POLYOLEFIN DISPERSIONS FOR AUTOMOTIVE INTERIOR APPLICATIONS

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Abstract

HYPOD™ aqueous polyolefin dispersions represent a new class of waterborne polymeric material produced by a proprietary mechanical dispersion process utilizing BLUEWAVE™ Technology. These dispersions are commercially available for use in various coating applications, and have characteristics similar to other water-based dispersions/emulsions (e.g., 40 to 50% solids, particle sizes 0.15 to 2.5 μm, viscosities from 300 to 3500 cP, and pH ranging from 7 to 11). With a wide array of olefin chemistries and crystallinities available from Dow, the polyolefin dispersion (POD) composition can be tailored to a specific application and performance requirements. Experimental POD dispersions have been developed for automotive interior applications, targeting soft skins and other automotive interior applications. The drivers for these applications are light weight, lower emissions, and potential recyclability. In addition, these skins show direct adhesion to polyurethane foams without any pretreatment. These dispersions can be tailored to fit various processing technologies – spray, cast and extrusion. This paper will provide a summary of these unique PODs tailored for the above processes.

Introduction

Traditionally, polyolefins have been available as pellets which are processed by conventional thermoplastic processes such as extrusion, thermoforming, injection molding, and blow molding. The lack of a viable emulsion polymerization process for the production of polyolefins has prevented the availability of these polymers in a waterborne emulsion form, suitable for use in coatings, binders, adhesives, and other applications where emulsion polymers are typically used. BLUEWAVE™ Technology is Dow's proprietary high-shear mechanical dispersion process technology [1, 2] that enables the production of waterborne dispersions of traditional thermoplastic polymers and elastomers, not possible via conventional emulsion polymerization process. The resulting dispersion has a narrow particle size distribution (approximately 1 μm) and solids content of up to 60 wt%. Low surfactant content enables customers to minimize surfactant effects, and maintain a very high level of product performance. When applied to a heated substrate, the water evaporates, forming a coating that is thin and cost effective for a variety of applications. These dispersions when applied to various substrates offer the exceptional characteristics of polyolefins, including water and chemical resistance, heat sealability, thermoform ability (embossing), adhesion to polyolefin substrates, low temperature flexibility, and others. This technology permits the use of polyolefins in a wide range of new applications including coatings, sealants, binders, adhesives, and foams.

Aqueous polyolefin dispersions have the potential to be utilized for a variety of automotive applications such as soft skins, artificial leather, adhesives, and carpet binders. There are several methods to make soft skins for an automotive interior article, such as an instrument panel, door panel, console, glove compartment cover, and others. Soft skins are used in automotive interior applications for superior touch/feel/haptics. Positive thermoforming, negative thermoforming, slush molding, and spray coatings are four major processes used to make skins. Slush molding and spray processes offer the most design freedom and provide the ability to do complex geometries and fine grain detail (can even imitate stitching). Until recently, polyvinyl chloride (PVC) was the material of choice for interior skins, and is ideally suited for slush molding. However, PVC formulations suffer from migration and volatilization of the plasticizers over time, and this leads both to physical property changes during aging and fogging of the car window glass. PVC also suffers from being heavier than alternative materials. This is an important consideration in the current design of automobiles with the emphasis on lighter materials to reduce the overall weight of the vehicle and thus increase fuel efficiency. Additionally, the low temperature (-40 °C) ductility, and air bag deployment, is an issue with PVC, especially maintaining ductility with time (and heat aging).

Alternatives to PVC include thermoplastic polyurethanes (TPU), thermoplastic polyolefins (TPO), and polyolefin elastomers (POE). TPU has good scratch and mar properties and better low temperature properties than PVC, but aromatic based TPUs have poor ultraviolet (UV) light resistance. Aliphatic isocyanates can be used to prepare TPUs having good UV light resistance but at a significant cost penalty.

Blends of polypropylene (PP) and a polyolefinic rubber, referred to as thermoplastic polyolefin (TPO), is a good alternative [3, 4]. TPO possesses better ductility than PVC. Moreover, it retains its ductility over time since it does not contain any low molecular weight plasticizers, as does PVC. TPO performs better in comparison to PVC in interior automotive applications. TPO is less expensive as compared to TPU.

Polyurethanes (PU) have been the resins of choice for spray processes. A polyurethane reaction mixture is sprayed onto a mold surface and allowed to cure to produce the skin layer. For PU materials, volatile organic compounds (VOCs) are released and scrap is not recyclable. Further, polyurethane spray process equipment requires complex mixing capabilities as well as the need for solvent flushing.

The polyolefin spray skin approach offers the following advantages over a PU spray process:

- Lighter weight – lower density as compared to PU. Also potential of thin gauging.
- Lower VOCs – aqueous polyolefin system.
- Recyclability - scrap and captured overspray could be recycled in-house (it's a thermoplastic elastomer).
- Eliminate solvent flush needed for PU.
- Simplified process with a single component system with no mixing and curing requirements.

