Low Energy Surface Plastic Adhesives

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The use of polypropylene (PP), polyethylene (PE), and other thermoplastic olefins is growing because of their low cost and excellent properties, durability, flexibility, and resistance to heat, moisture, and solvents. Unfortunately, some of the same properties that make these plastics attractive to designers also make them difficult to bond with adhesives, a preferred method of attachment. The problem is that LSE plastics have low surface energy rendering them (like Teflon). Surface energy is important because it influences the ability of adhesives to adequately wet plastic surfaces and create strong bonds.

The surface energy or wetability of a material is measured in dynes/cm (see Table 1).

Table 1: Relative Surface Energy of Materials

Material	Surface Energy (dynes/cm)	Contact Angle (degrees)
Copper	1,103	
Aluminum	840	
Glass	250 - 500	
Polycarbonate (PC)	46	75
Acrylonitrile Butadiene Styrene (ABS)	35	82
Polypropylene (PP)	30	88
Polyethylene (PE)	30	88
Polytetrafluoroethylene (PTFE)	19	120

Plastics with relatively high surface energy, acrylonitrile butadiene styrene (ABS) and polycarbonate for example, bond readily because they are easily wet by conventional adhesives. Properly prepared aluminum, with a surface energy of 840 dynes/cm strongly bonds with adhesives. Surface energy is determined by measuring the contact angle of a water droplet on the surface of a material (see Illustration below).

Contact angles greater than 90 degrees indicate lower surface energy, and a surface that is more difficult to wet. Contact angles less than 90 degrees indicate higher surface energy, a surface that is easier to wet. A surface producing a contact angle near 180 degrees would be very difficult to wet: the water in effect beads up, like water on your waxed car. A surface producing a contact angle approaching zero degrees is easily wet: the water forms a sheet. The better a liquid adhesive wets a material surface the more area it can cover. This has two beneficial results. Better wetting increases the attraction and interaction of reactive groups in the adhesive and the substrate, making a stronger chemical bond. Better wetting also promotes surface penetration, which fills in microscopic surface irregularities producing adhesive interlocks that make a stronger mechanical bond.

Achieving Better Adhesive Bonds

Surface energy, in terms of the performance of an adhesive, is a relative phenomenon. Ideally, the surface energy of a plastic should be 7 to 10 dynes/cm higher than the surface energy of an adhesive. Therefore, there are two ways to improve bonding with LSE plastics:

1. Raise the surface energy of the LSE plastic – This is usually accomplished by pre-treating LSE plastics with primers, flame, plasma, or corona discharge processes that change the surface chemistry of the plastic, rendering it wetable by conventional adhesives.

2. Lower the surface energy of the adhesive – A liquid or pressure-sensitive adhesive with a surface energy of 20 dynes/cm will spontaneously wet out LSE plastics with surface energies of 30 dynes/cm or more. With double-coated transfer tapes, tackifiers are added to the adhesive formulation to produce an aggressive bond.

Raising the surface energy of LSE plastics adds cost and time to assembly or production processes. Flame, plasma, and corona discharge treatments produce surface changes that may improve bonding, but often only for a limited time measured in minutes, days or weeks depending on the plastic.

LSE Plastics Adhesives

Pressure-sensitive adhesive technologies produce excellent structural bonding with many LSE plastics without the use of priming or other pretreatment steps. Toronto Stamp offers Decals with a "High Tack" adhesive suitable for applying to low energy plastics, styrene, painted equipment, smooth wood or plywood.

Surface Energy and Adhesive Wetting

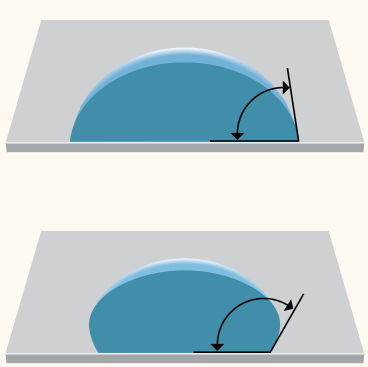

illustration 1: The water drop (top) has a contact angle less than 90 degrees indicating a substrate material with a higher surface energy. The drop (below) has a contact angle greater than 90 degrees indicating that the substrate material has a low surface energy.

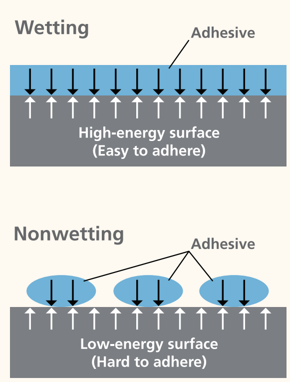

illustration 2: A high surface energy substrate (top) promotes wetting by the adhesive, which creates a stronger adhesive/substrate bond. The low surface energy substrate (bottom) impedes wetting and creates a weaker adhesive/substrate bond.

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