Available online at www.sciencedirect.com

ScienceDirect

Procedia Structural Integrity 5 (2017) 539–546

Structural Integrity Procedia

www.elsevier.com/locate/procedia

2nd International Conference on Structural Integrity, ICSI 2017, 4-7 September 2017, Funchal, Madeira, Portugal

Effect of fiber length on the mechanical properties of high dosage carbon reinforced

C. Capela[a,b,] *, S. E. Oliveira[a], J. Pestana[a], J.A.M. Ferreira[a]

[a]*CEMMPRE, Center for Mechanical Engineering, Materials and Processes, Department of Mechanical Engineering, University of Coimbra, Rua Luís Reis Santos, 3030-788, Coimbra, Portugal*

[b]*Department of Mechanical Engineering, ESTG, Instituto Politécnico de Leiria, Morro do Lena – Alto Vieiro, 2400-901 Leiria, Portugal*

Abstract

Short fibers are effective reinforcements in strengthening and toughening polymer materials. It is reported that even small amounts of fibers drastically increased composite strength. However, for high fiber dosage the dispersion and interface adhesion is quite poor reaching to lower stiffness and strength efficiency. The effects of fiber length on mechanical properties of low content of short fiber reinforced composites is usually associated with a gain with the increasing of fiber length, but for high dosage this statement is not entirely consensual. This paper intends to contribute for the better understanding of the effect of the fiber length on the mechanical performance of high dosage fiber reinforced composites. Composite plates were manufactured by compression moulding, using short carbon fibers reinforcements (2, 4 and 6 mm in length) with 60% wt fiber fraction and the Biresin®CR120 resin as matrix. The specimens were machined from the plates for desired dimensions to the tensile and DMA tests. High dosage composites exhibits very low efficiency parameters both in stiffness and particularly in tensile strength. Stiffness increases in order of 25% when fiber length increases from 2mm to 4mm, but afterwards decreases for 6mm fiber length composites. The same tendency was observed for the tensile strength meaning that poor fiber dispersion and disorder was achieved for 6mm fiber length. The results of DMA indicate, however, that modulus storage increases when fiber length increases from 2mm to 6mm.

Peer-review under responsibility of the Scientific Committee of ICSI 2017

Keywords: Composites, Mechanical properties, Short fibber composites.

* Corresponding author. Tel.: 351 244 820 300
E-mail address: ccapela@ipleiria.pt

2452-3216 © 2017 The Authors. Published by Elsevier B.V.
Peer-review under responsibility of the Scientific Committee of ICSI 2017
10.1016/j.prostr.2017.07.159

1. Introduction

Short fiber-reinforced exhibits some advantages in comparison with the continuous fiber-reinforced composites, like: lower cost, quasi-isotropic mechanical properties and easier manufacturing processing, which leads to their widely use in automobile and other industries. Short fiber reinforced composites are designed to occupy the gap corresponding to the large difference between mechanical properties of continuous fiber laminates used as highly charged primary structures and unreinforced polymers used in non-load-bearing applications, Fu et al. (2000), Gordeyev et al. (2001) and Kuriger et al (2002). Epoxy resins have high modulus, excellent thermal performance and chemical resistance, Jin et al. (2011). Short carbon fibers have high length to radius ratio (L/D ratio), showing complex failure mechanisms, like fiber pullout, debonding and fiber breakage, Zhang et al. (2011). Literature reports the use of carbon fibers (CFs) as reinforcement for high the performance of reinforced composites using matrix thermoplastic, like polyamide, Botelho et al. (2003) and PPS, Jiang et al (2008).

Short carbon fibers composites are easily manufactured by using conventional techniques, like extrusion compounding and injection moldingor the compression moulding, which is an inexpensive process. Factors like fiber dispersion, fiber length and volume fractions play important role to enhance the mechanical properties of short fiber polymer composites. Shao Fu and Lauke (1996) predicted analytically the effect of fiber length on the tensile strength of short fiber reinforced polymers showed significant increasing of the strength with the increase of the mean fiber length. Literature reports the increasing of composite mechanical performance with increasing fiber content for low and medium dosage. However, for high dosage fiber dispersion and disorder is quite difficult becoming poor fiber enhancement and complex failure mechanisms, which need better understanding. In that case, the improvement of the composites performance depends of its capacity to obtain good fiber dispersion.

Tiesong Lin et al. (2008), studied the effects of fiber length on mechanical properties and fracture behavior of short carbon fiber reinforced geopolymer matrix composites, and obtained important gains on flexural strength, which reached the maximum values for the fibber length of 7 mm. F. Rezaei et al. (2009), used DMA to measure the damping properties of short carbon fiber reinforced polypropylene composites, and shown that an increase in fiber length can enhance the thermal stability and improve the damping properties as well.

Current investigation intends to study the effect of the fiber length on mechanical and thermos-mechanical properties of short carbon fibers composites, using 2, 4 and 6 mm fibers length to reinforce an epoxy resin matrix. Mechanical properties were obtained by conventional tensile tests and dynamic mechanical analysis (DMA). DMA was used to determine the viscoelastic properties of the composites.

2. Materials and testing procedure

The composite plates were manufactured using short carbon fibers reinforcements (2, 4 and 6 mm in length) with 60% mass fraction. The matrix was the Biresin®CR120 resin, formulated by bisphenol A - epichlorhydrin epoxy resin 1,4 - bis (2,3-epoxypropoxy) butane, combined with the hardener CH120-3, both supplied by Sika, Stuttgart, Germany. The short carbon fibers were supplied by the company, Sigrafil, SGL Group, Germany.

Carbon fibers were dispersed in closed erlenmeyer adding 150 ml of dichloromethane solvent to 1 g of fibers. Therefore, the mixture was immersed in an ultrasonic bath for 7 min, which globally improve the dispersion of the fibers. Afterwards, it was filtered through a qualitative filter 202 moderate speed, Ø90mm and the solvents were recovered. Finally, the mixture was subjected to a process of evaporation for about 40 hours at room temperature. Fig. 1 shows de aspect of the mixture after evaporation.

The composites were processed by compression using a metal mold specially manufactured for this study. The resin was previously prepared and placed under vacuum. Then it was added a desired amount of short carbon fibers. Afterwards, the materials were mixed slowly, and the mixture were placed in the mold cavity. A compression force of 1500 kg was applied (as shown in Fig. 2), which corresponds to a pressure processing of about 60 MPa. The produced plates were then subject to a cure and post cure processes. The cure was at room temperature for 8 hours in the mold, and the post cure was carried out as follows: 55 ºC for 16 hours, 75 ºC for 3 hours and finally 120 ºC for 12 hours.