New generation of low-density hot-melt packaging adhesives

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ABSTRACT: Hot-melt adhesives for packaging applications have undergone significant improvements to meet customer demands for faster set times, wider ranges of end-use temperature, and adhesion to more difficult to bond substrates. Recent adhesive developments have allowed for the formulation of a new generation of packaging adhesives that has expanded the temperature use range (both low and elevated temperatures) of hot-melt adhesives. These new adhesives also exhibit very fast set speeds, excellent adhesion to a wide variety of substrates (including recycled boardstock), and a low density (below 0.95 g/cc) for greater adhesive mileage and easier removal in the recycling process.

KEYWORDS: Adhesives, EVA polymers, hot melts, low density, packaging, polyethylene, recycling, and temperature.

Hot-melt packaging adhesives are encountering more demanding customer requirements in various areas, including faster set times as the speed of packaging lines increase, wider end-use temperature ranges as expectations for freezer-to-oven applications increase, improved adhesion to difficult-to-bond substrates as the use of coated, recycled, and high-performance boardstocks increase, and aiding or not interfering in the recycling of old corrugated containers (OCC) as a greater percentage of OCC is recycled.

Most hot-melt packaging adhesives are based on either a low-density polyethylene (PE) polymer or an ethylene vinyl acetate (EVA) copolymer. Formulating with these base polymers in the past generally has led to adhesives that have desirable properties for specific applications, but it often required optimizing the formulation for a specific performance property—such as elevated temperature performance—while sacrificing another performance property such as low-temperature performance. The adhesives to be discussed in this paper extend the performance window of these traditional adhesives and broaden the performance ranges possible for hot-melt packaging adhesives. Adhesives have been developed that extend the temperature use range and improve adhesion to more difficult-to-bond substrates while maintaining a low density for increased mileage and easier removal in the recycling process.

Advances in paper manufacturing also have challenged hot-melt adhesive manufacturers. Paper companies have been able to reduce the basis weight of kraft paper while maintaining strength by improving fiber orientation through the use of extended nip pressures, higher temperatures, and chemical additives. Such paper is commonly referred to as high-density or high-performance paper. This paper is frequently used in edge-crush boardstock, but it can be used on paper tested by the more commonly used burst strength ratings. It has been estimated that 20–25% of today's kraft paper is of this type. Depending on the process and feedstocks used, along with recycle content, some high-performance papers are relatively easy to bond while others tend to be quite difficult, particularly when fiber tear is expected under cold storage. The new adhesives developed exhibit a broader range of adhesion to a variety of boards, again while maintaining a good balance of other performance properties.

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I. Temperature performance ranges of general purpose adhesives

Properties	General purpose polyethylene adhesive	General purpose EVA adhesive
Viscosity at 350°F, cp	900	900
Relative set time, s	Very fast 3.8	Very fast 3.8
IoPP heat stress failure temp., °F	165	135
Minimum fiber tear temp., °F	35	20
Density, g/cc	0.95	0.99

II. Temperature performance ranges of general purpose adhesives vs. a new generation adhesive

Properties	General purpose polyethylene adhesive	General purpose EVA adhesive	New generation adhesive
Viscosity at 350°F, cp	900	900	1200
Relative set time, s	Very fast 3.8	Very fast 3.8	Very fast 2.8
IoPP heat stress failure temp., °F	165	135	180
Minimum fiber tear temp., °F	35	20	0
Density, g/cc	0.95	0.99	0.95

III. Performance ranges of low-temperature adhesives

Properties	Low-temperature polyethylene adhesive	Low-temperature EVA adhesive
Viscosity at 350°F, cp	1100	1300
Relative set time, s	Fast 4.8	Very fast 3.8
IoPP heat stress failure temp., °F	155	130
Minimum fiber tear temp., °F	–20	–35
Density, g/cc	0.94	0.98

Test methods

Adhesive test methods used in this work were American Society for Testing and Materials (ASTM) D3236 (viscosity) and ASTM D792 (density). Set and open time testing was performed using a Waldorf packaging line simulator *(1)*. Elevated-temperature performance was evaluated by using the IoPP method for heat stress failure temperature *(2)*. Low-temperature testing was performed by aging bonded samples at the test temperature for 24 hours and then determining the degree of fiber tear at the test temperature. All testing was performed on a standard 200-lb burst strength corrugated board.

