Primerless Heat Seal Coatings for Film Substrates

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ABSTRACT

Water based heat seal coatings based on acid copolymers are well known to the art. They are typically applied in two steps: first a primer, then the heat seal coating. The result is a coated film that offers good seal strength, hot tack, machinability and optical clarity. This paper presents a single pass, aqueous heat seal coating which exhibits excellent hot tack and a wider operating window as compared to conventional heat seal coatings and common extruded sealants.

INTRODUCTION

Many flexible package structures require a heat seal closure mechanism to protect foods and consumer products from the threat of spoilage and contamination during storage and handling. Most films, such as biaxially oriented polypropylene (BOPP), polyester (BOPET) and polyamide (BOPA) do not inherently heat seal unless pushed beyond their melting temperatures, at which point the film deforms and produces an aesthetically undesirable package. Coatings and coextruded sealant resins that soften or melt at lower temperatures than the film substrate can produce an adequate heat seal without distorting the package.

This paper is about aqueous coatings intended to be roll coated onto flexible packaging substrates and activated through a combination of contact, heat and pressure. These coatings can deliver lower seal initiation temperatures and broader seal windows, as compared to (co-)extruded sealants. By using 1 to 2 dry g/m^2 (0.6 to 1.2 lbs/3,000 ft^2 ream) of aqueous heat seal coating in lieu of 10 to 16 g/m^2 (6 to 10 lbs/ream) of (co)-extrusion coated sealant resin , converters have an opportunity to down gauge their structures by using less than 15% of the amount of resin to close a package.

WATER BASED HEAT SEAL COATINGS FOR FILM

The film coatings described may find utility in packages designed for applications such as snacks, baking needs and mixes, confections, overwraps, medical devices, pharmaceuticals, health and beauty aids. To characterize the suitability of a water based heat seal coating, we looked at these properties:

- Low seal initiation temperature, SIT, suitable for heat sensitive substrates and enabling higher line speeds
- Broad heat seal temperature range, which makes the coating versatile enough to run on a variety of machines under different sealing conditions
- Adhesion to a variety of film substrates
- High hot tack strength, the cohesive strength of the adhesive at elevated temperatures, important for seal integrity during high speed automated filling operations
- Optimized Coefficient of friction, CoF, the ability of the coating to easily glide over machine parts
- Optical clarity, to maintain the aesthetic appearance of the overall structure
- Food contact compliance for food applications.

Conventional Heat Seal Coatings

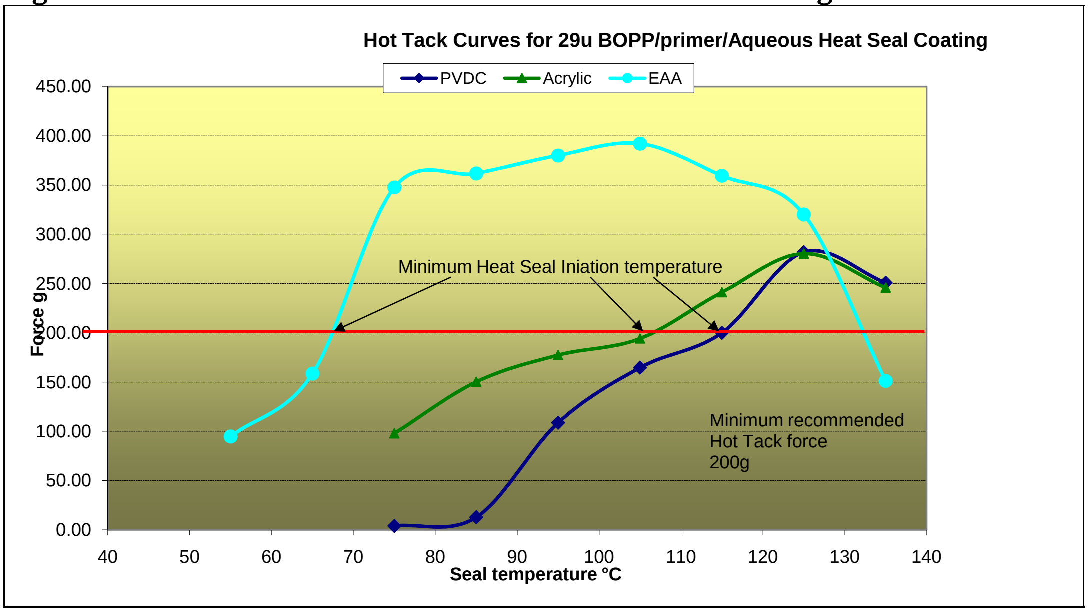
Figure 1 compares SIT and hot tack performance for well known heat seal coating technologies based on polyethylene acrylic acid, EAA; “acrylic” (a general term for polymers, copolymers and blends based on alkyl acrylates); and polyvinylidene chloride, PVdC. The minimum hot tack strength is defined to be 200 g force. Hot tack strength below this value is deemed insufficient to maintain closure during the stresses imposed during the filling and sealing processes in a form-fill-seal machine. The SIT is lowest temperature at which the hot tack strength reaches 200 g force.

