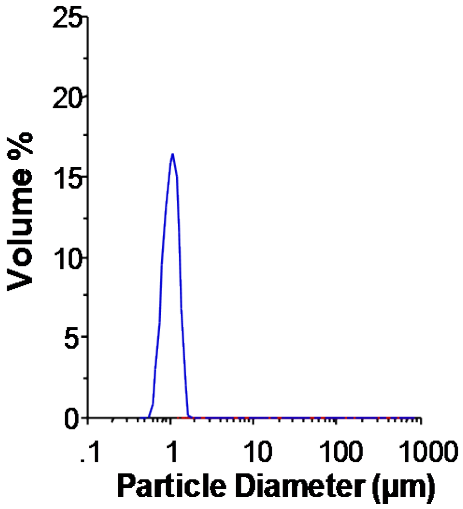
Materials	Material Properties	Flow Rate g/10 min	Density g/cm^3
OBC-1	Shore A = 83	5	0.887
OBC-2	Shore A = 60	5	0.866
EAA Copolymer	20.5 wt% acrylic acid content	300	0.958

- Thickeners

Materials	Material Properties
CELLOSIZE™ QP 15000H	Medium MW cellulosic polymer
CELLOSIZE™ QP 100MH	High MW cellulosic polymer

- PO Dispersions

Material Properties	POD-1	POD-2
Polymer Used	OBC-1	OBC-2
Average Particle Size (µm)	1.07	0.97
Viscosity @ 20°C (cP)	280	250
Solids (wt%)	40.2	39.8
pH	10.4	10.2

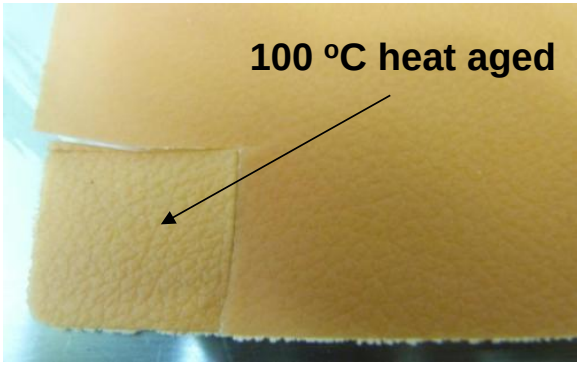


Spray Skins – Physical Properties

- Physical Properties
  - Comparable Shore A and tear strength
  - Lower Tensile strength and elongation at break
    - Impact on part performance (during air bag deployment) is expected to be minimal
    - Requires validation

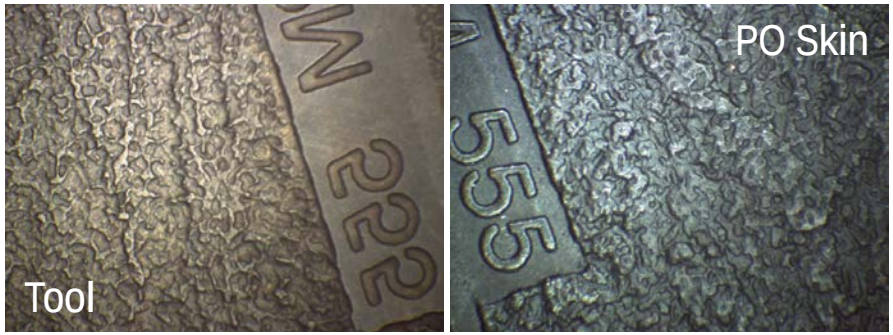
Skin Type	Shore A	Tear Strength ISO 34-1 (N/mm)	Tensile Strength ISO 527-3 (N/mm^2)	Elongation at Break ISO 527-3 (%)
PO Spray Skin 1	73-78	24	5.0	170
PO Spray Skin 2	73-78	21	4.8	160
Aromatic PU Spray Skin	73-78	14	6.7	240
PVC Slush Skin	73-78	31	11.0	301

