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Advanced carbon fibre composites via poly methacrylic acid surface treatment; Surface analysis and mechanical properties investigation

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ABSTRACT

In the present study the enhancement of fibre-matrix interfacial strength in carbon fibre composites was investigated via the electro-polymerization of poly methacrylic acid on commercially available carbon fibre fabrics. The surface modification of the fabrics was examined by means of Infrared (IR) and X-Ray photoelectron (XPS) spectroscopy whereas the surface morphology was studied via Scanning Electron Microscopy (SEM) and Atomic Force Microscopy(AFM). The wetting properties of the modified carbon fibres were investigated via contact angle measurements in single fibre and bundle specimens. For the mechanical performance assessment carbon fibre reinforced polymers (CFRPs) were prepared, via the vacuum resin infusion technique, using both modified and pristine fabrics and subsequently tested via macro scale mechanical testing. All modified composite specimens exhibited increased mechanical performance whereas the most optimum result was reported in Interlaminar Shear Strength (ILSS).

Keywords: Carbon Fibre, Polymer Composites, Delamination, Interface, Electro-polymerization

1. Introduction

Carbon fibre (CF) reinforced composites (CFRPs) have proven to be one of the most reliable composite materials with a wide range of applications, from automotive industry and aerospace applications to sports and leisure, due to their astonishing mechanical and physical properties, such as high strength and light weight (1, 2).However,because of the small active specific surface area, low energy and lipophobic surface, non-polar characteristics and chemical inertness, carbon fibre surface exhibits weak interfacial adhesion, consequently stresses are not adequately transferred from the matrix to the reinforcing fibres, and thus mechanical integrity by means of toughness, longitudinal, and transverse strength remain questionable(3, 4). Therefore, most CFRPs exhibit a tendency to fail in the fibre-matrix interface as a result of weak physical bonding, thus exposing the fibre from the matrix (pull out effect). This phenomenon can significantly reduce the overall mechanical properties of the composite such as the interlaminar shear stress (ILSS). Various surface treatment techniques have been utilized to address this issue; e.g. gas and liquid oxidation plasma treatment as well as electrochemical methods. However, the optimum surface treatment should induce sufficient bonding between fibre and matrix to a certain extent since extreme bonding in the interface could result to brittle CFRP behavior (5). A proper engineered interface is crucial to assure the required load transfer from matrix to reinforcements; this will facilitate the relief of internal stress concentrations while improving mechanical integrity and environmental stability of composites efficiently (6).