Adhesives for sanitary napkins

Winifred Dabroski

Positioning adhesives must provide a balance between secure hold and easy removal.

There are two types of adhesives used in sanitary napkins:

- Construction adhesives—tie the various pad components into a unified product.
- Positioning adhesives—hold the pad in place against the panty.

Construction adhesives

Construction adhesives hold the barrier, cover, and absorbent material together to make a unified product. These adhesives have little or no tack and can be water based or hot melts.

The requirements for construction adhesives are much less than for positioning adhesives. The construction adhesive must adhere to the materials it is holding together and have enough "open time" (green strength) to allow for a good bond. It also must be compatible with the process and pass medical safety tests.

The water-based adhesives include polyvinyl acetate, ethylene vinyl acetate (EVA), and acrylic in homopolymer or copolymer form. These adhesives can be sprayed or extruded. They may require thickeners, antifoam, or wetting agents, depending on the desired method of application, wetting, penetration, etc. Addition of plasticizers to increase softness or flexibility is to be avoided, since plasticizer migration can affect the integrity of the positioning adhesive. Softness and flexibility are obtained through polymerization.

The chief advantage of water-based adhesives is the inexpensive application equipment, which allows direct cycling of the adhesive onto the polyethylene (PE) or polypropylene barrier without distortion. The main disadvantage is the addition of water to the napkin, which could promote bacteria and mold growth, especially if the napkins are packaged in plastic pouches and bags. In addition, processing can be a problem, especially in the case of clogged nozzles caused by the encrustation of the polymer.

Hot-melt construction adhesives include EVA, block copolymers, and polypropylene. These are sometimes formulated with resins, waxes, etc., to obtain the properties needed for adherence, open time, and processibility.

Spraying and slot-coating extrusion are the main methods of hot-melt application. The adhesive can be sprayed directly on the PE or polypropylene barrier without destroying barrier integrity. Slot coating onto the low-melting barrier material requires the use of chill rolls or other means of cooling the adhesive after application to prevent burn through of the barrier.

The main disadvantage of spraying is overspray beyond the edge of the target area. This problem has been reduced through developments in spray technology over the past few years. The major suppliers of spray systems include Meltex, Nordson, Mercer, Spraymation, and Accumeter.

Positioning adhesives

Positioning adhesives can be either water based or hot melt. Solvent-based adhesives are not suitable because heat is required and residual solvent can be a health hazard.

Acrylic pressure-sensitive adhesives are the main water-based adhesives. Acrylics can be polymerized to give a broad range of properties and are hypoallergenic. The polymerized adhesives usually do not require compounding with antioxidants, resins, etc. The level of tack and adhesion can be adjusted through polymerization of long- and short-chain monomers or by mixing polymers of high and low molecular weight.

The polymerization approach is better, since separation of the mixed polymers can leave a residue from the low-molecular-weight component on the undergarment. Molecular weight of the polymer is also a factor in obtaining cohesive strength to prevent transfer of the adhesive. High molecular weight improves shear but reduces tack, as shown in **Table I**.

Alkyl acrylates and methacrylates containing 4–17 carbon atoms are the monomers most often used for pressure-sensitive adhesives. The commonly used monomers are ethylhexyl acrylate, butyl acrylate, ethyl acrylate, and acrylic acid. Vinyl acetate is sometimes used to reduce the cost of the adhesive.

There are some good acrylate adhesives suitable for use as a positioning adhesive, but they contain 40–50% water. The added moisture in the pad can promote growth of bacteria and mold in the napkin, especially if packaged in a plastic pouch or bag.

Hot-melt adhesives are preferred because they can be formulated to provide a wide range of properties. They are 100% solid and leave no solvent or moisture residue. Depending on the formulation, these adhesives pose no

Dabroski is a senior product development engineer at Personal Products Co., Van Liew Ave., Milltown, N.J. 08850.

I. Shear and tack for low- and high-molecular-weight polymers

Molecular weight	Shear, lb/in.^{2}	Probe tack, GMS
600,000-800,000	4.6	130
200,000-450,000	2.8	190

II. Comparison of adhesives made from D and G polymers

Adhesive[a]	Shear,[b] lb/in.^{2}	Transfer
Kraton D 1107	1.2	Yes
Kraton G 1652	3.8	No

[a] Aged 6 months, 100°F.
[b] Tested on cotton.

III. Typical formulation for positioning adhesive

Ingredient	Parts by weight
Block copolymer	15
Polyterpene resin	55
Naphthenic oil	28
Pigment dispersion	1
Antioxidants	1

IV. Removal force for thick and thin pads with identical positioning adhesive

Napkin type	Removal force, oz.
Maxi	44.0
Thin maxi	25.6

V. Removal force for various fabric types

Fabric	Removal force, oz.
Cotton	30
Nylon	52
Lycra	50
Cotton/polyester	44

health hazard.

