UNIVERSITI TEKNOLOGI MARA

CHARACTERIZATION AND RHEOLOGICAL PROPERTIES OF HYBRID FILLERS FILLED HIGH DENSITY POLYETHYLENE BIO-COMPOSITE

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ABSTRACT

As the world tries to minimise possible harmful destruction of our environment and move towards GO GREEN Agenda, hybrid fillers have been widely used as alternative reinforcing filler for thermoplastic polymer composite. One of the most characteristic features of hybrid composite lies in its balanced performance of strength, as well as other properties, which include manufacturing cost. In this research, different fillers were used to obtain optimal hybrid composite composition from kenaf, rice husk (RH) and calcium carbonate ($CaCO_3$). Different varying compositions up to 30 wt% of mixed kenaf and rice husk with $CaCO_3$ were compounded with 40-70 wt% of high density polyethylene (HDPE) using twin screw extruded at 50rpm, to produce two different hybrid composites, HDPE/kenaf/$CaCO_3$ and HDPE/rice husk/$CaCO_3$. Properties of hybrid composites were compared between particulate $CaCO_3$/kenaf fibrous form and $CaCO_3$/rice husk particulate form. Hybrid composites were tested for physical, mechanical, thermal, burning rate and rheological behaviour. From test results, addition of filler had decreased melt flow index (MFI) up to 72% and increased density of hybrid composites up to 19%. In general, addition of both natural fibres, either kenaf or rice husk with $CaCO_3$ decreased the tensile strength, elongation, and impact. However, addition of 20 wt% rice husk in fixed 30 wt% $CaCO_3$ showed an increment of about 10% in its impact strength. Increment of filler subsequently increased flexural strength, flexural modulus and Young Modulus properties of both hybrid composite systems. Water absorption properties were increased with addition of filler, while kenaf hybrid composite system exhibited higher water uptake, which is 6.47% in 80 days. For thermal properties, hybrid composite showed good thermal stability with addition of kenaf, rice husk and $CaCO_3$ fillers. HDPE/kenaf/$CaCO_3$ exhibited lower burning rate compared to similar filler loading of HDPE/rice husk/$CaCO_3$ hybrid composite. Viscosity of hybrid composites was increased due to addition of fillers. Rice husk/$CaCO_3$ particulate had lower viscosity compared to kenaf fibrous/$CaCO_3$ particulate hybrid composite system. From observations of Rule of Mixture (ROM) and Rule of Hybrid Mixture (RoHM), it was found that, there were lower and upper bound of hybrid composites which depended on compositions of their fillers. Meanwhile, observations from field emission scanning electron microscope (FESEM) revealed bonding between filler and matrix from impact fracture.

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TABLE OF CONTENTS

CHAPTER ONE
INTRODUCTION

1.1 BACKGROUND OF STUDY

Over the past few years, environmental-friendly products have been on demand due to environmental concern globally. Development of new materials from polymer composites is important to produce materials that have specific properties and low manufacturing costs. Interest in utilising natural fibres in thermoplastic had increased recently, mainly due to the need in overcoming environmental problems which were caused by agricultural by-products. Utilisation of lignocellulosic fibre offers lower cost of production, renewability, biodegradability, less abrasiveness and greater deformability, thus providing advantages to mechanical, physical and thermal properties of the material. Furthermore, filler from natural fibres, such as kenaf and rice husk, are lighter, cheaper, provide absence of associated health hazards and provide much higher strength per unit mass than most inorganic fillers, such as carbon black, talc, and zinc oxide (Kim, 2004).

Polymer matrix is often compounded with minerals fillers to enhance its toughness, stiffness, dimensional stability, and electric-insulation properties (Osman, 2007). Commonly used mineral fillers include silica, talc, calcium carbonate ($CaCO_3$), mica, kaolin, wollastonite, feldspar and barytes. Usage of mineral filler depends on physical attributes of the mineral itself towards a specific application. Superior properties of inorganic mineral filler can lead to better compound performance other than saving material cost factor. $CaCO_3$ can act as toughness agent, extender to the composite, and help to increase strength performance. From the above advantages offered by $CaCO_3$, it was shown that $CaCO_3$ can complement some properties which composites of natural fibre reinforced would have lacked. Usage of $CaCO_3$ counteracts, not just to optimise strength performance which increases toughness of the composite, but also acts as cheap fillers which could be combined with either rice husk or kenaf. With the use of $CaCO_3$, cost production can be lowered as $CaCO_3$ are one of the cheapest established filler used in plastic industry.

In recent years, thermoplastic polymer has been considered in a wide range of product application. Polyethylene (PE) is one type of polymer that has been widely