Going Beyond Adhesion: the Dual Functionality of Tie Layers

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Abstract

The AMPLIFY™ family of tie-layer resins, ionomers and compatibilizers are designed to provide optimal adhesion for a wide range of processes and products, including multilayer films, metal lamination, semi rigid and rigid multilayer containers, multi-layer pipe, wire and cable and recycled plastics. The platform benefits from Dow's continuous investment in developing new products focusing on food and performance packaging and plastic recycling. In this paper, an innovative new product is introduced with successful examples of its utility in barrier films.

A high performance graft concentrate (0.912 g/cc density and MI of 3 g/10 min) was developed to enable converters the ability to blend in-line yet achieve highly consistent adhesion levels in a barrier structure. This grade was developed in connection with one of the most recent advances in LLDPE technology. Consequently, it has gone beyond adhesion to provide enhanced abuse resistance relative to similar competitive grades. Examples of its utility will be demonstrated.

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Introduction

The AMPLIFY™ family of adhesives includes tie-layer resins, ionomers and compatibilizers. They are designed to provide optimal adhesion, process benefits and good optical properties for a variety of products such as multilayer coextruded and laminated films, semi rigid and rigid multilayer containers, multilayer pipe, wire and cable, artificial turf, and recycled plastics. AMPLIFY™ TY, a growing member in the family, is specially designed for film and packaging applications. Currently, TY has 17 grades of commercialized tie-layer resins providing outstanding adhesion between polymers such as PE, PP, PS and PET and EVOH or polyamides. Moreover, the number of TY products continuously expands, benefitting from Dow's persistent investment in developing new tie-layer products focusing on food and

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performance packaging. In this paper, a new tie-layer concentrate is introduced with successful examples of its applications in barrier films.

TY 1057H, a high performance MAH graft concentrate, was developed in connection with one of most recent advances in LLDPE technology. Consequently, it has gone beyond adhesion to provide enhanced abuse resistance relative to similar competitive grades. Because of its slightly higher MI than competitive grades of MAH concentrate, it also has a higher critical capillary number for good dispersion than others. As a result, this grade enables converters the ability of in-line blending with a variety of PE resins. Its other properties are on par with competitive concentrate grades in the market.

Experimental

TY 1057H (0.912 g/cc density and MI of 3 g/10 min) (concentrate A) was used to formulate tie-layer resins with ELITE™ 5400 PE resin at 7%, 10%, 15% and 20% concentrations by inline blending. In comparison, a competitive tie-layer concentrate (0.91 g/cc density and MI of 2.7 g/10 min) (concentrate B) was also used to formulate tie-layer resins the same way as concentrate A. The tie-layer resins were evaluated in a model 5-layer barrier film with EVOH or polyamide in the middle layer. The structure and layer thickness of the film are as follows

LLDPE (30%)/Tie (10%)/EVOH or polyamide (20%)/Tie (10%)/LLDPE (30%)

The total thickness of the film was 4 mil. The use of relatively thick film here was to ease the subsequent film characterizations, especially the measurement of adhesion strength. Film properties, including, adhesion, puncture, dart, tensile and haze are measured according to ASTM standards.

All the films were fabricated utilizing a Labtech 5-layer blown film line in the Packstudio at Freeport, TX. Extrusion conditions include die size= 2.95”, layflat = 11.6”, BUR=2.5, die gap =78.7 mil and output = 42 lbs/hour. Besides tie-layer resins, other materials used in the study include LLDPE DOWLEX™ 2045G, EVOH EVAL H171B and polyamide Ultramid C33L-01.

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Results and discussions

Adhesion strength of tie-layer

Table-1 summarizes the adhesion strength (ASTM F904) of tie-layer concentrates A and B to both polyamide and EVOH in the LLDPE let-down resin at four loading levels. It can be seen from the results that adhesion properties of the two concentrates are mostly comparable to each other, despite some minor differences between their tendencies to adhere more to polyamide vs. EVOH. It is also important to note that at 7% loading, both concentrates A and B demonstrate borderline adhesion to EVOH in films.

