UNIVERSITI TEKNOLOGI MARA

HYPERELASTIC CONSTITUTIVE ANALYSIS OF AGAR SILICONE AND KENAF SILICONE BIOCOMPOSITE

NURUL NADIAH BINTI AZMI

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ABSTRACT

The complicated behaviour of skin has made it hard to be replicated. In most studies on human and animal skin, skin is assumed to behave like a hyperelastic material, although in reality it exhibits a more complex behaviour. Silicone rubber is usually treated as a hyperelastic material that is widely used as aesthetic and orthopaedic prosthetics, as well as medical disposables but silicone biocomposites behaviour is still not well understood and explored. Therefore, this study aims to synthesis a new silicone biocomposites and investigate the material constants of the biocomposite material, with the expectation that it could potentially mimics the skin deformation. In this study, the material characteristics of silicone biocomposite were determined using three commonly used constitutive hyperelastic models; Neo-Hookean, Mooney-Rivlin and Ogden. A platinum cured soft silicone, Ecoflex 0030 was used as the matrix. Two types of silicone biocomposite, which were agar and kenaf silicone were synthesised, each with three mass variances (10%, 20% and 30%). The reinforcement material were weighed and mixed into the liquid silicone rubber before pouring it into the mould according to ASTM D638-10 Type IV. After synthesising ten specimens for each variances, uniaxial tensile test were performed. Numerical approach and analytical approach were adapted where the engineering stress and stretch curve were plotted (σ_E - λ) and compared to the results obtained from the uniaxial tensile test. In the analytical approach, the mean and standard deviation of the material constants were taken. The results show that the determined parameter for Neo-Hookean (C1) ranges from 34-38 kPa for kenaf silicone and 52-57 kPa for agar silicone biocomposite. As for Mooney-Rivlin, the parameters for kenaf silicone are 29-32 kPa (C1) and 7-57 kPa (C2). Agar silicone has the value of 34-38 kPa and 47- 54 kPa for C1 and C2 respectively. Ogden parameters (Ogden coefficient, μ and Ogden exponent, α) for kenaf silicone and agar silicone are 46-49 kPa; 2.45-2.59 (μ;α), and 48-54 kPa; 2.17-2.19 (μ;α) respectively. The material constant increases with the increase of reinforcement material. Agar silicone and kenaf silicone biocomposites are proven to be much softer than the skin. Thus, in the future, other materials for reinforcement might be used to synthesis a material that could imitate skin's behaviour.

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CHAPTER ONE
INTRODUCTION

1.1 RESEARCH BACKGROUND

Skin, the largest and important organ in a human body comprises of three main layers; which are epidermis, dermis and hypodermis. It represents the outward appearance of a person, covering an area of 1.7m^2 and weighs approximately 4kg [1, 2]. Besides that, it also acts as a barrier against harmful substances such as ultraviolet rays. A scar or wound on the skin that is left untreated could lead to a more serious infections. In short, it functions as vitamin D synthesiser, temperature regulator, barrier against water, chemicals and UV lights. Although it acts as a barrier, it allows oxygen to infuse through it.

Skin mechanical properties and behaviour are of wide interest in a number of fields. Among the studies done to understand skin's mechanical behaviour includes the studies by Mahmud *et al.* [3-5], Adull Manan *et al.* [6], Pereira *et al.* [7] and many others. Besides that, a number of studies have been carried out to comprehend skin's basic functions and behaviour which in turn, leads to the study of artificial skin as a feasible form of skin substitutes. These skin substitutes can be further categorised as either biological or synthetic and temporary or permanent skin substitutes [8]. Both temporary and permanent skin substitutes serves different roles, depending on the need of the patient. While the permanent skin substitutes function to permanently achieve wound closure and to replace the skin components, the temporary skin substitutes only serves as temporary dressing to facilitate re-epithelialisation and pain control [8]. However, in this study, the preferred classifications of skin substitutes are the biological and synthetic.