Providing Solutions in
Pressure-Sensitive Films

FLEXCON

WHITE PAPER

Adhesive Solutions to the Challenges of Bonding to Low Surface Energy Surfaces

FLEXcon has been an active participant in the design and manufacturing of pressure-sensitive adhesive (PSA) containing composites for over 50 years. These products range from material used for bumper stickers to the highly engineered PSAs used for sound damping or for bonding to low surface energy materials such as silicone rubber. The emphasis in this technical paper will be on the engineered PSAs.

Our engineered PSAs cover a wide variety of application requirements. They include adhesives that:

- meet aerospace, medical, and security requirements
- are designed to form a bond in sub-zero cold, or to maintain adhesion at temperatures in excess of 500°F (260°C)
- bond to low surface energy substrates
- resist "out gassing"
- respond to low frequency AC
- greatly resist dielectric breakdown
- act as a thermal insulator, or facilitate heat transfer
- are designed to lift a fingerprint, or can leave a fingerprint on the substrate if removed
- can be cleanly (no residue) removed
- can survive the strict requirements for LOCA (loss of coolant accident)
- can bond sound damping materials to the inner skin of aircraft, or can be the noise reducing component itself.

This paper will focus on adhesion to low surface energy substrates. Other papers on specific topics are available.

What is Surface Energy?

In liquids, the molecular layer at the boundary where the surface of one material meets a second material (such as liquid to solid, or liquid to air) is different than the constituent molecules beneath the surface. This difference is the result of an imbalance between the intermolecular forces. For example, a molecule of water beneath the surface is surrounded by other water molecules in the X, Y, and Z directions. The molecule of water at the very surface has no water on top. This imbalance causes the top water molecules to pull closer together (laterally). This phenomenon is referred to as "surface tension." Surface tension plays a role in water beading up on a freshly waxed car, water bugs walking on water, and people water-skiing.

A similar effect occurs in solids, but is often referred to as "specific surface energy" and is usually measured as a distortion of a drop of a liquid on the test surface of the solid in the form of a "contact angle" (see Figure 1).

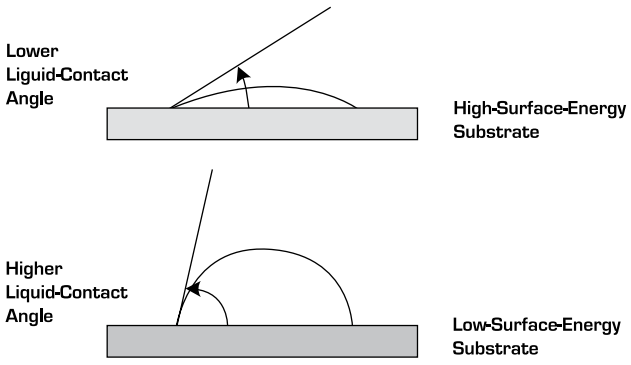

FIGURE 1

For a given liquid with its own surface tension properties, the lower the contact angles, the higher the specific surface energy of the solid material. Conversely, the higher the contact angle, the lower the specific surface energy of the solid material. Pressure-sensitive adhesives are viscoelastic liquids. As such, their degree of surface contact will depend on the specific surface energy of the substrate to which the adhesive is being applied.

A familiar demonstration of this principle is the ease of removal of the protective liner from a bumper sticker or band-aid. The liners are often silicone-coated. Silicones have very low surface energies, in the 22-24 dynes/centimeter (common units of surface energy) range, compared with most PSAs, which are between 30 and 36 dynes/cm. The silicone-coated liner presents a difficult surface for the PSA (a viscoelastic liquid) to make surface contact (or "wet-out"). This results in low adhesion to the liner — so low that these protective liners are often referred to as "release liners."

Figure 2 gives the "Specific Surface Energies" of some common materials. Note that materials such as the fluorocarbons and silicone, normally associated as "non-stick" surfaces, have very low specific surface energies and so are difficult to adhere to. Materials such as copper, aluminum, and tin, which have high specific surface energies, are generally known to be easy to adhere to.