The polymers used most frequently are Kraton® thermoplastic rubbers, which are based on three types of block copolymers. These are styrene-butadiene-styrene (S-B-S), styrene-isoprene-styrene (S-I-S), and styrene-ethylene-butylene-styrene (S-E-B-S). The polystyrene occurs in two blocks, one on each end of an elastomeric material. The S-B-S and the S-I-S make up the Kraton D series, and the S-E-B-S makes up the G series.

The polymers in the D (1100 series) have an elastomeric midblock that is unsaturated. Kraton G (1600 series) has an elastomeric midblock that is a saturated olefin rubber. The G polymers possess better heat-degradation resistance and cohesive strength than the D polymers.

The adhesives made from the G polymers perform better during manufacture and in use. Cohesive breakdown does not occur at room- or high-temperature aging. Adhesives based on D 1107 tend to break down cohesively on aging. **Table II** shows shear and transfer for adhesives made with D 1107 and G 1652 with identical resins, oils, antioxidants, and aging. **Table III** shows a typical formulation for a positioning adhesive.

Considerations in choice of positioning adhesive

Tack, peel, and shear are not the only variables to be considered when choosing a hot-melt pressure-sensitive positioning adhesive for use in sanitary napkins. The substrate (material on the back of the pad), adhesive pattern, pad thickness, perfume additions, method of application, aging characteristics, material and design of the panty to which the pad will adhere, and medical safety all must be considered.

Substrate

The adhesive must be firmly anchored to the material on the back of the pad. Common substrates include perforated and nonperforated PE or polypropylene as well as nonwovens consisting of rayon, polyester, polypropylene, and fusible fibers.

Adhesive patterns

The strength and temperature resistance of the cover material on the back of the napkin is an important factor in choosing an adhesive pattern. The type of adhesive and the pad design are also important factors.

Adhesive patterns range from complete coverage of the back of the napkin to less than 50% coverage. Adhesive is applied in one or more lines, commonly 0.125-, 0.25-, 0.5-, or 1-in. in width. These lines are shorter than the length of the pad.

The perforated PE substrate has the lowest tensile strength and the least heat resistance. Thus it has the widest adhesive line (complete coverage). This pattern provides a thin layer of adhesive over a greater area for adherence to the panty and distributes the removal forces evenly so the adhesive does not transfer and the pad does not tear. Two 0.125-in. and two or three 0.25-in. lines are used on nonperforated nonwovens and on 1-1.5-mil PE and polypropylene.

The advantage of multiple lines is the ability to attach to a wider area without increasing the adhesive weight. Also, the forces and stresses associated with normal body movement are distributed better than they would be with a 0.5- or 0.75-in. single line. The improved distribution of forces reduces the chance of transfer and tearing by the adhesive.

Napkins with wings have small squares of adhesive on each wing to hold them to the panty. The area covered by adhesive on Japanese napkins is considerably less than other napkins. Some have a rectangle 0.375 in. × 1.5 in. on each end only. This pattern holds the napkin because tight-fitting panties are sold for napkin use. With improved methods of application and pad designs, the adhesive pattern can and will be varied.

Pad thickness

The force needed to remove the pad is affected by pad thickness. For two pads with the same adhesive, the removal force is higher for a thick pad than for a thin pad. The thicker pad has a larger area under stress, which increases the removal force. **Table IV** shows the removal force for thick and thin pads.

Oil resistance

Some pads contain perfume. Adhesives for these products must be able to resist the plasticizing effect of migrating oils. Such oils can reduce the adhesive's cohesive strength, causing it to transfer to the undergarment. Higher-viscosity adhesives are usually more resistant to oils.

Adherence

A good positioning adhesive must adhere to both the napkin material and the panty. Adherence to the panty must be secure under light pressure, and the adhesive must be sufficiently cohesive so that there is no residue left behind when the pad is removed. The adhesive must conform to the surface of the panty material and possess enough elastic cohesiveness to resist flow under stress.

Consumer

The adhesive must be capable of sticking to a wide variety of undergarments, including pantyhose as well as briefs and bikinis made from cotton, stretch cotton, polyester, nylon, Lycra®, terry cloth, and blends of these fibers. It also must separate cleanly from the garment. Some of these fabrics and designs create higher shear forces than others.

For instance, in the case of stretch cotton, the pad is applied to a stretch fabric that is in a relaxed mode. As the panty stretches, the adhesive is subjected to high shear forces. If the shear of the adhesive to the cotton is lower than these forces, the pad will move and possibly fall off. The type of fabric affects the removal force, as shown in **Table V**.