Table-1 Adhesion strength of tie-layer concentrates A and B

Adhesion Strength N/15mm	Polyamide		EVOH	
Loading	Conc. A	Conc. B	Conc. A	Conc. B
20%	9.4	8.2	9.7	Film Inseparable
15%	9.5	9.2	8.0	9
10%	9.3	9.1	8.8	6.9
7%	8.3	8.3	2.8	4

Dart, puncture and tensile strength

Table -2 shows the data of dart (ASTM D1709), puncture (Internal method) and tensile strength (ASTM D882) of 5-layer barrier films containing tie-layer concentrate A or B at 20% loading. It is very obvious from the results that the films containing tie-layer concentrate A demonstrate higher dart and puncture values than those with tie-layer concentrate B, despite the fact that the tie-layer concentrate only contributes to ~4 wt% of the total film. The higher abuse resistance of the film imparted by concentrate A can be attributed to the base resin used, which is one of the most recent advances in LLDPE. Regarding tensile strength, even though the break stress and break strain of films containing polyamide are similar for both tie-layer concentrates A and B, they are different in the films containing EVOH. These

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differences are associated with different extensibilities in connection with the base resins. Nonetheless, either ~300% or 350% stretch potential can meet most of the packaging needs for barrier films.

Table-2 Dart, puncture and tensile strength of 5-layer barrier films containing tie-layer concentrate A or B

Properties of 5-layer film	Polyamide		EVOH	
	Conc. A	Conc. B	Conc. A	Conc. B
Dart (g)	-	-	616	508
Puncture (ft*lbf/in^3)	145	121	48	44
Tensile-Break stress-CD (psi)	4223	4373	2912	3241
Tensile-Strain at break-CD (%)	441	445	288	342

Haze

Table-4 summarizes the values of total haze (ASTM D1003) of 5-layer films containing tie-layer concentrate A or B at four loading levels. The results indicate that the use of concentrate A in multilayer barrier films may slightly increase total haze comparing to concentrate B by an average of ~2%. However, for most packaging application, this minor change in haze is within the error of the test.

Table-3 Total haze of 5-layer barrier films containing tie-layer concentrate A or B

Total Haze (%)	Polyamide		EVOH	
Loading	Conc. A	Conc. B	Conc. A	Conc. B
20%	15	12	17	16
15%	13	12	18	17
10%	13	14	17	16
7%	13	12	18	15

In addition to its overall relatively low haze, concentrate A also has relatively low gel levels and color, which are similar or slightly better than concentrate B.

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Extrusion

The process parameters, such as back pressure and torque, measured at 4.2 lbs/hr output are summarized in Table-4 for both concentrate A and B at four different loadings. The results clearly indicate that extrusion of concentrate A requires less energy and generates less backpressure than concentrate B. This can be attributed to the slightly higher MI of concentrate A than concentrate B.

Table 4 Back pressure and torque for extrusion of concentrates A and B

	Back Pressure (psi)		Torque (Current %)	
	Conc. A	Conc. B	Conc. A	Conc. B
20%	3105	3206	65	73
15%	3303	3325	70	79
10%	3343	3440	74	81
7%	3482	3514	77	77

Conclusions

Tie-layer concentrates A and B were used to formulate tie layer resins and compared in a model 5-layer barrier film with either EVOH or polyamide as the barrier layer. The results indicate that the film containing tie-layer concentration A, even only at 4wt% of the total film, can have up to 20% improvement in abuse resistance than that with concentrate B. The improvement in both dart and puncture can be attributed to one of the most recent advances in LLDPE technology. Furthermore, these two concentrates showed comparable performance in adhesion, haze and processability. In conclusion, concentrate A is recommended to use in place of concentrate B in application where better dart and puncture properties are desirable.

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