Pressure-sensitive adhesives (PSAs) are materials which in dry form are aggressively and permanently tacky at room temperature and firmly adhere to a variety of dissimilar surfaces upon mere contact without the need of more than finger or hand pressure. They are widely used in familiar, everyday products such as masking tapes and office tapes, finger bandages and labels.

The true PSA does not require activation by solvents or heat and adheres firmly to a wide variety of surfaces. Despite their aggressive tackiness, "they can be handled with the fingers and removed from smooth surfaces without leaving a residue."1

The earliest commercial PSAs of importance were blends of natural rubber (NR) and wood resins.2 The rosin, subsequently categorized as a member of a class of materials called tackifying resins, imparted to the rubber the necessary degree of tackiness. With the NR/rosin blends, largely in response to a need for masking parts to be protected in painting operations, the PSA industry had its origins. In time other elastomers were utilized and the original wood resins were chemically modified to provide a large variety of tackifiers. Hydrocarbon-based tackifiers were added and other elastomeric polymers, particularly polyacrylates, came into use after World War II.

The availability of PSAs with improved properties led to an explosive growth in their use. From a post-World War II value of less than $100 million the industry has expanded to a current dollar volume, at the manufacturer's level, of about $3 billion.3 Tapes account for roughly 60% of this market, with labels, including decals, taking about 30%. The remainder is utilized for decorative and protective sheets, sanitary napkins, floor tiles, various medical applications, sun control films, EMI shielding and numerous specialty items. The PSA market additionally requires a significant dollar volume of release coatings, to provide surfaces to which the PSA has low adhesion for handling and transfer of products.

Originally PSA products were manufactured by drying a solution of the adhesive on a suitable backing. In the 1970s, in response to cost increases in solvents and regulatory restrictions regarding emissions, the industry turned to water-based (emulsion) PSAs and 100% solid compositions or so-called hot melt pressure-sensitive adhesives (HMPSAs). These market forces have had a profound effect on the selection of PSA materials.

Although rubber-based adhesives still constitute the largest component of the PSA market, NR has been supplanted by the styrene-isoprene-styrene (S-I-S) block copolymers as the dominant hydrocarbon elastomer in this category because, to a large extent, the S-I-S

1. Skeist (ed.), Handbook of Adhesives
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polymers lend themselves to hot melt formulations; in contrast, NR adhesives are still mostly solvent-based. The utilization of latex vehicles based on hydrocarbon elastomers is still relatively minor and is largely restricted to styrene-butadiene emulsions and some natural rubber latex. However, in the case of acrylic PSAs, emulsions now surpass solution adhesives in volume consumed.

These trends are expected to continue, with water-based and hot melt formulations gradually supplanting solution polymers. A newer technology, radiation polymerization or cure of PSAs, at present is of minor industrial importance, although at least two of the major producers of PSA products are reported to operate manufacturing lines utilizing electron beam radiation. UV radiation use may grow in time.

**CONSTRUCTIONS**

Pressure-sensitive products basically consist of an adhesive coated on a backing or carrier. Most often the backing is a flexible film, foil, or fabric, although many products utilize rigid supports or have the adhesive directly coated onto the form or object that is to be bonded to another surface. A typical construction is shown in Fig. 1.

**Manufacture**

PSAs are applied to backings in several ways depending on the nature of the adhesive. Solutions or latices are coated on a moving web of backing or release liner, in a continuous operation including drying in an oven. If the adhesive is coated on a release paper or liner, it can be subsequently laminated or transferred to the desired backing and the liner retained or removed. Hot melts, or 100% solid adhesives, are applied to the backing using either a hot melt coater, a calendar, or an extruder. For most purposes the final coating is relatively thin, of the order of 2–3 mils in thickness, but it may be as thick as 12 mils. In general, the 100% solids adhesive lend themselves better than solutions or latices to heavier coatings.

**Drying Lines.** Oven drying lines represent large capital investments, of the order of several million dollars, and the same line is frequently used to handle both solutions and latices. The metering equipment may be either reverse roll coaters, which offer maximum flexibility, or knife-over-roll coaters, which are less expensive. For thin films a wire-wound rod to remove excess material can be used. Because of coating difficulties encountered with latex vehicles such devices as an air knife or flexible blade are sometimes used with these products.

Coating of tapes is often directly onto the backing. Label adhesives, in contrast, are always coated on a release liner which is then laminated (nip rolls) to the paper or other backing and used or sold in this construction.

The drying step of necessity must be relatively slow to avoid bubbles, etc., and the web speed in commercials ovens is usually restricted to 25–50 yards per minute. Hot air ovens are the most common type of dryer, although the air flow is often supplemented by infrared heating. For solvent operations the modern oven either incinerates the solvents, for fuel value, or permits recovery of the solvent by condensation or by absorption on activated charcoal. The energy requirements for drying latices are actually less than for solvents since less hot air is required; the air volume must be large to avoid an explosive concentration of vapors in the case of solvents.

In almost all cases the adhesive is coated on wide-width material and then slit into narrow widths for tapes, which are subsequently wound into rolls, or diced or otherwise cut into the shapes desired for other products.

**Hot Melt Coating.** HMPSAs are heated to achieve a bulk viscosity suitable for the equipment used and then conveyed to a roll-backed web. The term hot melt coater refers to equipment that has viscosity limitation, while an ex-