The Art of Strong Bonds

Surfaces. Bonding plastics poses a challenge because of the special problems associated with low-energy surfaces. While these can prove intriguing for researchers and users alike, they can be resolved successfully thanks to innovative adhesive technologies and high-performance bonding solutions.

Structural bonding of a polypropylene fan duct (figures: 3M)

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Polyolefins such as polyethylene (PE) and polypropylene (PP) are an integral part of industry because they offer numerous advantages over conventional materials such as wood and metal. Since they have so many varied applications, the choice of a suitable joining technique must be preceded by a thorough analysis of the application. Given the right adhesives, there is a variety of ways to connect thermoplastics to each other or to other materials. For bonding to low surface-energy plastics, the surface energy is of central importance. The choice of adhesive tapes, adhesives and labeling products is strongly linked to this factor.

Thus, polytetrafluoroethylene (PTFE) has a surface energy of just 18 mN/m. The figures for PP and PE range from 30 to 32 mN/m. Metals, by comparison, have values between 1,000 and 5,000 mN/m. In practice, this energy is mostly determined with the aid of special inks. On a low-energy surface, as in the case of PTFE or PE, the ink contracts. Even if the surface is cleaned first, an intact ink film is not formed. Many plastics manufacturers or suppliers today already provide information about the surface energy of their materials. Where they do not, the water-droplet test can be instructive. If a droplet forms, a low-energy surface can be assumed, whereas if the droplet spreads out, a high-energy material is indicated **(Fig. 1)**.

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Different factors need to be considered before low-energy surfaces are bonded. It is important inter alia to analyze the types of load that an adhesive bond is subjected to. In general, shear and tensile forces are not a problem, as the force is distributed over the entire surface. Where splitting and peel forces will occur, it is best to avoid them by means of a redesign, because the forces in such cases are distributed only over a small part of the adhesive surface **(Fig. 2)**. Furthermore, a bonded joint can be permanently impaired by dynamic alternating loads, vibrations or the effect of plasticizers in plastics. Also, many applications need to be resistant to cold, heat, weathering, UV radiation, or chemical agents such as solvents, acids and alkalis.

Reliable Bonding Even Without Pretreatment

Optimum preparation of the adherend surfaces is essential for proper bonding of →

plastics; the surfaces must be dry, free of dust, oil, release agents and other contaminants. This is the only way to reliably ensure that a high bond strength develops. Special pretreatment processes are additionally available for polyolefins and serve to boost the polarity, wettability, and surface energy of the material. The best known processes include corona, free-jet corona, low-pressure plasma, and atmospheric plasma treatment. Others are gas-phase fluorination and flame treatment.

However, any form of pre-treatment constitutes an additional technological process and increases the cost of bonding. Thanks to dedicated research, 3M, a multi-technology company, offers solutions that make costly pretreatment with primers or upstream physical processes a thing of the past. The focus in bonding is on low-energy surfaces, especially where adhesives and self-adhesive products are concerned. 3M's access to a variety of proprietary technology platforms goes a long way to supporting its ambition to provide an innovative adhesive solution for each new challenge. A positive side effect of this is that advances are often accompanied by more-productive and cost-efficient manufacturing processes in the industry. For that reason, the specific requirements of the bonding technique should be considered at project commencement.

Overcoming Strong Challenges

3M bonding technology is subdivided into specific product categories that have plenty to offer low-energy surfaces. Recommended products in the adhesives category are 3M Scotch-Weld DP 8005 (translucent/black) and 3M Scotch-Weld DP 8010 (white), which are acrylic, 2-part structural adhesives. These score points for the fact that they can be used to structurally bond PE and PP to each other or to other materials in applications that until recently were deemed to be unfeasible in the absence of surface pretreatment. The bonding of acrylonitrile-butadiene-styrene terpolymer (ABS), glass-reinforced plastics (GRP), polycarbonate (PC), PE, PP, and polymethylmethacrylate (PMMA) proceeds with a high strength build-up and a short processing time. Demand is particularly heavy for 3M Scotch-Weld DP 8005 in the automotive manufacturing and subcontractor industry. A PP fan duct bonded with this product is shown in the **Title figure**.

