Improved extrudable hot-melt melt adhesive for lidding

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ABSTRACT

Government regulations restricting VOC emissions have prompted the development of alternate compliant heat-activated adhesives with performance equivalent to solvent systems. Although varying degrees of success have met the many approaches taken, a hot-melt adhesive designed for lidding application with extrusion coating equipment shows many improvements. In other applications, the improved technology of this system could provide VOC-free adhesive systems matching the performance of materials previously available only as high VOC- containing solvent systems.

Application:

New extrudable hot-melt systems exemplified by a lidding adhesive offer the promise of performance previously available only with high VOC solvent systems.

BACKGROUND

Hot-melt adhesives for extrusion coating have been available since the early 1970s. Technology developed then is still useful today for many applications. The adhesives find use primarily in packaging applications. They cover a broad spectrum of heat seal applications ranging from controlled peel to substrate destroying bonds depending on the adhesive and substrates chosen. The adhesives often fall short compared with high-performance solvent-based systems for more demanding end uses.

Although hot-melt adhesives can form heat-activated bonds when sealing materials face-to-face, the primary use for extrusion grade adhesives is to effect heat seal bonds between adhesive coated and uncoated surfaces. The substrates can be the same or dissimilar to encompass a variety of combinations. The adhesives also provide improvements in water vapor transmission resistance (WVTR) and afford some degree of oxygen barrier.

The improved performance properties of the adhesives compared with similar hot-melt technology designed for application with gravure or a conventional slot die are superior hot tack and product resistance. These improvements come from the much higher molecular weight polymers in the materials coupled with the modifiers incorporated into the adhesive systems.

EQUIPMENT CHOICES

Application of these adhesive systems typically uses screw extrusion equipment with length to diameter ratios (L/D) of 24:1 and higher with conventional dies and screws. Screw extrusion equipment with contact dies also work, but are not as prevalent. Although slot die equipment sometimes applies extrusion grade adhesives, the variety of materials that can run on this equipment has limitations due to the adhesive melt flow characteristics.

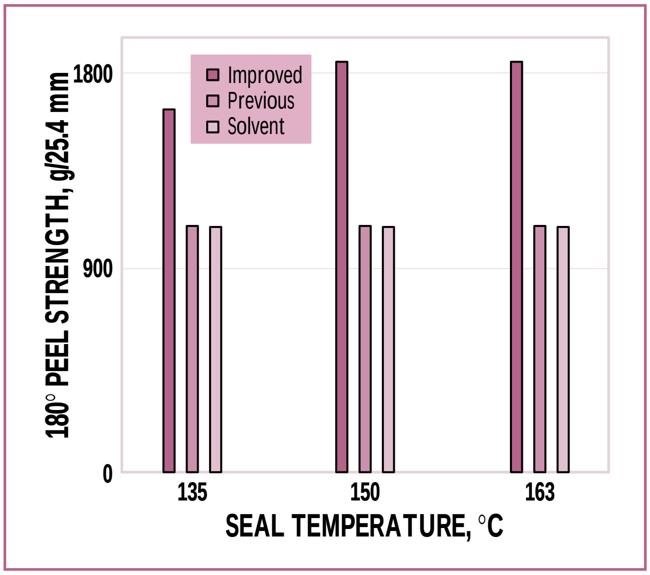
Application temperatures for the products are 121–204°C (250–400°F). Most are 150–182°C (302–360°C). Application weights are 8–52 g/m² (5–32 lb/3000 ft²). Most applications use 13–22 g/m² (8–14 lb/3000 ft²).

CURRENT ADVANCES

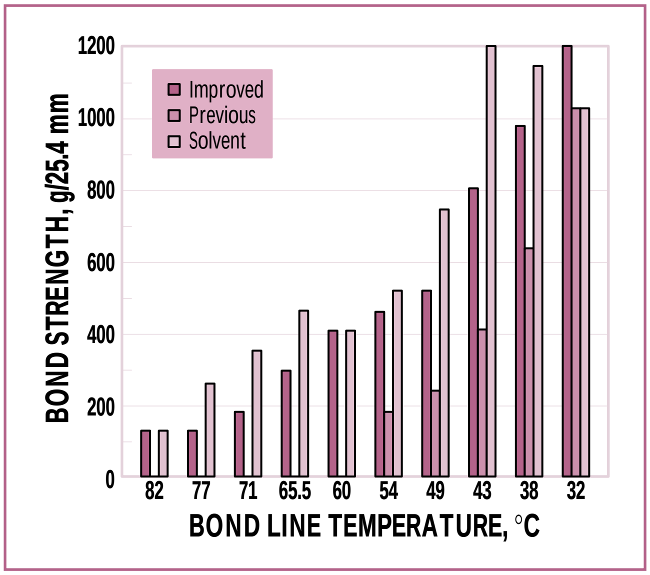
High-performance lidding adhesives used for unit portion food packaging have long been the domain of solvent-based technology. Many previous attempts to replace these items with hot-melt melt or aqueous materials have met with moderate or no success. This is particularly true for hot fill items used on high-speed filling lines. The primary deficiencies of the alternate technologies have been poor hot tack, poor hot hold, poor block resistance, and odor contribution to the food product being packaged.

New technology has led to extrusion grade adhesive systems that address these deficiencies for many unit portion package constructions. **Figure 1** compares the peel strength using three adhesives systems coated on the polyester side of a treated polyester to foil lamination combined with high impact polystyrene (HIPS). The peel strengths for a previous extrusion grade hot-melt melt and a solvent borne system are equivalent. The higher bond strength of the improved extrudable system addresses the current requirements for European applications and some domestic markets.