New developments

The properties of a typical general purpose polyethylene-based packaging adhesive and a general purpose EVA-based adhesive are shown in **Table I**. Both these products have low viscosity for efficient, clean machining and a very fast set time for satisfactory processing at high line speeds. The polyethylene-based product exhibits higher elevated-temperature resistance while the EVA-based adhesive exhibits better low-temperature performance. The two adhesives also exhibit the density difference normally observed between a polyethylene- and EVA-based material, with the polyethylene-based adhesive having a significantly lower density.

Table II shows the performance of one of the new generation adhesives compared to the general purpose polyethylene and general purpose EVA-based products. The new generation product exhibits a low viscosity similar to the general purpose products; however, it does exhibit a significantly shorter set time than the other two products. This gives the new generation product the capability to perform on the fastest packaging lines. The tempera-

ture use range for the new product is also much broader than the general purpose products. This is illustrated in **Fig. 1** and shows that the heat stress failure temperature is 180°F, with low-temperature fiber tearing bonds down to 0°F, which extends the performance range compared to the general purpose products on both ends. This performance is possible while maintaining a low density of 0.95 g/cc, which increases the mileage of the adhesive. **Figure 2** shows that a 5% mileage advantage is possible with the low-density adhesive when compared to the higher-density EVA product.

Density also plays an important role in the removeability of the adhesive in the recycling of OCC. As reported at the TAPPI 1992 Hot Melt Symposium *(3)*, adhesives with densities below 0.98 g/cc are efficiently removed by using reverse cleaners, and at 0.95 g/cc the new generation product is low enough in density to easily meet this requirement.

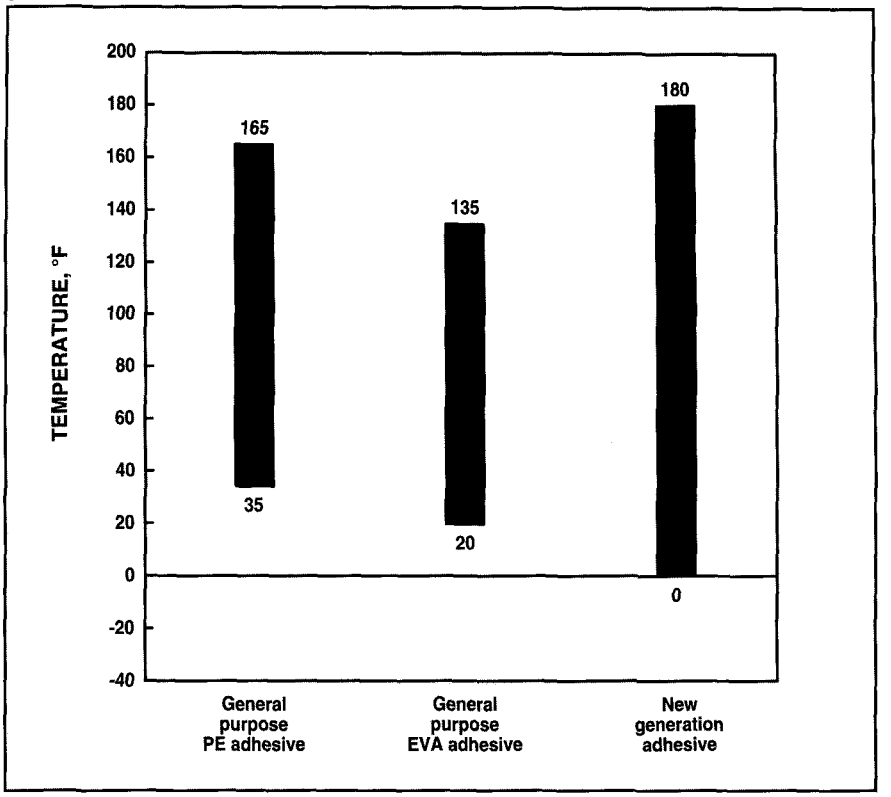
The overall balance of properties and adhesion characteristics of the new generation products is such that they offer significant benefits in faster set speeds and broader temperature performance ranges while maintaining a low density for more efficient adhesive usage (improved mileage) and more efficient removal in the recycling process.

