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A comparative study of fibre/matrix interface in glass fibre reinforced polyvinylidene fluoride composites

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ABSTRACT

Due to the extreme chemical inertness and high thermal stability, fibre reinforced polyvinylidene fluoride (PVDF) composites have great potential for pipelines and vessels applications. In this study, surface properties of three differently sized glass fibres as well as a highly non-reactive thermoplastic PVDF and PVDF modified by maleic anhydride grafted PVDF (MAH-g-PVDF) 5 ppm have been studied. A Wilhelmy method was used to characterise wettability of glass fibre and matrices, and estimate surface free energy and fibre diameter. In order to understand acidic/basic surface functionalities and the effect of dissociated functional groups on glass fibre surfaces, zeta-potential plateau values and the position of isoelectric points were recorded by zeta-potential measurements. The results of water contact angles and zeta-potentials for MAH-g-PVDF indicated that the concentration of the dissociated acid groups in the matrix bulk was increased by grafting maleic anhydride, but remained roughly constant on the surface.

A single fibre pull-out technique was used for interfacial adhesion measurements. The results obtained for MAH-g-PVDF revealed the increased apparent interfacial shear strength by 135% and 75% for the acidic and basic surface fibre, respectively. No changes in interfacial shear strength in case of neutral surface glass fibre were observed. Therefore, better mechanical properties of composites can be achieved by improved interactions between acidic/basic surface glass fibre and MAH-g-PVDF matrix.

1. Introduction

It is well known that properties of fibre-reinforced composite materials largely depend on the nature and intensity of adhesive interaction between the matrix and fibre surface. To tailor composites having desirable properties, it is necessary to know mechanisms of the polymer–fibre adhesive contact formation and its behaviour under mechanical loading. The relationships between the surface properties of variously modified reinforcing fibres and the mechanical properties of composite materials conclusively exist, they, however, are as yet incompletely understood although several authors have reported a correlation between the surface energy, the surface chemical composition and the mechanical strength of the interface [1–4]. Proving such a correlation is of major practical interest: its existence would mean that an "ideal" reinforcing material – matrix pair obtained by optimising the surface properties then would show the expected strength as well. Besides the technological objective (for *adhesion technology*), the scientific goal (for *adhesion science*) would also be partly achieved, i.e., a quantitative description of interfacial phenomena in order to establish a link between the molecular attraction and mechanical properties of heterogeneous systems [5].

The first step in searching for such a correlation is a quantitative determination of the potential adhesion activity of given surfaces for both fibres and polymers. The philosophy [6] according to which a surface may be estimated to be inert, monopolar (acidic, basic) or bipolar (amphoteric) seems to be logical and reasonable. In our previous studies, glass fibres of various surface properties (sized and unsized ones) were investigated by means of inverse gas chromatography [7] and solvatochromisms [8] as well as the ageing effects of glass fibre sizing on adhesion of epoxy/glass fibre composites [9]. In other studies [4,10,11], the impact of epoxy matrix modification by polysulphone on the interfacial and mechanical properties of glass fibre composites with the same glass fibre sizing composition was investigated.

The present study aimed to investigate the interfacial adhesion in glass fibre reinforced composites by variation of both components–fibre surface and matrix. A highly non-reactive thermoplastic fluopolymer polyvinylidene fluoride (PVDF) and PVDF modified by maleic anhydride grafted PVDF (MAH-g-PVDF) 5 ppm were used as matrices commercial glass fibres with three different type of sizing compositions were used as reinforcing materials.

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