EAA is a good foundation for a face-to-face (A/A) heat seal coating because it is transparent and compliant for food contact applications. A formulator may select a grade of EAA with low melt viscosity, and this property facilitates rapid chain mixing when pressed against itself in heated jaws for a fraction of a second. The ability for the polymer to quickly melt and combine with itself leads to good bond strength and hot tack properties. There is an upper limit in the hot tack range at 133^{o}C, however, where the polymer becomes too thin and loses its cohesive strength. At this point, there is a risk of heat seal failure.

Acrylics are well known for versatility, clarity, printability and food contact compliance. They are suitable for sealing to themselves (A/A), or to other surfaces (A/B).The figure shows, however, inferior hot tack and higher SIT as compared to EAA.

PVdC may also be used as a heat seal coating in food applications, though it is better known as a moisture and oxygen barrier coating. The figure shows inferior hot tack and higher SIT compared to EAA. Further, heavier coat weight is required to achieve similar bond strength and the final coating tends to discolor over time.

Figure 1 Hot Tack Data For Conventional Heat Seal Coatings

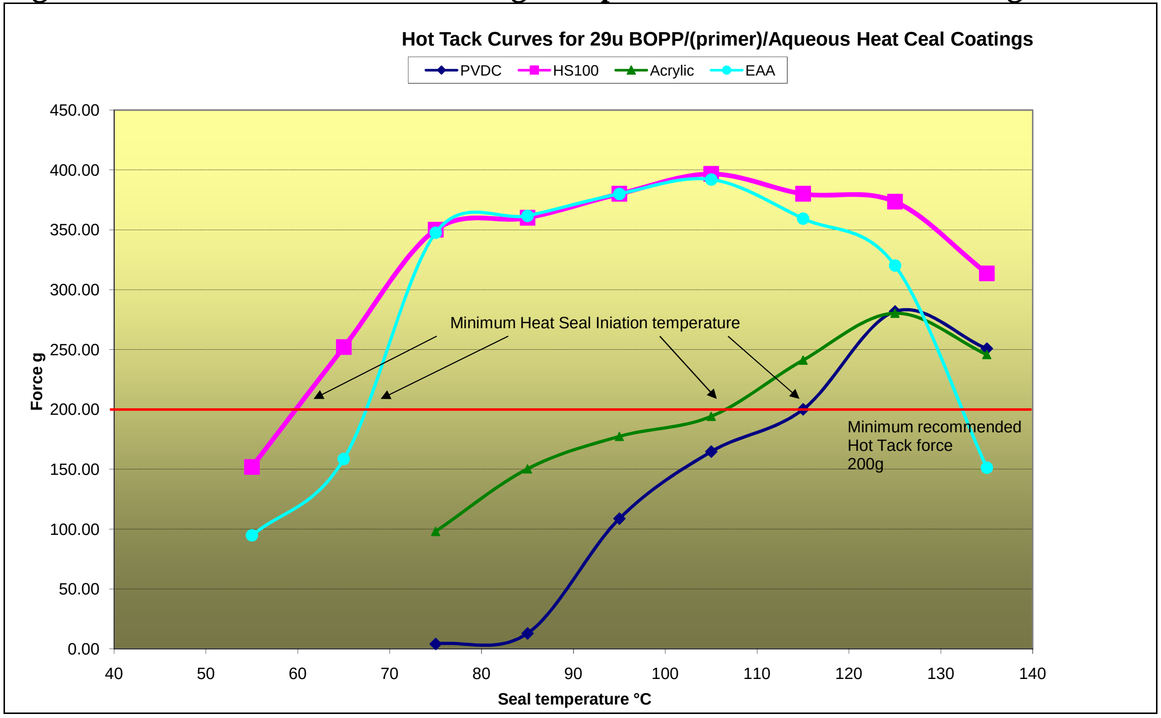


Innovation – Primerless Heat Seal Coating

EAA, acrylic and PVdC coatings all require a primer to adhere to film substrates. This means that converters and film producers must invest in either tandem roll coaters or else suffer through costly two-pass production. It was for these reasons that we developed a new formulation, designated HS100, which exhibits improved substrate adhesion. This characteristic eliminates the need for a prepriming step.