Table III shows the properties of current polyethylene-based and EVA-based adhesives specifically formulated for frozen food applications. Both of these products exhibit very workable viscosities. The low-temperature performance of the polyethylene-based adhesive has been extended by sacrificing set speed and some elevated temperature performance. The EVA adhesive has very good low-temperature performance but exhibits a lower elevated temperature performance.

Table IV shows the performance properties of a new generation adhesive specifically formulated for frozen food applications compared to the current polyethylene- and EVA-based adhesives just described. The new generation product exhibits a viscosity in the same range as the two current products. It also shows a very fast set time and is significantly faster than the current polyethylene-based adhesive. The new generation adhesive also illustrates exceptional performance at low temperatures while extending the elevated temperature performance of the current adhesives. This is illustrated in **Fig. 3**.

The performance of the low-temperature new generation adhesive is possible while maintaining a low den-

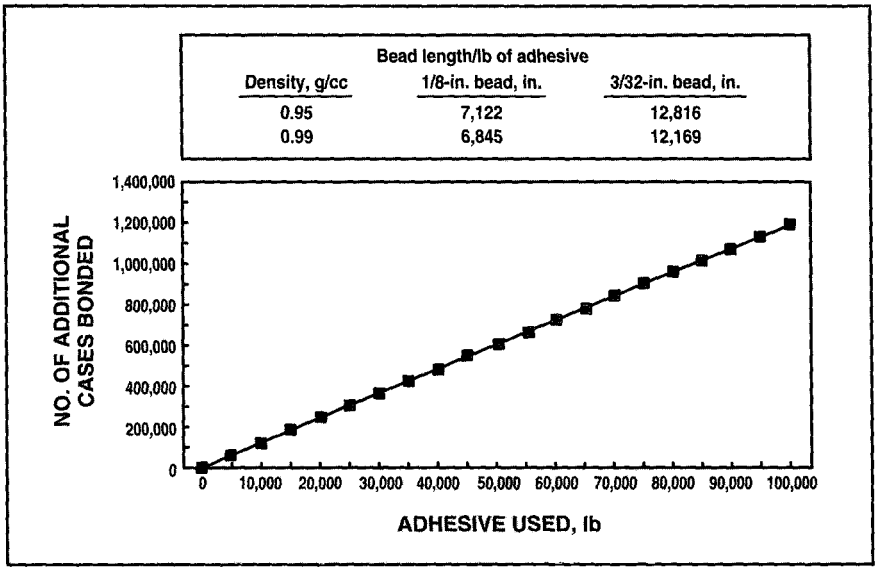
1. Temperature performance ranges of general purpose adhesives (PE and EVA) vs. a new generation adhesive



