A COMPARISON OF PRIMER COATING AND CALCIUM CARBONATE ADDITION METHODS OF ACHIEVING LDPE COATING ADHESION TO CLAY-COATED BOARD

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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 reduced coating COF, increased coating surface energy, and in this test allowed the reduction of melt temperature by 5° C (10° F) while still yielding 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)*. Other papers *(3, 4, 5)* 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) that 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 and 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

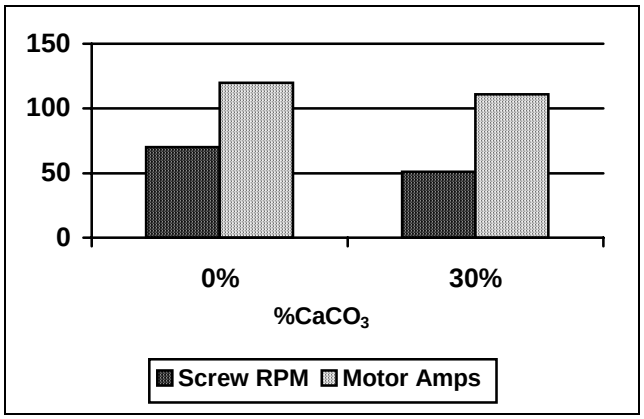
Heritage Plastics H-TEC™ calcium carbonate concentrate, comprising 75wt.% of the surface-treated calcium carbonate described above, compounded into an autoclave-process LDPE homopolymer, was used to prepare pellet/pellet dry blends with the base LDPE. This allowed processing of $CaCO_3$-containing coatings on a standard extrusion coating line. A dry blend of 40% concentrate and 60% LDPE base resin was prepared to yield a 30wt.% calcium carbonate loading. Samples of clay-coated board were coated at this mineral loading and with 100% LDPE.

A 114mm (4.5 in.) 30/1 L/D extruder fitted with a flat die deckled to 710mm (28 in.) exit width was run at a constant line speed of 500 ft/min to yield a coating weight of 14.7 lb./ream.

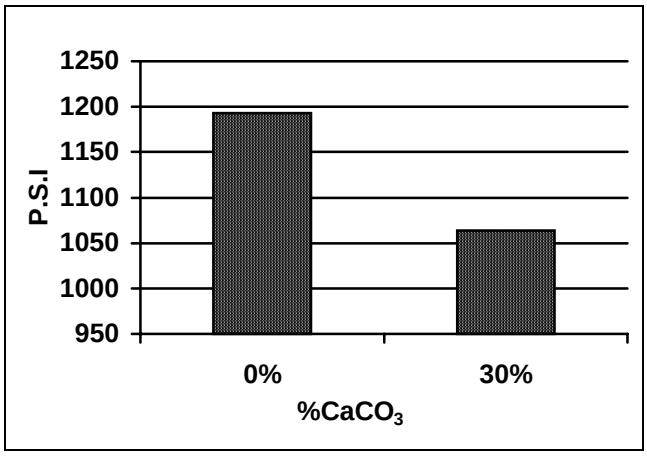
The board surface was flame-treated at a level of 14,000 Btu/in. prior to primer and LDPE coating.

A standard commercial polyethylenimine (PEI) primer coating was employed as the control method of promoting adhesion. One part of primer was diluted with one part isopropyl alcohol and three parts water and coated onto the board using a direct gravure applicator method.

The processing conditions employed for each run are summarized in **Table I.** Mineral addition yielded an increase in extruder specific output. Extruder screw speed had to be reduced from 70 to 51 rpm to maintain a constant line speed and coating weight. As a result, extruder head pressure and motor current were also reduced, as shown in **Figs. 1 and 2.** The results are consistent with what has been observed in previous tests and are a consequence of the increase in thermal conductivity of the melt with mineral addition. This effect is shown in **Fig. 3.**



1. Extruder screw speed and motor current response to $CaCO_3$ addition to 5.0 MI/0.923ρ LDPE

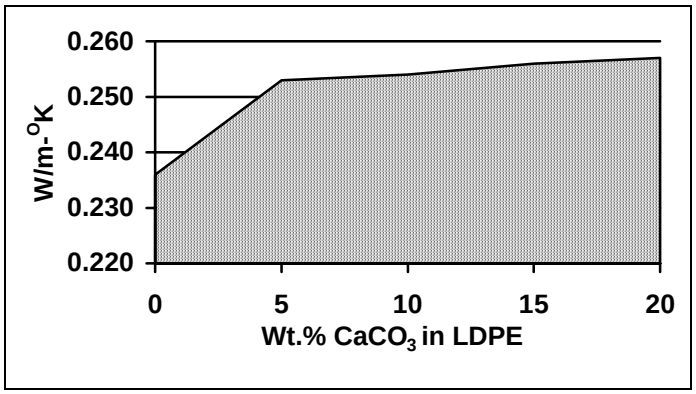


2. Extruder head pressure response to $CaCO_3$ addition to 5.0 MI/ 0.923ρ LDPE

Coating-to-substrate adhesion comparison of primer-coated board and unprimed board coated with LDPE containing 30wt.% calcium carbonate