FLEXcon Adhesives for Adhering to LSE Surfaces

Specific Surface Energies (in dynes/cm)		
Polytetrafluoroethylene (Teflon® *)		18.5
Polychlorotrifluoroethylene		31
Polyethylene		31
Polypropylene		31
Polystyrene		33-35
Polyvinyl chloride (rigid)		39
Polyvinyl chloride (V400-FW) (flexible)		33-38
Polyvinyl fluoride (Tedlar® *)		28
Polyvinylidenedichloride		40
Polyvinylidenedifluoride		25
Polyacrylamide		35-40
Polyacrylate (acrylic film)		35
Polymethyl methacrylate		33-44
Polyethylene terephthalate (polyester film)		38-42
Poly(6-aminocoproicacid)		43
Poly(11-aminoundecaroicacid)		33
Poly(hexamethylene adipamide)**		46
Poly(tetrafluoroethylene-co-chlorotrifluoroethylene)	80:20	20
	60:40	24
Poly(tetrafluoroethylene-co-ethylene)	50:50	26-27
Poly(tetrafluoroethylene-co-hexafluoropropylene	94: 6	19
	92: 8	18.3
	86:14	18.2
	84:16	18
	77:23	17.8
Cellulose (regenerated)		44
Poly (dimethyl siloxane)		24
Copper (dry)		44
Aluminum		45
Iron (dry)		46
Glass, soda lime (dry)		47
Silica, fused		78
Titanium dioxide (anatase)		91
Ferric oxide		107
Tin oxide		111
*Teflon and Tedlar are registered trademarks of E. I. DuPont Co. ** Different types of Nylons		

FIGURE 2

High-performance adhesives have become an increasingly important pressure-sensitive bonding solution, responding to market trends that not only include increased use of low surface energy plastics, but also:

- harsher end-use application environments
- unusual product shapes that require adhesion to curved surfaces

High-performance adhesives are an effective solution where a general purpose, removable, or aggressive adhesive cannot quite meet the demands of the application.

An important trait to keep in mind about a high-performance adhesive, however, is that it provides high performance for a specific function or in a specific environment. It is not necessarily a high performer in all situations. For example, FLEXcon offers high-performance adhesives specifically designed to withstand the service temperature extremes of automotive or electronic components. That same adhesive may not provide high performance in resisting the effects of, for example, long-term UV exposure or chemicals.

To establish the necessary "high performance" characteristic(s) and make an appropriate adhesive recommendation, FLEXcon asks a series

of questions to the Design Engineer or other knowledgeable application participant about the product on which the adhesive will be used. The questions include: What industry will the product be servicing? What is this product expected to do? What surfaces are receiving adhesives, and which surface will be receiving adhesive first? What is the size, texture, and shape of the application surface? Are there specific performance requirements, such as particular test method or spec? FLEXcon also asks questions related to environmental concerns, temperatures, type of equipment that will be used to process the product, and the processing concerns that the customer/converter has. This thorough analysis assures the most appropriate adhesive recommendation.

FLEXcon currently offers high-performance adhesives in its FLEXmount® line designed for meeting difficult bonding challenges.

V-778 is a permanent, highly aggressive acrylic adhesive ideal for use with low surface energy plastics such as thermoplastic olefin (TPO) materials. V-778 is an appropriate choice when applying gasketing and sealing products to products that are traditionally resistant to pressure-sensitive adhesives. V-778 can be used as an assembly aid during the attachment process in manufacturing. Further, it provides sealing properties when bonding two low surface energy plastics or other smooth products together.

V-478 is a permanent pressure-sensitive acrylic adhesive that is ideal for use with powder-coated painted surfaces.

V-483 fills the gap between regular solvent acrylic adhesives and silicone adhesives. In high temperature applications, where the temperature is not so high that a silicone adhesive is required, FLEXcon's V-483 can meet the need. V-483 is effective in harsh environments, including areas with wide variations in temperature, such as electrical fuse boxes as well as automotive and aerospace components. V-483 bonds well to metals as well as low surface energy and high surface energy plastics.

FLEXcon SA6000 Series are tacky silicone adhesives that provide the pressure-sensitive characteristics of traditional pressure-sensitive adhesives, but with the added benefit of continued performance in extremely low or high-temperature applications where acrylic adhesive performance would not suffice. The FLEXcon SA6000 Series includes product constructions developed for automotive, aerospace, electronics and other high-temperature applications.

FLEXcon can provide any of these adhesives in a format appropriate for the application — as a transfer tape, as a component of a single-coated protective product, or as part of a double-coated construction using an additional adhesive when it is necessary to bond two incompatible surfaces.

About the Author

Shirley Monte is a Business Development Manager for the Performance Products Business Team. Reach her at (508) 826-4646 or smonte@flexcon.com.

About FLEXcon

FLEXcon is an ISO 9001:2008 worldwide manufacturer of pressure-sensitive films and adhesives for applications including indoor and outdoor advertising, bonding/mounting, and product identification, safety, hazard, bar-coded, and primary labels. The company's Value-Better-Supreme (VBS) product offering is the most extensive standard product offering in the pressure-sensitive film industry. FLEXcon is also a leader in developing custom solutions to meet unique converting or application needs. FLEXcon's mission is to provide its customers the highest quality products with exceptional service. The company is headquartered in Spencer, Massachusetts, and has operations throughout North America and Europe, with distribution worldwide. For more information on FLEXcon, visit www.FLEXcon.com.