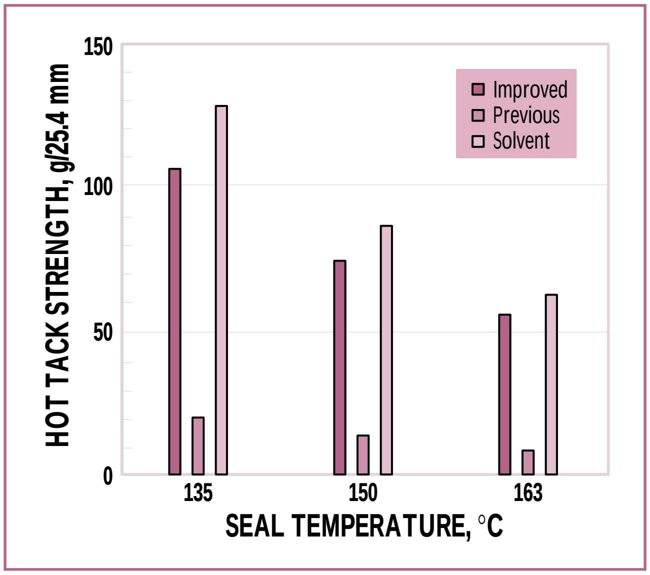
Comparison of the bond development of the adhesives in **Fig. 2** as the bond line cools after preparing the seal shows that the improved extrusion grade hot-melt melt is superior to its predecessor and equivalent to the solvent system. This feature is important for packaging applications containing hot-filled goods. Since the package temperature decreases slowly, the adhesive must have sufficient strength while warm to resist the abuse the package undergoes during down-line processing on the filling lines.



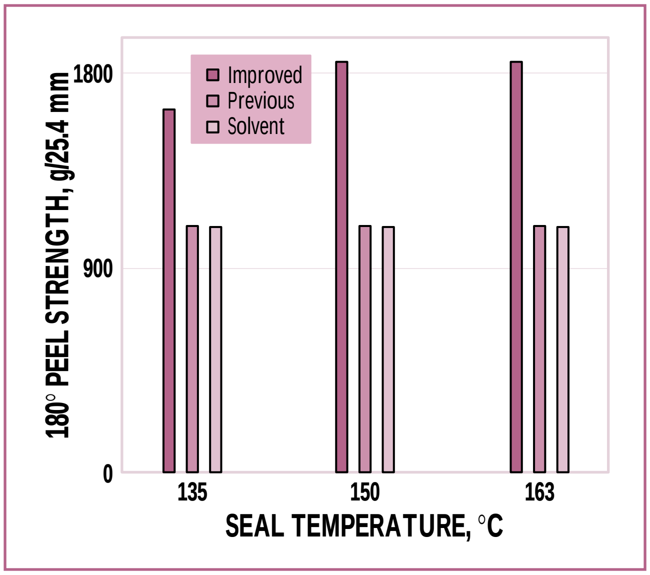
1. 180° peel strength variation seal with temperature at a jaw separation rate of 30.5 cm/min



2. Bond strength vs. bond line temperature



3. Hot tack strength variation with seal temperature



4. DMA using parallel plate at 5°C/min vs. temperature

Figure 2 shows that bond development of the improved extrudable adhesive system is approximately equivalent to a solvent borne system. The previous extrusion system does not begin to develop appreciable bond strength until the bond line cools to approximately 54°C.

Hot tack of the improved system is also superior to previous hot-melts melts and conventional solvent systems as **Fig. 3** shows. This feature is important for high-speed filling lines and particularly necessary for stretch register lines. Hot tack values used the spring test method during bonding of an adhesive-coated polyester to foil lamination with HIPS. Values are the force the adhesive will resist immediately after removing sealing jaw pressure.

Our development work used Dynamic Mechanical Analysis (DMA) as a tool to differentiate the physical characteristics of the adhesives under study. We made comparisons of morphology of the previous hot-melt melt and the dried solvent borne system to achieve target values deemed necessary for the desired performance. We targeted two key features. One was increased softening point for improved block

KEYWORDS

Adhesives, bonding strength, extrusion coating, hot-melts, solventless formulations, VOC.

resistance. The other was improved substrate wetting during the sealing operation through improved fluid flow at seal interface temperatures above 120°C. We coupled these features with the ability to form the desired bond strengths between dissimilar surfaces.

As the DMA data in **Fig. 4** shows, the improved system has a much higher initial softening point than the previous hot-melt melt or the solvent borne adhesive. In addition, the elastic flow at 120–140°C for the improved system is less than that for either of the other adhesives. Using the predicted DMA model developed from these studies led to the selection of the modifying ingredients needed to obtain the hot tack and hot hold properties desired.

An odor has traditionally been a concern when using extrudable adhesive systems. This is due to the nature of the materials used in the formulation of these adhesives coupled with the thermal oxidation obtained in the extrusion process. Current systems have addressed these concerns by using more highly stabilized modifying ingredients and improved stabilizer packages. With these improved methods to obtain improvements in odor generation, it is possible to improve the adhesive systems available for many years by using the enhanced stabilizer packages.

SUMMARY

Technology advances in producing extrusion grade adhesive systems have led to the development of high-performance materials used for lidding stock in food packaging applications. Transferring the methods used to gain such improvements to other extrusion grade adhesives is possible in assembly applications as one example. This would provide volatile organic compound (VOC) free technology with performance equaling or at least approaching solvent technology combined with improvements in hot tack, hot hold, odor generation, and block resistance. **TJ**

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