INVESTIGATION INTO THE EFFECT OF SURFACE TREATMENT ON THE WETTABILITY AND THE BONDABILITY OF LOW SURFACE ENERGY MATERIALS

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An experimental effort has been undertaken to examine the effect of surface treatment on various low surface energy thermoplastic materials to promote wettability and bondability of these substrates. Changes in wettability were followed by contact angle measurements. These measurements were correlated with the bondability of treated surfaces using a usual two-part epoxy adhesive. Air-plasma cleaning is a more effective treatment than the usual chemical-acid etching in increasing the surface energy of polymers to make them more wettable and bondable, except for polypropylene and for polytetrafluoroethylene. This work has enabled several satisfactory solutions for bonding these substrates by selecting suitable surface treatments and adhesives for each.
INTRODUCTION

The continuing increase in the use of thermoplastic materials has led to investigate the different means of joining them together. The use of adhesives offers many advantages when compared to other more conventional methods such as welding, riveting and bolting. A necessary, though sometimes insufficient, requirement for developing strong adhesive joints is the establishment of intimate molecular contact at the interface. Many theories or the mechanisms of adhesion are found in the literature. For adhesive joints, the adsorption and wetting theory is the most generally accepted one. Wetting may be quantitatively defined by reference to a liquid drop resting in equilibrium on a solid surface.

The main difficulty for bonding thermoplastic materials is due to their low surface free energies. Zisman and co-workers established that, for low energy solids and a series of liquids, a rectilinear relationship frequently existed between the cosine of the contact angle, \( \cos \theta \), and the surface tension of the wetting liquid, \( \gamma_{LV} \). He defined the critical surface tension of wetting, \( \gamma_c \), as the value to which \( \gamma_{LV} \) tends as \( \cos \theta \) approaches unity, i.e. as \( \theta \) approaches zero degree. Then he used the critical surface tension to characterize and compare the wettability behavior of low-energy surfaces.

Sharpe and Schonhorn proposed that the single most important factor influencing adhesive joint strength is the ability of the adhesive to spread spontaneously on the substrate. They developed a criterion for the case when the adhesive will spontaneously spread on the substrate and, using Zisman's critical surface tension concepts, proposed that the \( \gamma_c \) of the adhesive must be less than or equal to that of the substrate. When we look at the values of \( \gamma_c \) given in Table I, it becomes easy to understand why thermoplastic materials such as polyethylene and polytetrafluoroethylene are difficult to bond with usual adhesives.

However, other ways to characterize surfaces of low-energy materials exist and are reported in the literature. In these two articles, Mittal has reviewed and discussed the relationship between \( \gamma_c \) or other surface energetic parameters and joint strength.