- Thermal Stability of PO spray skins
  - 100°C, 4 h in a convection oven
  - Melting point of PO skin ~ 122°C
  - Excellent grain retention



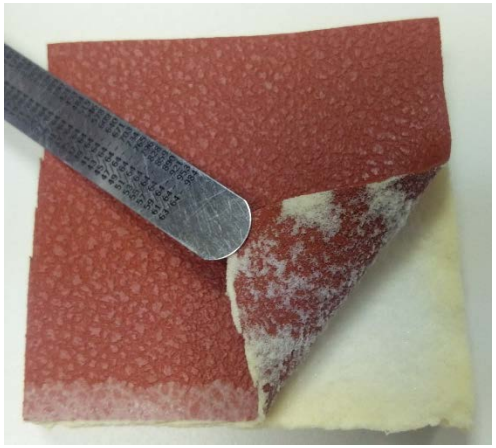
Spray Skins – Grain Replication

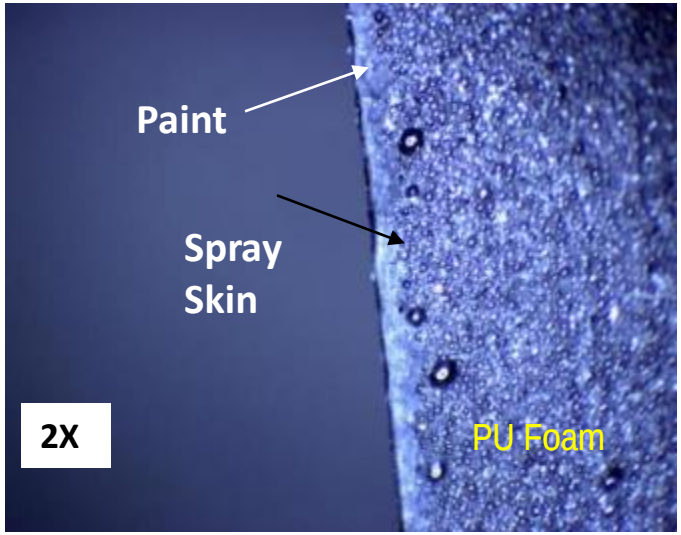
- Excellent grain and feature replication

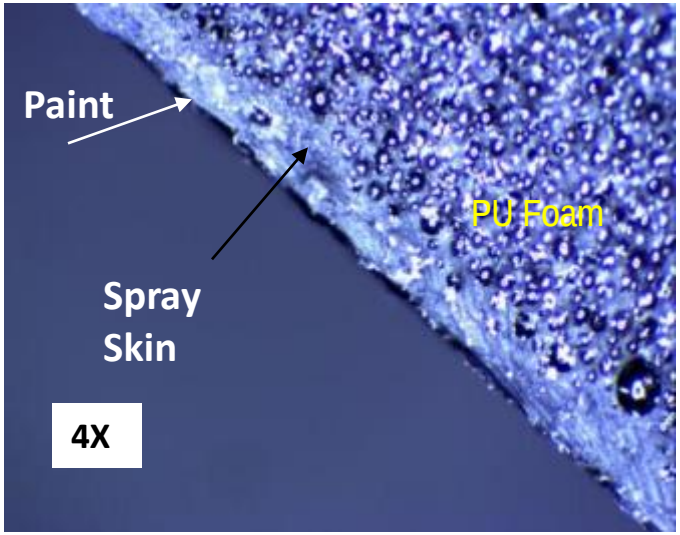


Spray Skins – Adhesion to PU Foam

- Dow PU foam system (PAPI-94 isocyanate and NM 858)
  - Cohesive failure
  - Excellent adhesion
    - Foam
    - Paint

