EFFECT OF PROCESSING ON THE PERFORMANCE OF WATERBORNE HEAT SEAL COATING

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Abstract

Aqueous polyolefin dispersions represent a new class of waterborne polymeric materials produced by a proprietary continuous, 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., final solids content from 40 to 50%, particle size from 0.15 to 2.5 µm, viscosity from 300 to 3500 cP, and pH ranging from 7 to 11). The wide variety of olefin chemistries and crystallinities available from The Dow Chemical Company enable the tailoring of the polyolefin dispersion (POD) composition for a specific application and performance requirements. This paper describes the effect that the type of process, batch mixing versus continuous BLUEWAVE™ Technology, has on the final performance of a water-based heat seal coating. The results obtained from the application tests of the heat seal coating produced using the continuous BLUEWAVE™ Technology show improved properties (appearance, shelf stability, aging, hot tack, and heat seal bonds) over that produced in a batch process.

Introduction

Heat seal coatings (HSCs) are adhesives that are applied as a non-blocking layer to a flexible substrate. Upon exposure to heat and pressure, these provide a peelable adhesive bond to another rigid or flexible substrate. Consequently, HSCs are used in food, pharmaceutical, and industrial packaging applications [1]. Examples of heat seal coating products include high molecular weight terpolymers which can be produced as water-based dispersions.

Waterborne heat seal coating products are typically manufactured by a batch dispersing process which requires a long cycle time and can also exhibit substantial batch-to-batch variations in the produced dispersions. In addition, the batch dispersion process requires significant amounts of processing aids in order to help with dispersibility and reduce the melting viscosity of the mixture, but can negatively affect adhesion properties. Furthermore, the terpolymer resin is likely to be subject to degradation in the batch dispersing process because of longer processing times and high temperatures which can result in the reduction of the performance of the heat seal coating. Accordingly, a continuous dispersion process with short residence time can be preferable to mitigate the degradation of the terpolymer resin.

Recently, and with the limitations of batch processes in mind, waterborne heat seal coatings have been produced by Dow's proprietary, continuous, high-shear, mechanical dispersion process known as BLUEWAVE™ Technology [2, 3]. This technology enables the continuous production of waterborne dispersions of traditional thermoplastic polymers and elastomers, which are not possible via a conventional emulsion polymerization process. Some of its defining characteristics include narrow particle size distributions, small particle size, and solids content of up to 60 wt. %. In addition, low surfactant content enables customers to minimize surfactant effects and maintain a very high level of product performance.

The characterization and performance results obtained after testing the dispersions produced by means of a continuous, BLUEWAVE™ Technology process showed equal or better performance when compared to samples produced by means of a batch process. Namely, the material produced by means of BLUEWAVE™ Technology exhibited better appearance, shelf stability, aging, hot tack, and heat seal bonds.

Materials and Methods

A terpolymer resin is used along with a blend of a low molecular weight hydrocarbon compound (HC) and dispersing agent (DA) to produce a water-based dispersion using a conventional batch mixing process (Figure 1) and the proprietary BLUEWAVE™ Technology (Figure 2). Table 1 shows the properties of the polymer resin and additives used in this study.

Table 1. Raw Material Properties.

Materials	**Properties**	**Density (g/cm^3)**
Terpolymer	*MI = 6 g/10 min	0.96
HC-1	**MT = 59 °C	0.96
DA-1	MT = 144 °C	1.069

*Melt Index (190 °C/2.16 kg).
*Melting Temperature.

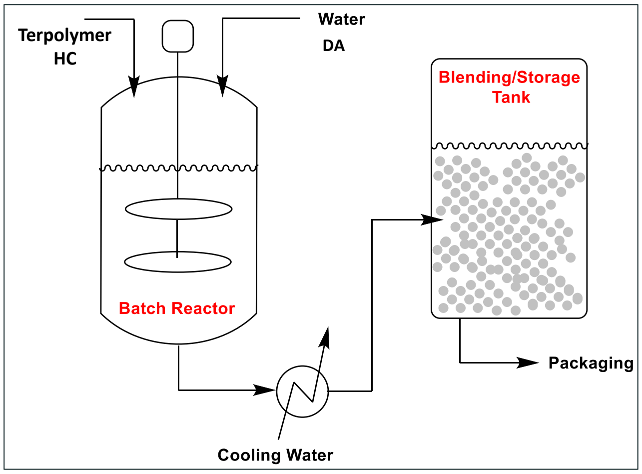


Figure 1. Batch Process.