Materials and Methods

An olefin block copolymer (OBC) is used along with ethylene acrylic acid copolymer (EAA) based dispersing agent to produce a polyolefin dispersion using the proprietary BLUEWAVE™ Technology (Figure 1). Material properties of the polymers (supplied by The Dow Chemical Company) used in this study are presented in Table 1. The OBCs used were soft and covered a Shore A hardness range of 60 to 85.

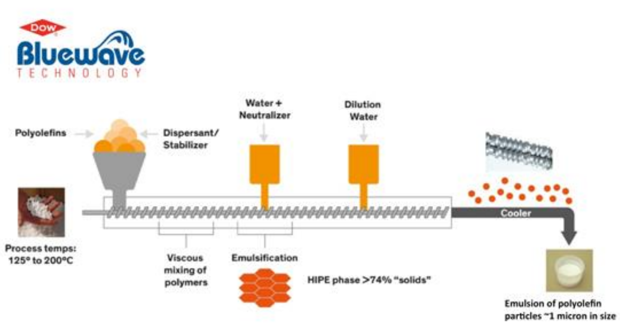

Figure 1. BLUEWAVE™ Technology.

The hydroxyethyl cellulose (HEC) based thickeners used in this study (supplied by The Dow Chemical Company) were:

(a) CELLOSIZE™ QP 15000H (medium molecular weight cellulosic polymer)

(b) CELLOSIZE™ QP 100MH (high molecular weight cellulosic polymer)

Table 1. Raw material properties.

Materials	Material Properties	Flow Rate, g/10 min (1)	Density, g/cm^3
OBC-1	Shore A = 83	5.0	0.887
OBC-2	Shore A = 60	5.0	0.866
EAA Copolymer	20.5 wt% acrylic acid content	300	0.958

(1) 2.16 kg @ 190 °C

Methods used for characterization of the various physical properties of the polyolefin dispersion are described in Table 2.

Table 2. Characterization methods for polymer dispersion.

Measurement	Instrument Used	Condition
Particle Size	LS 13 320 Beckman Coulter particle size analyzer	Test done with dilute solution of sample
Viscosity	Brookfield viscometer	RV2, 50 rpm
Solids	Sartorius moisture analyzer	1 g sample at 120 °C

Results and Discussion

The physical properties of the aqueous dispersion produced using the BLUEWAVE™ Technology dispersion process is presented in Table 3 and the particle size distribution is presented in Figure 2.

Skins were made by spraying the dispersions with a hand held pneumatic spray gun on a 5" x 5" grained tool (Figure 3a) that was pre-heated to 80 °C in a convection oven. The tool was then placed in an oven to remove the excess moisture. Figure 3b shows the quality of the grain in the skins produced using the dispersion.

Table 4 presents the mechanical properties of the two polyolefin spray skins prepared using POD-1 and POD-2 respectively along with aromatic PU skin made via spray process and PVC skin made via slush molding process. As presented in the table, the Shore A and tear strength of all the skins are comparable to each other. The tensile properties are also comparable though it is slightly lower than the PU or PVC skins. Any impact on the part performance, especially air bag deployment, is expected to be minimal. However, this would have to be validated on an actual part.

Table 3. Physical properties of the polyolefin dispersions.

	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

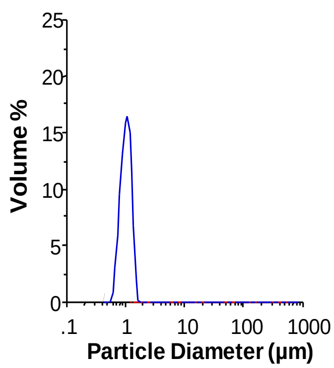

Figure 2. Particle size distribution of the polyolefin dispersion.

Figure 3. (a) Grain pattern of the tool used for producing skin, (b) grain pattern of the polyolefin skin produced.

Table 4. Physical Properties of the Polyolefin Dispersion.

Skin	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	301

One of the key requirements of such polymeric skins is the thermal stability up to at least 100 °C. Figure 4 presents the DSC scans for the prepared OBC skin – showing the melting point of the skin to be above 120 °C. To further confirm the thermal stability of the prepared skins, small sections of these skins were aged in an oven at 100 °C for 4 h. The skin, after heat aging, showed excellent grain retention, thereby indicating that these skins are thermally stable up to 100 °C.

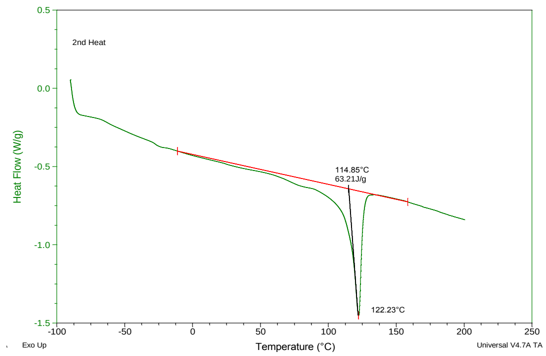

Figure 4. DSC Scan of the Polymer Skin (Tm=122 °C).