Heat degradation

The selection of a pressure-sensitive adhesive depends in part on the method of melting and applying the adhesive to the pad. Heat degradation can be a problem in the melt phase unless there is an understanding of the adhesive's heat history. Conditions must be maintained to achieve an acceptable heat history.

Heat degradation is caused by oxidation, polymer degradation, or subsequent polymerization. The signs of degradation are color changes (becoming darker), viscosity changes (increase or decrease), phase separation (two or more layers), gelling (particles), and loss of cohesive and bond strength. Time and temperature are the processing variables with the greatest effect on degradation. **Figure 1** shows the effect of time at temperature on viscosity for a typical adhesive.

Melt process

There are several ways to liquefy hot-melt adhesives. The most common are heated tanks holding 30-60 lb of adhesive and drum unloaders, which are designed to handle either 5-gal or 55-gal containers.

Heated tank. Most tanks heat with a grid, so the adhesive is not at the same temperature throughout the tank. The temperature needed for application is at the lower grid. The adhesive at the upper grid is melted, but at a lower temperature. This approach prevents the whole tank from charring if the machine is down for a long period of time. Prolonged heating at the lower grid can cause degradation, and the temperature should be decreased to prevent char when the machine is down for a long time. Degradation also can occur when the process temperature is too high for the material's heat history. This can happen by setting the temperatures too high or if the tank temperatures are higher than the indicator reads.

Running the adhesive cooler is not the way to eliminate or reduce degradation. Processing the adhesive at below-optimum temperatures will affect the viscosity, which will affect the wet out and penetration of the adhesive into the substrate. This, in turn, will reduce the bond and possibly cause adhesive transfer. The viscosity of some adhesives drops dramatically with small changes in temperature, as seen in **Fig. 2**.

The best way to avoid degradation during the melt process is:

1. Educate operators on the proper adhesive melt and application temperature as well as the operation of the equipment.
2. Set temperatures for adhesive processing conditions, keeping in mind the heat history of the adhesive.
3. Keep the temperature indicators in good working order. Check periodically with a calibrated pyrometer.
4. Keep the tank and applicator clean and clear of char.
5. Do not mix adhesives without checking for compatibility.
6. Avoid prolonged heating of adhesive when not in use.
7. Keep lid on tank to reduce smoking.

Drum unloader. The drum unloader pumps the adhesive as it melts, minimizing exposure to the air and melting only what is needed. The bulk of the hot melt is not heated if the coating equipment is down.

The drum unloader consists of a heated platen, which rapidly melts a thin layer of adhesive that is pumped immediately to a small heated reservoir or directly to the applicator. As the adhesive is used, the platen moves down and melts the next layer of adhesive. Purchasing hot melt in drums reduces the cost and is not as labor intensive as hot-melt cakes or pillows. None of the adhesive is wasted, since the layer of hot melt at the bottom of the drum is removed and placed on the top of the next drum.

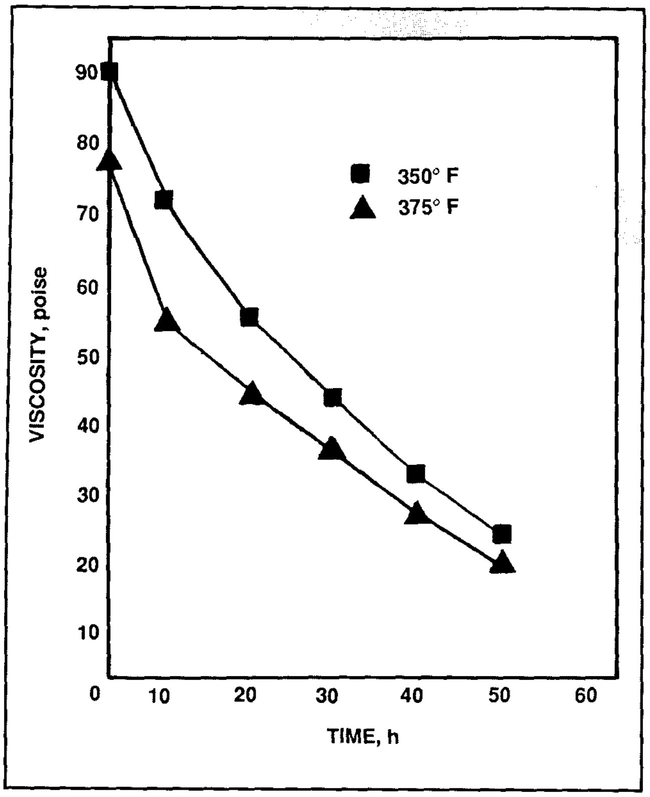
Application systems

Application systems include slot nozzles, spray, and print roll.

