Fracture Behaviour of Rubber- and Silica Nanoparticle-Toughened Glass Fibre Composites under Static and Fatigue Loading

Shamsiah Awang Ngah, Ambrose C. Taylor

PII: S1359-835X(18)30069-1
DOI: https://doi.org/10.1016/j.compositesa.2018.02.028
Reference: JCOMA 4942

To appear in: *Composites: Part A*

Received Date: 3 August 2017
Revised Date: 12 February 2018
Accepted Date: 18 February 2018

Fracture Behaviour of Rubber- and Silica Nanoparticle-Toughened Glass Fibre Composites under Static and Fatigue Loading

Shamsiah Awang Ngah[1,2], Ambrose C. Taylor[1]*

1. Department of Mechanical Engineering, Imperial College London, South Kensington Campus, London SW7 2AZ, UK.

2. Present address: Department of Architecture and Civil Engineering, University of Bath, Bath BA2 7AY, UK.

*Corresponding author: Email: a.c.taylor@imperial.ac.uk Tel: +44 20 7594 7149

Abstract

The crosslinked polymers used in fibre composites are very brittle, and require toughening for structural applications. Research over many years has increased the fracture energy, but the fatigue resistance of these toughened polymers is very poor, limiting the optimisation of structures. This work reports the first successful use of hybrid toughening to increase both the quasi-static interlaminar fracture energy, G_{IC}, and the fatigue threshold strain-energy release-rate, G_{th}. Amine-cured epoxy glass-fibre composites were toughened using carboxyl-terminated butadiene-acrylonitrile (CTBN) which forms micron-sized rubber particles and 20 nm-diameter silica nanoparticles. The toughening mechanisms were identified as cavitation of rubber particles and debonding for the silica nanoparticles, followed by plastic void growth. The CTBN greatly increases G_{IC}, and the nanoparticles increase G_{th}. Combining both particles as a hybrid has a synergistic effect on the fatigue resistance. This demonstrates the effectiveness of hybrid toughening, enabling the design of optimised composites by combining micro- and nanoparticles.

Keywords:

A: Glass Fibres; A: Nanoparticles; B: Fatigue; B: Fracture

1. Introduction

Epoxy polymers can be used as adhesives, coatings or as the matrices of fibre-reinforced composite materials. They are highly crosslinked thermosetting polymers, and this structure results