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A Simple Chemical Approach to Regenerating Strength of Thermally Recycled Glass Fibre

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Abstract : Glass fibre is currently used as reinforcement in over 90% of all fibre-reinforced composites produced. The high rigidity and chemical resistance of these composites are required for optimum performance but unfortunately results in poor recyclability; when such materials are no longer fit for purpose, they are frequently deposited in landfill sites. Recycling technologies, for example, thermal treatment, can be employed to address this issue; temperatures typically between 450 and 600 °C are required to allow degradation of the rigid polymeric matrix and subsequent extraction of fibrous reinforcement. However, due to the severe thermal conditions utilised in the recycling procedure, glass fibres become too weak for reprocessing in second-life composite materials. In addition, more stringent legislation is being put in place regarding disposal of composite waste, and so it is becoming increasingly important to develop long-term recycling solutions for such materials. In particular, the development of a cost-effective method to regenerate strength of thermally recycled glass fibres will have a positive environmental effect as a reduced volume of composite material will be destined for landfill. This research study has demonstrated the positive impact of sodium hydroxide (NaOH) and potassium hydroxide (KOH) solution, prepared at relatively mild temperatures and at concentrations of 1.5 M and above, on the strength of heat-treated glass fibres. As a result, alkaline treatments can potentially be implemented to glass fibres that are recycled from composite waste to allow their reuse in second-life materials. The optimisation of the strength recovery process is being conducted by varying certain reaction parameters such as molarity of alkaline solution and treatment time. It is believed that deep V-shaped surface flaws exist commonly on severely damaged fibre surfaces and are effectively removed to form smooth, U-shaped structures following alkaline treatment. Although these surface flaws are believed to be present on glass fibres they have not in fact been observed, however, they have recently been discovered in this research investigation through analytical techniques such as AFM (atomic force microscopy) and SEM (scanning electron microscopy). Reaction conditions such as molarity of alkaline solution affect the degree of etching of the glass fibre surface, and therefore the extent to which fibre strength is recovered. A novel method in determining the etching rate of glass fibres after alkaline treatment has been developed, and the data acquired can be correlated with strength. By varying reaction conditions such as alkaline solution temperature and molarity, the activation energy of the glass etching process and the reaction order can be calculated respectively. The promising results obtained from NaOH and KOH treatments have opened an exciting route to strength regeneration of thermally recycled glass fibres, and the optimisation of the alkaline treatment process is being continued in order to produce recycled fibres with properties that match original glass fibre products. The reuse of such glass filaments indicates that closed-loop recycling of glass fibre reinforced composite (GFRC) waste can be achieved. In fact, the development of a closed-loop recycling process for GFRC waste is already underway in this research study.

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