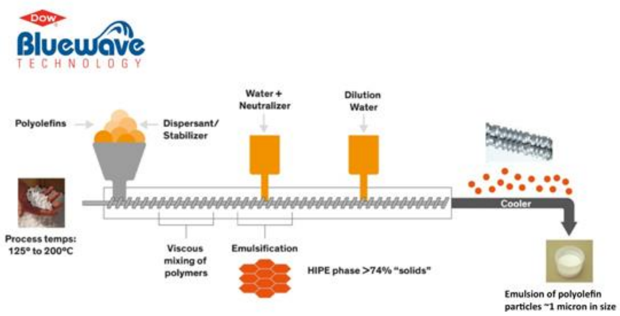


Figure 2. BLUEWAVE™ Technology.

Table 2 describes the methods used for characterization of the various physical properties of the terpolymer dispersions.

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

Viscosity and Shelf Stability (Aging)

Figure 3 shows the viscosity measurements for dispersions freshly prepared by means of a batch or BLUEWAVE™ Technology process. Upon comparison, the difference in viscosity between these samples is negligible. However, after aging both samples at 45 °C over 4 weeks, the viscosity of the sample prepared by means of a batch process exhibits a drastic increase in viscosity after 15 days (Figure 4). By comparison, the material processed by means of BLUEWAVE™ Technology maintained its viscosity without degradation due to accelerated aging.

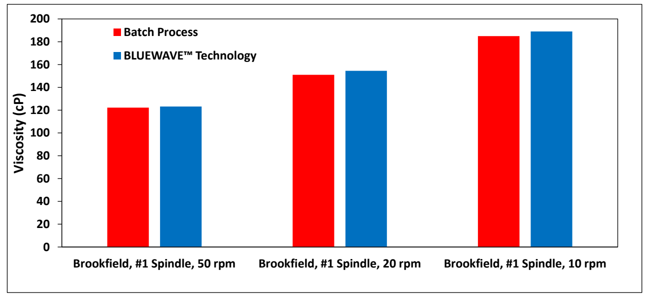


Figure 3. Viscosity comparison between samples prepared by means of a batch or BLUEWAVE™ Technology process.

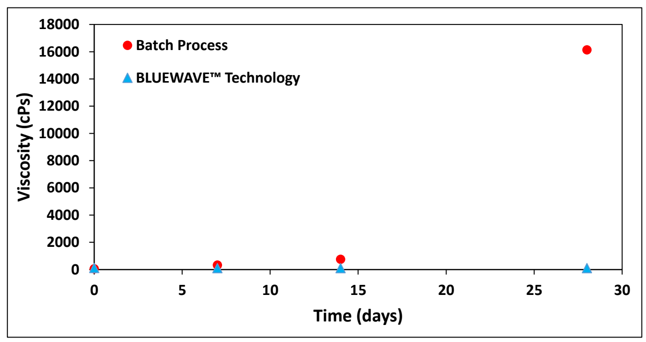


Figure 4. Viscosity as a function of time. Temperature held constant at 45 °C.

Hot Tack

Figure 5 shows the response of the Hot Tack (Force) as a function of temperature. In general, the sample produced by means of BLUEWAVE™ Technology has an effective lower on-set temperature and higher hot tack bonds than those exhibited by the sample produced by means of a batch process at a given temperature.

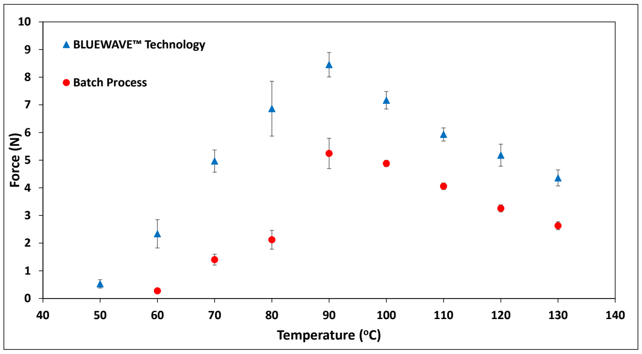
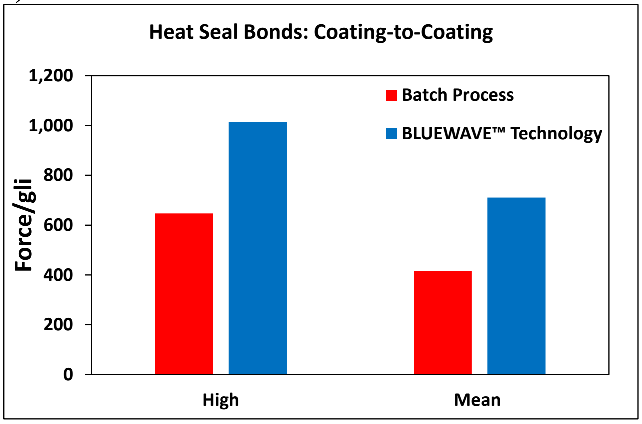


Figure 5. Hot Tack response as a function of temperature.

