Studies on Recycling of Carbon Fibers from Carbon Fibers-Reinforced Plastics and Their Mechanical Interfacial Properties

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Abstract

The world-wide demand for carbon fibers-reinforced plastics (CFRPs) is growing rapidly due to the applications for renewable energy systems, aerospace, and automotive. According to the statistics, the world-wide market value for CFRPs was approximately 25 billion USD in 2013 and this number is expected to double in 2022, indicating a growth rate of over 7.6\% per year. The increasing requirement of CFRPs has raised an environmental and economic awareness among researchers for the need to recycle the CFRP waste materials in a suitable way.

In order to obtain high quality recycled carbon fibers (R-CFs), CFRP wastes were pyrolysed with super-heated steam in a fixed bed reactor for varying reaction times. The mechanical and surface properties of the R-CFs were characterized with a single fiber tensile test, interface shear strength (IFSS), scanning electron microscopy, and X-ray photoelectron spectroscopy (XPS). The surface analysis showed that there was no matrix char residue on the fiber surfaces. In addition, from the XPS results, the contents of the oxygen-containing functional groups increased after pyrolysis in steam which improves the physicochemical interaction between the CFs and the resin matrix. The tensile strength and IFSS values of the R-CFs were significantly enhanced compared to those of virgin carbon fibers (V-CFs). The recycling efficiency of the R-CFs from the composites were strongly dependent on the pyrolysis temperature, reaction time, and super-heated steam feeding rate.

The ‘TrCF-550-60’ retained about 90.42\% of its tensile strength, which was the highest value among the obtained clean carbon fibers (CFs), compared to that of the virgin carbon fibers (V-CFs). In addition, from XPS results, the contents of the oxygen-containing functional groups increased (more than 15 \%) after pyrolysis in steam and air which improves the chemical activity between the CFs and the resin matrix.