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Promotion of Adhesive Polymer Bonding by Plasma Modification Using Defined Ambient Conditions and Process Gases

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Adhesive bonding technology is often the preferred solution for the joining of polymers. For improving the bond strength often a wet-chemical pretreatment has to be used to achieve sufficient adhesion strength and durability of the adhesive joint. Since several years, plasma treatment has been a proven method to attain these goals. However, conventional treatments in oxidizing gases such as air are often not satisfying. In this work, the polymers polypropylene (PP), polyvinylidene fluoride (PVDF), polyamide (PA6), polyoxymethylene (POM) and polycarbonate (PC) were pretreated by means of a plasma jet running at atmospheric pressure in a virtually oxygen-free atmosphere. The goal was the grafting of reactive nitrogen-containing functional groups on the plastic surfaces to increase the adhesive strength. For the detection of N-containing functional groups on the surface, chemical derivatization and X-ray photoelectron spectroscopy (XPS) were used. In addition, the effect of the plasma pretreatment on the surface free energy was determined using contact angle measurements. Furthermore, the stability of the pretreatment effect was investigated. The results showed that the functionalization of the substrate surfaces by means of atmospheric-pressure plasma in oxygen-free atmosphere (N_2) and by using small additions of H_2 (0.5 to 4.0 %, limited by safety considerations) can lead to a covalent bonding of the adhesive to the surface, resulting in a significant increase in joint strength. For example, the adhesive bond strength of PP increased from 0.2 MPa to 3.6 MPa. This improvement correlates with a decrease of the water contact angle from 101° to 32°. In the case of PVDF, PA6, PC and POM similar results were observed. Moreover, the adhesive bond strength was still high, even if the substrates were bonded four weeks after the pretreatment.

Keywords
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