



PAPER

Mechanical and free vibration properties of clamshell particles/polyester composites

OPEN ACCESS

RECEIVED

30 October 2019

REVISED

1 December 2019

ACCEPTED FOR PUBLICATION

10 December 2019

PUBLISHED

6 January 2020

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**Abstract**

In this work, an experimental investigation was implemented to identify the effect of adding clamshell powder (CSP) into the polyester matrix on the tensile and impact properties along with vibration characteristics of the particulate composites towards using eco-friendly reinforcement phase. Different weight ratios of clamshell powder, ranged from 0 to 20 wt%, were loaded into the polyester resin with particle sizes ranged from 25 to 75 μm . Tensile, Charpy impact and free vibration tests were performed to the specimens fabricated from the neat polyester and CSP-filled polyester. The results showed that the inclusion of CSP into the polyester matrix could improve the tensile modulus of the polyester up to 50% when the CSP weight ratio equals to 12%. Meanwhile, the strain-to-failure, tensile and impact strengths showed decreasing trends with increasing the CSP filler content owing to the weak adhesion (bonding) strength between CSP and the polyester matrix. Maximum improvements in the fundamental natural frequency and damping ratio of CSP-filled polyester were 24% (at 12 wt% of CSP) and 21% (at 8 wt% of CSP), respectively. Based on the results, the clamshell powder could be used as a very cheap bio-filler material within the polyester matrix if the high stiffness composites with improved damping properties are required.

Introduction

The shell waste is a big issue for the shellfish aquaculture industry as it can account for up to 75% of the total organismal weight [1]. The major component of the clamshell is the calcium carbonate (CaCO₃) which can be employed in several sectors. According to Kao *et al* [2], there are about 8 000 tons of clamshell waste produced each year that could be considered as a public health problem. These residues could be reused in construction and the pharmaceutical industries [3]. Nowadays, great effort is being made to increase the mechanical properties of the composite materials without affecting the environment. Natural reinforcements in the form of fibres or particles are used efficiently in producing fully or partially green composites. Natural-particles derived from plant or animal-based are low-cost materials that can be used as reinforcements in the polymeric composites to improve certain mechanical properties of the polymeric materials [4, 5]. Clamshell powder (CSP) is an example of the natural materials that could be used as a reinforcement in the polymeric composites.

The addition of particulate fillers into the polymeric matrix could enhance some of the mechanical and physical properties [6]. Previous studies regarding this topic showed that the mechanical properties of the particulate composites might be largely affected by the properties of the particles themselves such as their size and shape, their distribution throughout the base material, surface traction and surface energy, stiffness and hardness, and adhesion strength with the polymeric matrix [7]. Previous studies showed that good enhancement in the tensile modulus and strength of the particulate composites could be obtained at smaller particle sizes [7–12]. Yang *et al* [13] concluded that higher loading of CaCO₃ nano-particles into polypropylene matrix could easily agglomerate without significant effects on the flexural strength and modulus of the particulate composites. The results indicated that there was a specific filling weight ratio of CaCO₃ at which the mechanical properties of the composite reached their maximum values and then started to decrease with increasing the CaCO₃ wt%.