In figure 2, the hot tack curve for HS100 is compared to the curves shown for EAA, acrylic and PVdC. It is evident from this data that HS100 offers a lower SIT than the other materials tested. At the upper end of the temperature range (about 135^{o}C), EAA exhibits a limit at which point the hot tack strength diminishes to less than 200 g force. This may be thought of as heat sensitivity and can lead to seal failure during the filling step.

Figure 2 Primerless Heat Seal Coating Compared to Conventional Coatings



Slip properties are also important for a heat seal coating. CoF data was collected under ambient lab conditions (23^{o}C, 50% RH). Our target was to achieve coated/uncoated kinetic CoF of 0.2 – 0.3, as values much lower may lead to roll telescoping, and higher values do not slide over machine parts sufficiently. Table 1 compares SIT and CoF values for several aqueous heat seal coatings.

Table 1. SIT and CoF Values for Coated Film Samples

Coating	Seal Initiation Temp ^{o}C (^{o}F)	Kinetic Coef of Friction (coated to coated)	Kinetic Coef of Friction (coated to uncoated)
BOPP/1 µm HS100	60 (140)	0.42	0.24
BOPP/primer/ 1 µm EAA	68 (154)	0.42	0.24
BOPP/primer/ 1.5 µm Acrylic	104 (220)	0.24	NM
BOPP/primer/3 µm PVdC	114 (237)	>0.4	NM

Key: NM = Not Measured

COMPARISON TO EXTRUDED RESINS

These results encouraged us to consider whether HS100 could act as an alternative for slip modified (co-)extrusion coated sealants. As a starting point, we generated hot tack curves for 15 g/m^2 of three common extrusion coated sealants, EVA (18% VA, 1 MI), LLDPE (1 MI) and ionomer (Zn, 5 MI) resins and compared them to 1 g/m^2 of HS100 in figure 3. A SIT summary appears in table 2. Extrudates are often adjusted for slip behavior by incorporating migratory materials such as fatty acid amides at varying levels to the resin. These additives are likely to affect heat seal and hot tack performance. The evaluated sealants did not contain slip packages or other modifiers, and, therefore, had high CoF properties.

Figure 3. Comparison of Aqueous HS100 Heat Seal Coating to Extruded Sealant Resins