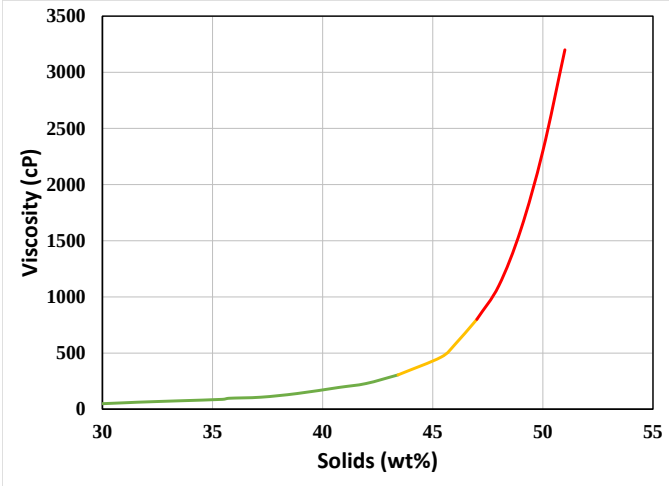




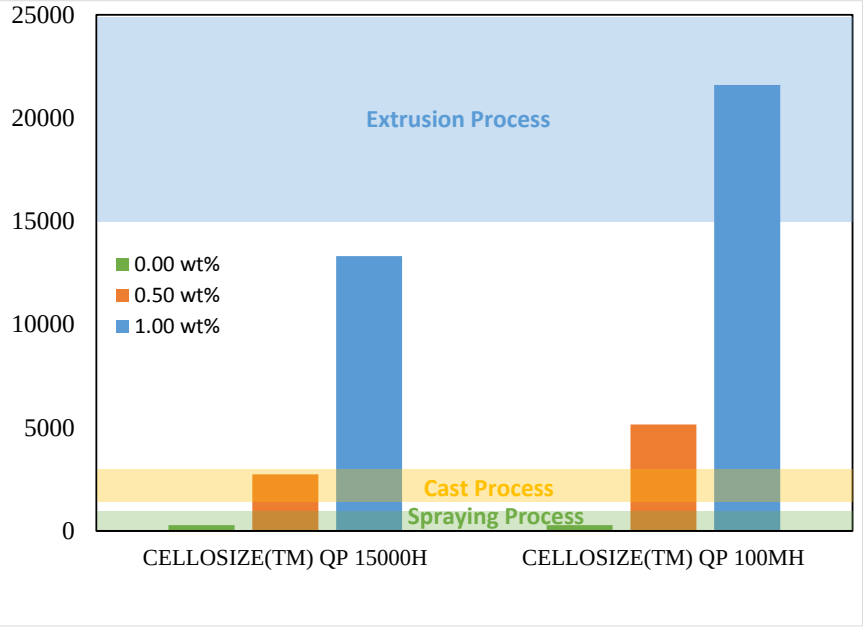


Alternative Processes for making PO Skins

- Viscosity requirements for various processes
  - Spraying Process (100 – 1000 cP)
  - Cast Process (1500 – 3000 cP)
  - Extrusion Process (15000 – 30000 cP)



- Use of thickeners
  - Process flexibility
    - One PO dispersion
    - Viscosity can be altered by thickener type & level
  - Two thickeners used in this study
    - CELLOSIZE™ QP 15000H
    - CELLOSIZE™ QP 100MH



Summary

- Dow has developed polyolefin aqueous dispersions specifically designed for the automotive market to meet interior application requirements
- Aqueous dispersions can be applied in a number of ways - sprayed, cast, dipped or extruded
- Focus area is for soft skins for IP/DP and for overmolding applications
  - Dispersion can be sprayed with existing spray equipment or a low capital paint line (process technology under development)
  - Skins have excellent haptics (feel), grain replication
- Direct adhesion to PU paint and foam and other polar substrates
- Initial data shows good mechanical performance & thermal stability
  - Further validation is needed
- Key advantages are lightweight, low VOCs, recyclability and design flexibility

Thank You