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Improvement of polymeric material adhesion by UV laser and plasma pretreatment

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ABSTRACT

The objective of the presented work was to determine the relationship between acid-base properties and parameters of UV laser and plasma surface pretreatment of polymers to increase their adhesive strength. A further aim of the studies was the preselection of material combinations with good adhesion properties.

To achieve this objective the following tasks were solved:

- evaluating acid-base properties of polymer surfaces and adhesives using wetting methods;
- investigating the influence of low pressure plasma and UV laser pretreatment on the surface free energy, its components and parameters;
- selecting optimal modes and parameters for the pretreatment of polymer surfaces based on the acid-base approach for a targeted modification of surface properties;
- verifying the effectiveness of acid-base approach by evaluating the adhesive strength for various polymer systems and adhesives.

The appropriate modification of the polymer surface free energy and acid-base properties was carried out by two pretreatment methods - low pressure plasma and ultraviolet laser - in order to enhance the adhesive interaction in polymer-adhesive systems.

The ideal exposure modes and characteristics (threshold of ablation, fluence, frequency and number of pulses for UV laser pretreatment; processing power and treatment duration for plasma pretreatment) were determined for the optimal modification of surface properties.

For the evidence-based selection of the components to be joined, the surface free energy, its parameters and components, as well as the shortened acidity parameter (modification of the model E. Berger) were calculated for acrylic, methacrylate, polyurethane and epoxy adhesives. The same properties were also determined for the high performance polymers polyether ether ketone (PEEK) and polyphenylene sulfide (PPS), the fluoropolymers ethylene chloro trifluoroethylene (ECTFE), perfluoroalkoxy alkane (PFA) and polyvinylidene fluoride (PVDF), as well as for various types of bioplastics like polybutylene succinate (PBS), polyhydroxybutyrate (PHB), polylactide (PLA) and their copolymers.

For investigated polymers, a higher adhesive interaction correlating with an increase of the absolute difference in the shortened acidity parameter $\widetilde{D}$ of the used adhesive and polymer pretreated with low pressure plasma and UV laser was observed.

Experimental data on the surface free energy and the acid-base properties of polymers used in various adhesive systems were acquired. To evaluate these properties by the Berger method the use of the shortened acidity parameter was proposed, which allows measurements without the use of aniline and phenol. Improved mechanical properties of adhesive joints (shear and tensile strength, peeling force) were presented.

It was shown that the roughness of polymeric substrates could be altered by UV laser and plasma pretreatment. The increase in roughness achieved by these methods enhances the mechanical adhesion and showed no significant effect on surface wetting.

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