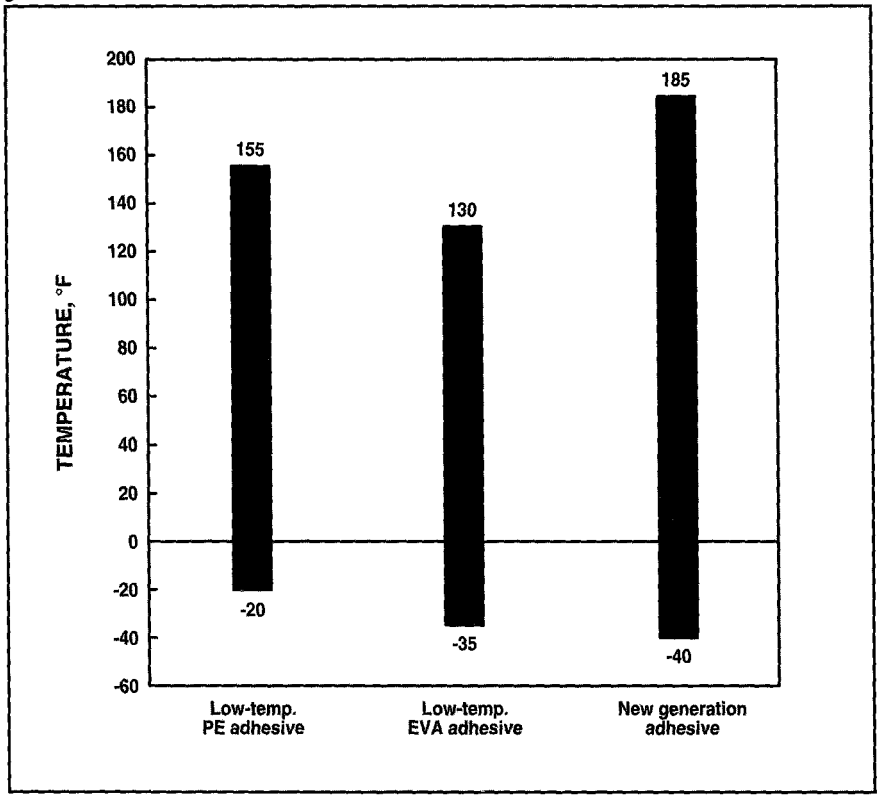
IV. Performance ranges of low-temperature adhesives (PE and EVA) vs. a new generation adhesive

Properties	*Low-temperature polyethylene adhesive*	*Low-temperature EVA adhesive*	*New generation adhesive*
Viscosity at 350°F, cp	1100	1300	1400
Relative set time, s	Fast 4.8	Very fast 3.8	Very fast 3.5
loPP heat stress failure temp., °F	155	130	185
Minimum fiber tear temp., °F	–20	–35	–40
Density, g/cc	0.94	0.98	0.94

2. Mileage advantage of low-density adhesives. Assumes eight 3-in.-long 1/8-in. beads per case.



3. Temperature performance ranges of low-temperature adhesives (PE and EVA) vs. a new generation adhesive



V. Adhesion performance of new generation adhesives

Substrates	*Current polyethylene adhesive*	*Current EVA adhesive*	*New generation adhesive*
High-performance board	FT to 50°F	FT to 35°F	FT to –20°F
Edge crush board	FT to 50°F	FT to 50°F	FT to 0°F

sity of 0.94 g/cc for the added benefits of increased mileage and higher removal efficiency in the recycling process. The performance of the new generation product also was tested on a variety of substrates. **Table V** shows the performance of the new generation product versus current polyethylene- and EVA-based products on difficult-to-bond substrates. The testing on high-performance board and edge-crush board shows that the new generation product is much better than the adhesives currently available. Performance on these two substrates with the new generation products is obtained at significantly lower temperatures than current adhesives.

Conclusions

New generation hot-melt packaging adhesives have been formulated that show the following improved performance benefits over currently existing hot-melt adhesives:

1. Faster set speeds
2. Extended performance at both elevated and low temperatures
3. Improved adhesive performance on difficult-to-bond boardstocks
4. Low density for additional adhesive mileage and higher removal efficiency in the recycling process.

Literature cited

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The authors thank Mike Ambrosini and Bill Campbell for their contributions to the data in the paper. We would also like to thank Steve Boyd for his tireless efforts in preparing and testing the adhesives described in the paper.

Received for review March 3, 1994.

Accepted April 12, 1994.

Presented at the TAPPI 1994 Hot Melt Symposium.