Achieving LDPE Coating Adhesion to Clay-Coated Board at Reduced Melt Temperatures Using Calcium Carbonate Addition

F. A. Ruiz
Heritage Plastics, Inc.
8096 E. Hwy. 78
Villa Rica, GA 30180 USA

Abstract

An LDPE-based pelleted calcium carbonate ($CaCO_3$) concentrate was used to add 30wt.% fine-ground, surface-treated mineral to a 5.0 MI, 0.923ρ autoclave-process LDPE homopolymer. This dry blend was extrusion coated onto flame-treated clay-coated board. Conventional aqueous-based polyethylenimine (PEI) primer coating of the board was used as the control.

The combined flame pretreating of the board plus the addition of 30wt.% $CaCO_3$ to the LDPE coating resin yielded fiber-tear adhesion equivalent to that achieved with primer coating. This adhesion was achieved without major changes in extrusion conditions or web neck in. Calcium carbonate addition allowed polymer melt temperature to be reduced to as low as 570° F before loss in fiber-tear adhesion.

Introduction

Calcium carbonate addition to LDPE has been shown to increase coating adhesion to several substrates, particularly clay-coated board[1,2,3,4]. Other paper[5,6,7] discussed the mineral factors (particle morphology, particle size distribution, particle surface chemistry, and chemical purity) and polymer factors (molecular weight, molecular weight distribution, branching type and distribution, density/crystallinity, and polymer chemistry, e.g. polar/non-polar) which affect the processing and product properties with mineral addition. Proper mixing and dispersion of the mineral into the polymer matrix is a critical processing factor in the complete realization of the benefits of this technology. Commercial extrusion coating equipment in good condition with modern screw designs has proven satisfactory in achieving the necessary level of homogenization.

Discussion

Mineral and Polymer Selection

A 5.0 MI, 0.923ρ autoclave-process polyethylene homopolymer (Chevron 4517) was selected as the base resin. Materials of similar melt index & density are commonly used for coating clay-coated board used as cup stock, liquid packaging, and boxes for bakery goods and frozen foods.

A wet-ground calcium carbonate with a 1.0μ mean particle size (MPS) and 8μ top-cut (maximum particle size) was treated with a fatty acid by the mineral supplier to form a hydrophobic coating on the surface of the mineral. This allows the polyethylene to "wet" the mineral surface, greatly improving the dispersion of the mineral into the polymer matrix and processability of the mineral/LDPE composite.

Polymer Processing and Substrate Coating

Heritage Plastics H-TEC™ calcium carbonate concentrate, comprising 75wt.% of the surface-treated calcium carbonate described above compounded into an autoclave-process LDPE homopolymer, was used to prepare pellet/pellet dry blends with the base LDPE. This allowed processing of $CaCO_3$-containing coatings on a standard extrusion coating line. A dry blend of 40% concentrate and 60% LDPE base resin were prepared to yield a 30wt.% calcium carbonate loading. Samples of clay-coated board were coated at this mineral loading. A 114mm (4.5”) 30/1 L/D extruder fitted with a flat die deckled to 710mm (28”) exit width was run at a constant line speed of 1000 feet per minute to yield a coating weight of 7.2 lb./ream.

The board surface was flame-treated at a level of 14,000 BTU/in. prior to LDPE coating at a melt temperatures of 610°, 590°, and 570°F (321°, 310° and 299° C).

The processing conditions employed are summarized and adhesion results obtained are shown in Table 1.

Table 1 Processing Conditions and Adhesion Levels

Melt Temperature, °C (°F)	321°C (610° F)	310° C (590° F)	299 (570° F)
Screw RPM	42	42	42
Head Pressure	1391	1548	1694
Motor Current	97	99	96
Adhesion	Fiber tear	Fiber Tear	Slight Edge Feathering Fiber Tear

At 590° F (310° C) coating adhesion to the substrate was still at fiber tear level. Only at 570° F (299° C) did a slight but noticeable loss in adhesion occur.

Summary

Calcium carbonate mineral enhancement of extrusion coated LDPE is a commercially viable method of achieving fiber-tear adhesion to clay-coated board, and for modifying coated board properties. Mineral addition yields this adhesion level to clay-coated board, when combined with substrate flame treatment, without the need to use primer coating or corona/ozone treatment. Using calcium carbonate, it may be possible to achieve adhesion at reduced melt temperature, avoiding problems with package organoleptic properties (taste and odor).

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