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Characterization of thermal and acoustic insulation of chicken feather reinforced composites

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Abstract

This work evaluates the application potential of chicken feather fibres in the reinforcement of polymeric materials, particularly thermosetting ones as epoxy resins. Due to the morphology of this type of protein fibres, which is characterized by being hollow, its study and application has particular interest as components being able to contribute for the thermal insulation, once air is well known as a bad heat conductor. Composite materials were produced using compression moulding process, and subsequently thermal and acoustic insulation tests were performed to evaluate the influence of chicken feather fibres as potential reinforcements for thermal and acoustic insulation composites applications. The experimental results show that the chicken feather fibres present high potential to be applied as reinforcement in composite materials. It was verified that the thermal resistance of composite materials is favourably dependent on the chicken feather fibres mass fraction, being registered a value of 0.175 m^2 K W^{-1} when an 80:20 ratio (chicken feather fibre and epoxy resin, respectively) was used. Moreover, comparing with coir fibres reinforcing polypropylene, it was verified a better performance, once this composite material just revealed a thermal resistance around 0.114 m^2 K W^{-1}.

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Keywords: Surface treatments; Flax fibre; Composites; Mechanical properties.

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1. Introduction

Chicken feathers are typically considered as residues of the poultry industry. This industry generates billions of kilograms of this waste per year, which are usually burnt and incinerated, without any use or recycling process. However, this waste disposal method led to the generation of greenhouse gases, which are hazardous to the environment [1]. Due to current concerns about the earth sustainability, several studies have been conducted on the use of recyclable and environmentally friendly materials. In this perspective, the fibres extracted from the chicken feathers have also been the subject of some research studies. Among these studies, it was concluded that morphological structure of chicken feather fibres has potential to be used as reinforcement of composite materials, mainly in textile applications related to thermal control. As main characteristics, these fibres present low density, high compressive [2] and tensile strengths [3], and Young's modulus of about 4.7 GPa.

Actually, composite and non-woven materials are the main applications of recycled or reused chicken feather fibres [4]. However, due the fact of the chicken fibres are not classified as high performance materials, their target applications have been registered as thermal and acoustic insulation [3].

In this paper, which explains the morphology of the chicken feather fibre and its combination with an epoxy resin, it was intended to study its influence on the thermal and acoustic insulation properties of composite materials. The fibre morphology was studied by optical and electronic microscopy, and the composite materials were produced using compression moulding process. Afterwards, chicken feather fibers reinforced composite plates were characterized by thermal and insulation characterization tests.

Nomenclature

SEM	scanning electron microscope
Au	gold
Pd	palladium
DSC	differential scanning calorimetry
PP	polypropylene

2. Experimental

2.1. Materials

Chicken feather fibres were extracted from chicken feathers supplied by Dudico, Cialine Group, Brazil. The animals were slaughtered after 42 days of life, and their feathers present can be grouped in 3 types, according to the length, namely: short, medium and long. The extracted fibres used in this research work present an average length of 2.6 cm.

Epoxy resin supplied by Sika, reference SR GreenPoxy 56, with up to 56% of its molecular structure coming from plant origin, was used to impregnate the chicken feather fibres. This percentage is a function of the carbon origin contained in the epoxy molecule. This resin is out coming from the latest innovations in bio-based chemistry. SR GreenPoxy 56 has a density of 1.198 g cm^{-3} and a viscosity of 800 mPa s at 25°C.

2.2. Morphological and thermal study of chicken feather fibres

Morphological characteristics of the chicken feather fibres were obtained by optical and electronic microscopic analysis. Optical microscopy was performed with an optical microscope Olympus BH2, coupled to a JVC TK1280E chamber and an image capture software. The chicken feather fibres were observed using a 40×65 magnification. Electronic microscopy was performed on ultra-high resolution scanning electron microscope (SEM), Nova NanoSEM 200 model. The chicken feather fibres samples were covered with 80:20 wt % Au-Pd (gold-palladium) film and the images were obtained with an acceleration voltage of 15 kV.