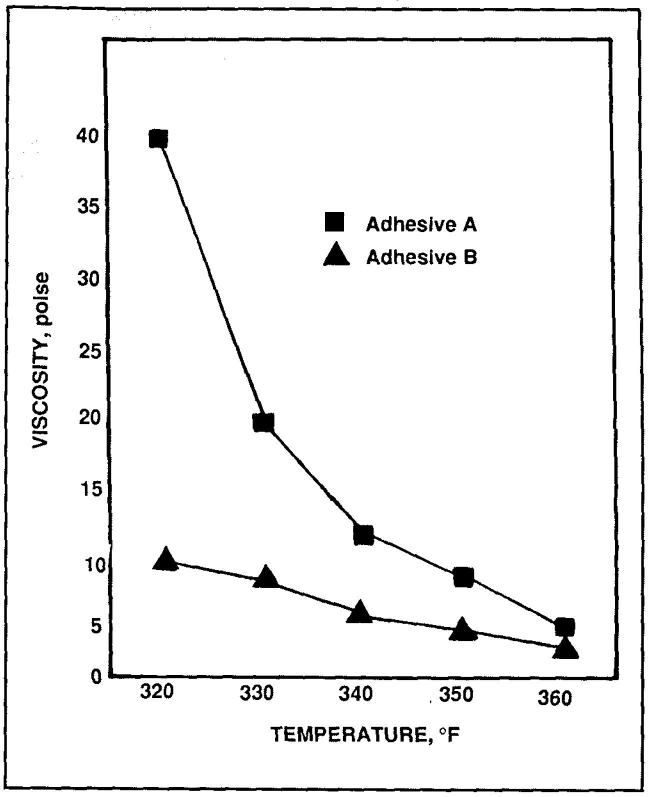
Slot nozzle. One or more slot nozzles can lay down adhesive in continuous or intermittent lines in various shapes. The slot nozzle extrudes melted adhesive from a reservoir in the body of the applicator. The adhesive is pumped through a thin orifice, and the high shear caused by the flow through the slot reduces the viscosity (shear thinning). The viscosity reduction is due to the non-Newtonian nature of the adhesive.

The coating head must maintain a constant temperature with good heat distribution. A head with hot and cold spots

1. Adhesive viscosity as a function of time at two levels of temperature



2. Adhesive viscosity as a function of temperature for two adhesives



will cause the viscosity to vary. Viscosity is very sensitive to temperature, as seen in Fig. 2. An adhesive that is applied at a low temperature and high viscosity will not wet or penetrate the surface, and the lines will have skips.

Adhesive can be coated directly or coated on release paper and then transferred to the pad. Penetration and anchorage of the adhesive is easier with direct coating. However, the uneven thickness of direct-coated adhesive makes this method unsuitable for high-speed application. Adhesive is usually applied through transfer from release paper to the substrate. The release paper has a smooth surface and a uniform thickness.

Again, temperature control of the applicator is very important. The adhesive is laminated to the substrate, and if the adhesive is too cool, it will not penetrate. If the laminating pressure is raised to compensate for cool adhesive, the release paper may wrinkle. There is a balance of temperature and pressure. Too much pressure on a hot adhesive can damage the barrier and/or leave too little adhesive on the surface of the pad.

Spray. Current spray methods use heated air to elongate and orient a filament of adhesive. The Nordson spray device swirls the filament to form even circles. The Meltex device provides a more elliptical pattern.

There are spray patterns from dots to fine filaments that can be applied in an array of patterns. Viscosity, high elasticity, and cohesive strength are probably the adhesive parameters with the greatest effect on sprayability.

Print roll. The print roll is just that, a roll with a pattern on it. The roll revolves in a reservoir of hot melt and prints the design etched on the roll as it contacts the substrate. The problem with this method is clean application of the adhesive, especially if the pattern has any depth. The most important adhesive characteristic for this process is cohesive strength. With sufficient cohesive strength, the adhesive will stick together for complete removal.

Conclusion

Sanitary napkins contain two types of adhesives. Selection of an appropriate construction adhesive is fairly straightforward and is determined, to a large extent, by the manufacturing process. The requirements for the positioning adhesive that holds the pad in place during use are much more rigorous. Positioning adhesives are subjected to substantially higher stresses than construction adhesives. In addition, the positioning adhesive must be able to adhere to a wide variety of materials and be sufficiently cohesive so that no residue is left behind when the device is removed. The best positioning adhesives are based on S-E-B-S block copolymers.☐

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