UNIVERSITI TEKNOLOGI MARA

EXPERIMENTAL AND NUMERICAL STUDY OF HEVEA BRASILIENSIS – SILICONE BIOCOMPOSITE

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MSc

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AUTHOR'S DECLARATION

I declare that the work in this thesis was carried out in accordance with the regulations of Universiti Teknologi MARA. It is original and is the results of my own work, unless otherwise indicated or acknowledged as referenced work. This thesis has not been submitted to any other academic institution or non-academic institution for any degree or qualification.

I, hereby, acknowledge that I have been supplied with the Academic Rules and Regulations for Post Graduate, Universiti Teknologi MARA, regulating the conduct of my study and research.

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ABSTRACT

Environmental issues such as climate change and global warming are becoming severe, and therefore green technology is one of the ways to reduce it. Accepting this challenge, the idea of replacing engineering materials with appropriate biomaterials is hoped to promote greener technology eventually could reduce environmental problems. Being abundant agricultural waste, the sawdust of Hevea brasiliensis or commonly called rubber tree, is known to have no economic value and having disposal problem. Taking this as an opportunity, this study for the first time attempts to utilize the Hevea brasiliensis sawdust as a filler material to produce a new silicone biocomposite material. Silicone rubber is an elastomer that is widely used in the aerospace, automotive and medical industry. Despite having numerous advantages, silicone rubber is known to have weak mechanical strength which limit its capability to a certain extend. Through incorporation of the hevea brasiliensis fibre, the mechanical strength of silicone rubber can be enhanced. The main objectives of the study are to quantify and assess the mechanical properties (tensile, compressive and impact behaviour) and morphology of this new Hevea brasiliensis-silicone biocomposite materials. The physical and mechanical properties of the biocomposite were explored using three techniques which are the uniaxial tensile, compression and low velocity impact test. The specimens were prepared in five weight compositions of 0 wt%, 4 wt%, 8 wt%, 12 wt% and 16 wt% according to established standards. Morphological properties of the specimens fractured surfaces were observed and studied through Scanning Electron Microscopy (SEM). Numerical analysis is then carried out using the most common hyperelastic constitutive equations (Neo – Hookean, Mooney – Rivlin and Ogden models) to quantify the tensile and compressive properties. Results from tensile test show that the material constants of pure silicone rubber are C1 = 0.04172 (NH), C1 = 0.04619, C2 = -0.05061 (MR) and μ = 0.03177, α = 2.3885 (Ogden). As the fibre content increases, these values also increase and the highest are at 16 wt%, where the material constants are C1 = 0.07781 (NH), C1 = 0.06639, C2 = 0.04986 (MR) and μ = 0.21942, α = 1.7808 (Ogden). Similar to the tensile test, results from compressive test show the same pattern. The material constants of pure silicone rubber are C1 = 0.02014 (NH), C1 = 0.01667, C2 = -0.00276 (MR) and μ = 1.0462, α = -0.07038 (Ogden). As the fibre content increases, these values increases and highest are at 16 wt%, where the material constants are C1 = 0.05230 (NH), C1 = 0.05418, C2 = 0.0015 (MR) and μ = 0.9957, α = -0.1931 (Ogden). For impact test, the energy absorbed, peak load and the deflection at peak load decreases with increasing fibre compositions. The SEM images shown from the morphological analysis displays good matrix-filler bonding and no agglomerations of fibres were found throughout the fractured surface of the specimens. Transition from smooth to rough surface could be seen as more fibres are added into the biocomposites. In terms of numerical analysis and hyperelastic modelling, the results show that Ogden model has most accurately mimicked the deformation behaviour of the materials for tensile property while Mooney – Rivlin model perform the best for the compressive property. The results and findings prove that the current study is significant and have contributed new knowledge about the experimental-numerical analyses of this new Hevea brasiliensis-silicone biocomposite materials.

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