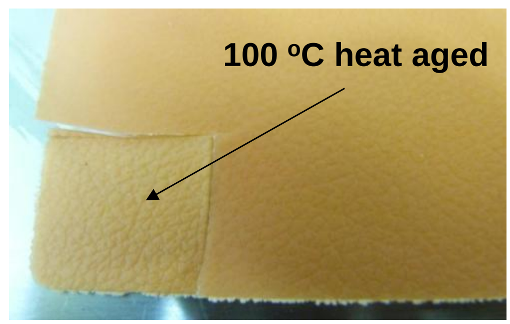

Figure 5. Excellent grain retention after thermal aging

Another critical requirement for interior skins is adhesion to PU foam. A typical instrument panel Dow foam system (NM856: prepared with PAPI-94 isocyanate and NM 858 polyol) was used to back foam these spray skins. Excellent PU foam adhesion (Figure 6) was achieved. Cohesive failure was judged visually (qualitative) based on the amount of area on skin that was covered with foam upon peeling.

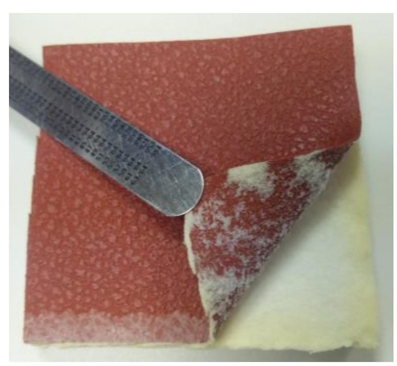

Figure 6. Cohesive Failure of the polyolefin skin and the PU foam.

Further, the possibility of the use of such aqueous dispersions was explored for its use in cast or extrusion process for making skins. Different applications have different viscosity requirements. For instance, dispersions for spray skins must be thin enough to be sprayed, yet thick enough to not drip off of a hot mold surface. Ideal viscosity for spray skins is about 100 to 1000 cP, while for cast skins, it is about 1,500 to 3,000 cP, so the dispersion can be laid onto a release paper and for extrusion process dispersions with significantly higher viscosities (15,000 to 30,000 cP) is required.

Viscosity can be tailored by either changing the dispersion formulation (e.g., solid concentration, surfactant type and concentration, etc.) or by the addition of thickeners which provides the benefit of working with one base polyolefin dispersion formulation. The later approach was investigated to test the viability of the polyolefin dispersion in cast or extrusion process. Two different hydroxyethyl cellulose based thickeners were chosen for this study (medium MW and high MW).

Small amount of the thickeners (0.5 and 1.0 wt%) were dispersed in the aqueous polyolefin dispersion using a Cowles blade mixer. The viscosity of the samples was tested after 24 h using a Brookfield viscometer at 50 rpm. The results are presented in Figure 7. Based on the data it is evident that thickeners can be used for altering the viscosity of such aqueous dispersions. This approach provides flexibility for using either spray, cast or extrusion process.

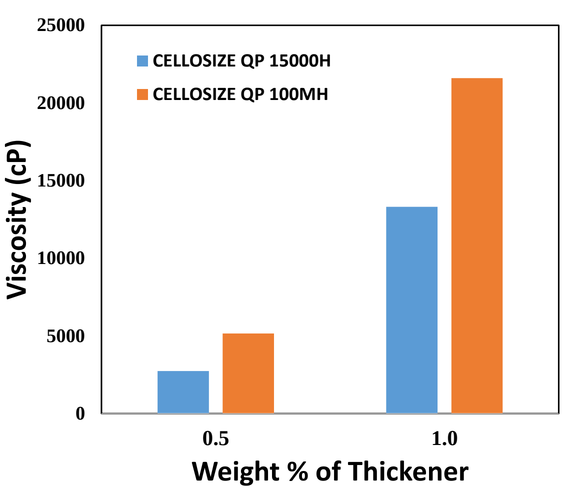

Figure 7. Effect of thickener on the viscosity of the dispersion

Conclusions

Aqueous dispersion of polyolefin elastomers prepared using BLUEWAVE™ Technology could be used to successfully produce soft skins that can be used in the automotive interior application. The spray skins demonstrated the following features:

- Excellent grain replication
- Good haptics
- Mechanical properties comparable to other soft skin materials and technologies
- Good thermal aging under conditions seen in interior applications (100 °C).
- Direct adhesion to PU foam (typically polyolefin substrates require flaming or primers)

These dispersions can be tailored to fit various processing technologies – spray, cast, and extrusion, by addition of a thickening agent [5]. Future work will focus on further development of the dispersion for validation of OEM specs and incorporation of color/UV package required for interior applications.

References

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