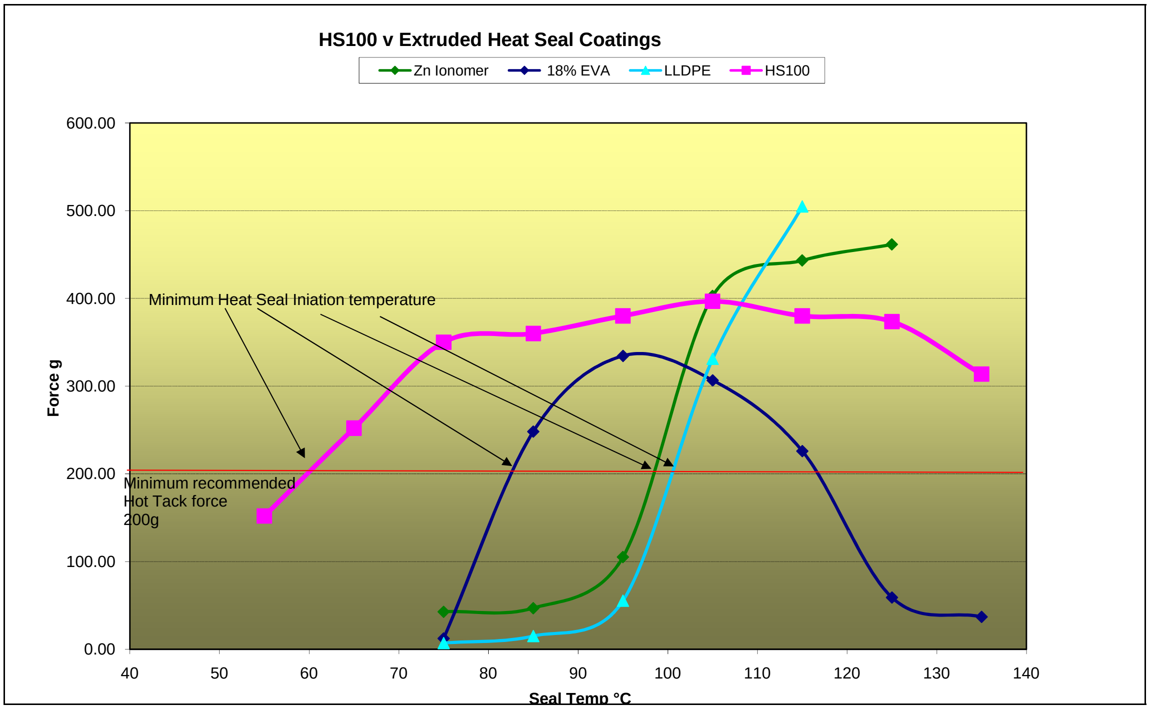


Table 2. SIT Values for Extruded Film Samples

Coating	Seal Initiation Temp °C (°F)
BOPP/ 1 gsm HS100 from water	60 (140)
18% EVA extrusion	82 (180)
Zn Ionomer extrusion	99 (210)
LLDPE extrusion	102 (216)

Key: NM = Not Measured

Keeping in mind that we are comparing 15µ of the extruded sealants to 1µ of HS100, we observed the following from the hot tack profiles shown in figure 3.

- EVA comparison: The seal initiation temperature of HS100 is 60C, which is significantly lower than the others in the series. The next lowest SIT is EVA, which is 22°C higher than HS100. Note that EVA hot tack strength decreases with elevating temperature and exhibits failure beyond about 117°C. HS100 does not exhibit this heat sensitivity.
- Ionomer and LLDPE comparison: These resins also exhibit much higher SIT temperatures compared to HS100, though once they have reached the threshold,

the hot tack is very high. HS100 provides better hot tack at much lower temperatures, which may enable higher line speeds.

LOOKING AHEAD

We see this technology as a way to promote source reduction by enabling converters to down gauge structures. Relatively thin layers of solution-applied heat seal coatings can be a promising alternative to heavier coat weights of sealants applied via (co-)extrusion coating or film/film lamination. For example, 1 - 2 µm of aqueous coating may serve as substitute for 10 – 16 µm of extruded sealant resin or a 25 µm sealant film lamination for less demanding niche applications such as dry snacks, bland powders and inert non-food contents.

There may be additional benefits in capital asset utilization. Compared to extrusion coating, shorter campaigns are more cost efficient when accomplished with gravure or flexo coating. Further, the aqueous heat seal coating alternative opens up opportunities for converters who do not have extrusion coating capabilities to apply sealants to web stock.

SUMMARY

This presentation described a new, high performance, aqueous heat seal coating for film. The coating exhibited substrate adhesion without requiring a primer, a low SIT, broad heat seal temperature range and high hot tack strength to allow versatility on packaging machinery. Further, it was formulated for good machinability, as measured by low COF and broad heat seal window, and is compliant for food contact applications.

This material may find utility as a primerless substitute for existing EAA, acrylic or PVdC coatings, or as an alternative to heavier layers of extruded sealant resins.

APPENDIX Hot Tack Sample Preparation and Testing

The aqueous coatings tested in this study were all cast from water based solutions onto BOPP film, dried, and allowed to age over one week under ambient conditions prior to testing. EAA, acrylic and PVdC all required a primer for adhesion to the substrates. Coated samples were prepared by corona treating the substrate, priming, drying, coating and drying again. HS100 did not require a primer and was applied in a single pass to corona treated film. We assigned the minimum seal initiation temperature as the point where the force to peel apart the heat sealed interface equaled 200 grams. Hot tack tests results are specific to the machine on which the samples were tested. We tested according to ASTM F1921-98 with a HT-IXS machine, flat jaws, both heated, 200 mm/sec peel speed.