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An automated software development for analysis of the morphological-tensile property relationship in egg shell bio-based particulate composites using machine learning algorithms

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ABSTRACT

This work explored the importance of quantitative observation through imaging methods of optical and electron microscopies on the mechanical properties of particulate polymeric composites. Egg shell powder (ESP) reinforced polypropylene carbonate (PPC) polymeric composites with different filler weight percentage (wt.%) from 1 to 5 wt.% were considered. A cost-effective Image Analysis Software (IAS) was developed to extract black particles from the original optical images. During this process, the optimal image can be reproduced based on its originality by controlling the threshold values from 0.1 to 0.6 in real time situation. Using one-dimensional (1D) Gaussian distribution analysis, the authentication of the particle distribution data was studied and linked to the tensile strength of the composites. The mean value of the particle area collected from the left and right side of the scattered curves has a significant effect on the tensile strength of the composites. The proposed model was validated by comparing the predicted statistical results with the measured tensile strength for different wt.% of ESP composites. From the results obtained, a close agreement of 99% accuracy was observed between the experimental results and the proposed model for the tensile strength of the composites. The innovative study provides more practical and quantitative knowledge on improved particulate polymeric composites, in addition to the detection of failure processes through optical/electron microscopic examination of images. Evidently, the proposed cost effective, accurate and less stressful model can be employed by several composite-based industries to correlate the tensile strengths of particulate polymeric composites with their morphological properties.

1. Introduction

Nowadays, particulate reinforced polymeric composites attract many engineering applications. This is due to their unique characteristics, which include lightweight, ease of manufacturing and eco friendliness. Several studies on particulate polymeric composites have been performed, considering effects of various factors: particle size, distribution, shape for the combination of various particles and polymer system on their mechanical properties. However, prediction of the structure-property relationship from the electron microscopy images has not been explored quantitatively. Hence, this work attempts to establish a common method to quantify the distribution of particles in the polymer matrix and their effects on the tensile properties, using Image Processing Technique (IPT). IPT has gained many attentions among the researchers, due to its cost effectiveness and the scope of providing data according to the user requirement [1]. Using this technology, useful information such as edge detection, contrast, intensity and application of mathematical operations from the images can be retrieved [2,3]. Due

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