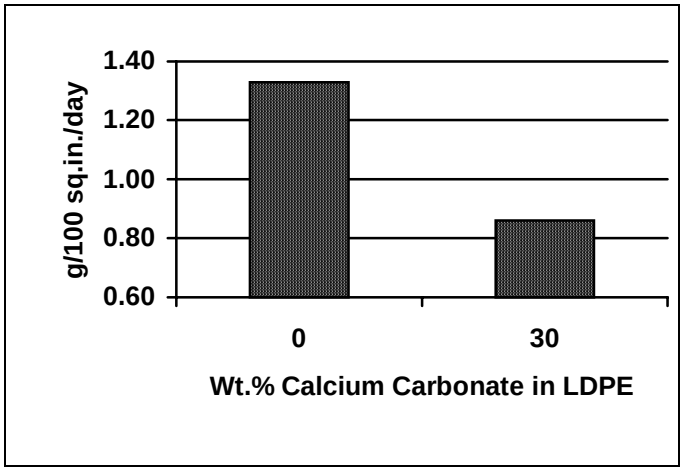
Coating-to-substrate adhesion was measured qualitatively by judging the difficulty in peeling the LDPE coating from the clay-coated surface of the board. Both methods of promoting coating adhesion yielded fiber-tear levels of adhesion.

A possible explanation for the increase in coating adhesion with calcium carbonate addition is that the increased thermal conductivity of the polymer with mineral addition (see Fig. 3) allows faster heat transfer from the bulk of the web to the polymer/substrate interface. This allows the polymer to stay molten and improves the wetting of the polymer onto the substrate surface.



3. Increase in LDPE thermal conductivity with $CaCO_3$ addition (6)

Modifications to LDPE coating properties with $CaCO_3$ addition



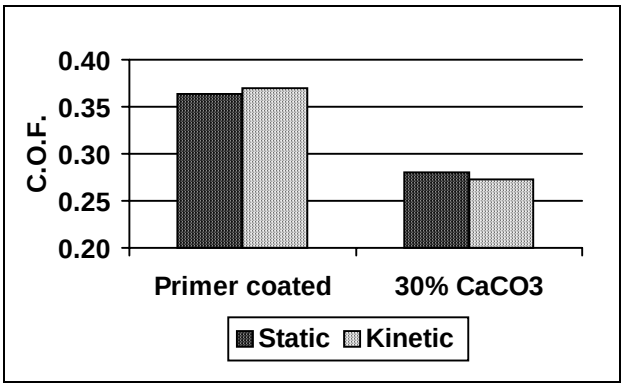
4. Decrease in coating MVTR with $CaCO_3$ addition.

The addition of calcium carbonate to the LDPE coating reduced the MVTR, as shown in **Fig. 4.** This reduction is due to the formation of a "tortuous path" for the passage of water vapor within the polyethylene, as it must diffuse around the calcium carbonate particles in the coating.

Calcium carbonate addition also reduces the coefficient of friction between the polymer-coated surfaces, as shown in **Fig. 5.** This should prove advantageous in operations where the coated surfaces must slide over each other, as in sheet-fed printing or box-making processes.

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. The reductions in coating MVTR and COF should be of value to flexible package converters and end users.



5. Change in poly-to-poly C.O.F. of LDPE coating with $CaCO_3$ addition

LITERATURE CITED

1. Ruiz, F.A., *TAPPI 1997 Polymers, Laminations, and Coatings Conference Proceedings*, TAPPI PRESS, Atlanta, p. 555.

2. Ruiz, F. A, *TAPPI J.*, 79(5): 139(1996).

3. Ruiz, F.A., *TAPPI 1994 Polymers, Laminations, and Coatings Conference Proceedings*, TAPPI PRESS, Atlanta, p. 89.

4. Ruiz, F. A., *Society of Plastics Engineers 1994 ANTEC Proceedings.*

5. Ruiz, F.A., *TAPPI J.*, 76(1): 174(1993).

6. Ruiz, F. A. and Allen, C.F., *TAPPI 1987 Polymers, Laminations, and Coatings Conference Proceedings*, TAPPI PRESS, Atlanta, p. 365.

7. OMYA Technical Bulletin No. US-PL-3.

8. Arina, M., and Honkanen, A., *Polymer Engineering and Science*, 19(1):30(1979).

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I. Processing conditions

Sample ID	Control using primer coating	LDPE + 30wt.% calcium carbonate
Coating weight, lb./ream	14.7	14.7
Line speed, m/s (ft/min)	2.54 (500)	2.54 (500)
Extruder screw speed, rpm	70	51
Extruder output, kg/hr (lb/hr)	189.6 (417)	189.1 (416)
Motor current, Amperes	120	111
Melt pressure, MPa (psi)	8.21 (1193)	7.33 (1064)
Melt temperature, °C (°F)	319 (606)	313 (596)