Heat Seal Bond Strength

To test the heat seal performance of the dispersions, a series of peel experiments were performed using the following conditions: dwell time (1 s), temperature (325 °F), pressure (40 psi), and velocity (10 in/min). A pre-measure took place at 0.1 in with the actual measure at 1.5 in. Figure 6 a) – c) shows the heat seal bond strength of each dispersion to different substrates, namely, coating-to-coating (90° peel), coating-to-high density polyethylene (HDPE) (180° peel), and coating-to-polyethylene terephthalate Glycol (PETG) (180° peel). In all three cases, the bond strength of the sample prepared by means of BLUEWAVE™ Technology is, at least, 40 and 35.6 % greater for the High and Mean cases, respectively.

a)



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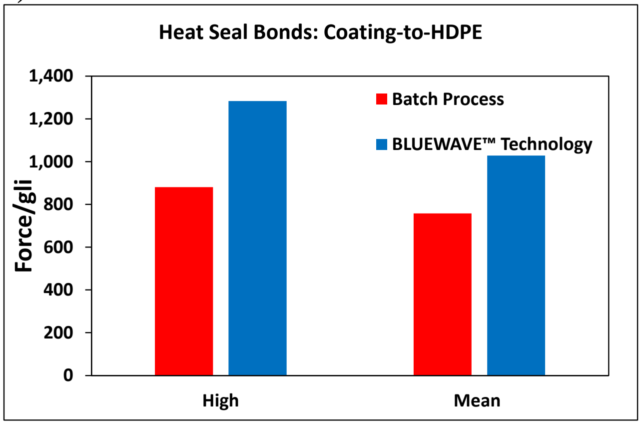

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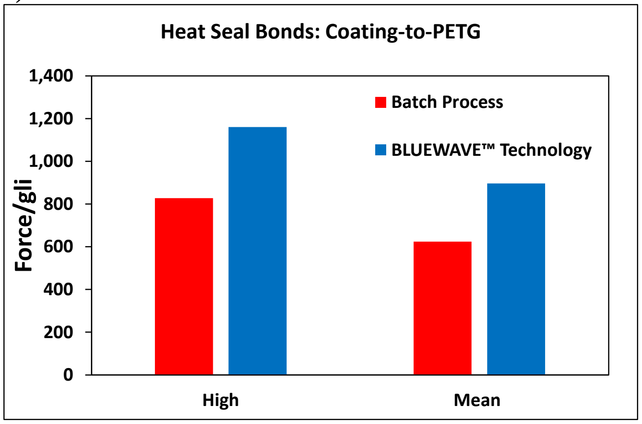

Figure 6. Comparison of bond strength of between samples produced by means of BLUEWAVE™ Technology and batch process. a) Coating-to-coating, b) coating-to-HDPE, and c) coating-to-PETG.

Appearance

Figure 7 shows a side-by-side comparison of the appearance of the samples prepared by means of a batch process and BLUEWAVE™ Technology. The latter sample exhibits a color improvement over the former (milky white vs. milky off-white), which translates into an aesthetic advantage in terms of dry coating appearance.

Figure 7. Appearance comparison between samples produced by means of BLUEWAVE™ Technology and batch processes.

Conclusions

In general, the BLUEWAVE™ Technology process enables the production of heat seal coatings that exhibit a performance equal to or that exceeds that of heat seal coatings produced by means of a batch process. For example, even though the viscosity of the freshly prepared heat seal coatings is similar, the viscosity of the sample prepared by means of BLUEWAVE™ Technology remains almost constant overtime (significantly longer shelf-life), whereas that of the batch process increases dramatically when exposed to higher temperatures. The Hot Tack tests showed that the dispersion produced by means of BLUEWAVE™ Technology exhibits an effective lower on-set temperature and higher bonds. Similarly, the dispersion prepared by means of BLUEWAVE™ Technology offers similar-to-higher bond strength on a variety of substrates. In addition, the dispersion prepared by means of BLUEWAVE™ Technology has a better appearance. Other advantages of a BLUEWAVE™ Technology continuous process include: 1) the ability to constantly monitor the process “in-line” to identify changes in the product in a timely fashion, which reduces the amount of potential waste (e.g., dismiss an entire batch vs. a few hundred pounds) and 2) better mixing, mass-, and heat-transfer as a consequence of smaller volume cross-sections inside the corresponding processing equipment.

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