As soon as both parts of the adhesive have been mixed with one another, a chemical reaction occurs on the wetted surface of the material, generating a higher-energy surface. Elimination of the pretreatment step translates to significant time and cost savings. The work life for 3M Scotch-Weld DP 8005 is 2.5 to 3 min. After 2 to 3 h, the bonded materials can be processed further. Where larger areas require bonding, e.g. plastic sheeting or piping, a better alternative is 3M Scotch-Weld DP 8010, which has a longer open time of 10 min. It can be processed after 30 to 60 min. This adhesive is also suitable for bonding thermoplastic elastomers (TPEs). The specific requirements of polymers such as ABS, polyamide (PA), PC, and polyvinyl chloride (PVC), as well as elastomers such as ethylene-propylene-diene rubber (EPDM) and styrene-butadiene rubber (SBR) can also be met by 3M Scotch-Weld Cyanoacrylate adhesives.

Bonding with Double-sided Adhesive Tapes

Adhesive tapes are also good at adhering to low surface-energy plastics and powder coatings. An example of this is 3M's VHB high-performance adhesive systems that have been widely used for over 30 years in numerous construction applications and for production tasks within the plastics industry. Comprising a functional specialty adhesive on a foamed viscoelastic acrylic core, VHB adhesive tapes are eminently suitable for creating permanent bonds to low-energy surfaces. They can be stretched up to three times their thickness, without losing their bond strength, and they are resistant to UV radiation, weathering and many chemicals. The products are therefore ideal problem solvers in many industries. The VHB 5952 series of adhesive tapes is primarily designed for bonding to powder-coated surfaces. One example of this is the bonding of PE cable ducts to the powder-coated surface of a packaging machine **(Fig. 3)**. This application was requested by a specialty machine maker who wanted to use a cover

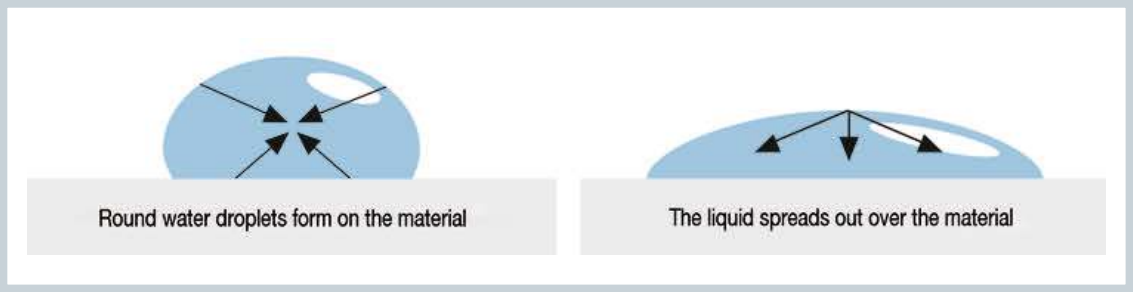

Fig. 1. The water-droplet test for determining a low-energy surface (left: low-energy surface; right: high-energy surface)

Fig. 2. a) Shear stress is across the adhesive bond. The bonded materials are forced to slide over each other;
b) Tensile stress is exerted equally over the entire joint and away from the adhesive bond;
c) Cleavage stress is concentrated at one edge and exerts a prying force on the bond;
d) Peel stress is concentrated along a thin line at the bond's edge. One surface is flexible

Fig. 3. PE cable ducts adhering to a powder-coated surface (right) by means of VHB adhesive tapes (left)

Fig. 4. Polyester films are ideal for grained (left), or textured, or velvety (right) substrates

to render cable strands invisible and to dispense with screws so as to protect the metal.

Adhesive Transfer Tapes and Polyester Films

Functional transfer adhesives, too, bond reliably to low surface energy plastics. Thus, film adhesives can be used from the roll in mechanical processes to make self-adhesive signage, front panels and membrane switches. The 3M 360 series of adhesive transfer tapes offers a combination of strong adhesion in this application and low adhesive coat weight, and is designed for quick and reliable bonding of substrates, such as ABS, PP, HDPE, LDPE or PA, as well as powder-coated and UV painted surfaces. Due to its excellent initial tack, this solvent-resistant adhesive transfer tape also makes for very fast processing.

Labels for application to demanding, textured plastic substrates can be ably implemented by films which are capable of withstanding high external stresses due to their high adhesive strength and flexibility. Thus, 3M Polyester Label Material 92200 was specially developed for plastic mixtures such as fiber-reinforced, filled PP and PA. The material is used inter alia to create injection molded surfaces which are currently in vogue. Particularly grainy, textured or velvety surfaces radiate an aura of high quality and are in high demand in the automotive industry. A corresponding application which illustrates the excellent adhesive power of the polyester film is shown in **Figure 4.**

Conclusion

Many plastics with low-energy surfaces can be bonded reliably without intensive pretreatment thanks to systematic research and advances in adhesives technology. The focus here is on customized application solutions. ■

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