UNIVERSITI TEKNOLOGI MARA

CHARACTERISATION AND PROPERTIES OF KENAF FIBRE/EPOXY COMPOSITE VIA ORGANOSOLV PULPING

MONA RITA BINTI OTHMAN

Thesis submitted in fulfillment
of the requirements for the degree of
Doctor of Philosophy

Faculty of Applied Sciences

March 2023

ABSTRACT

Natural fibre is a long-lasting material, yet it has limitations that limit its usage. As a result, by adopting a practical treatment, this research enhanced the conventional fibre treatments that are tedious and high energy consumption. This study was carried out by treating the raw kenaf fibres by using Organosolv treatment. Acetic and formic acids were used as the solvent in the treatment. The duration of fibre being treated was varied at 15, 30, 60 and 90 minutes. Bast and core fibre were used for this study. The characteristics and the tensile properties of the fibres were analysed. Next, study on epoxy was carried out. Epoxy was diluted with acetone at 1:1.25, 1:1.50, 1:1.75 and 1:2.0 and their viscosity was analysed. Tensile properties and weight uptake of single kenaf fibre wetted with the epoxy solution was also studied. Finally, kenaf/epoxy composite was prepared. Three different types of hardener were used namely boron trifluorohydride, N,N-dimethylethyldiamine and diethylenetriamine. The ratio of kenaf pulp fibre to epoxy was varied at volume ratio of 1:4, 1:5 and 1:6. Controlled samples were also prepared without fibre loading. Tensile test, flexural test and impact test were carried out on the composite. Acetic acid was found to produce higher tensile properties kenaf pulp fibre than formic acid. This is due to the characteristics of formic acid which is more corrosive and thus producing fibre with more damage and lower the properties of the fiber itself. For both types of acids, bast fibre showed higher tensile properties. In terms of chemical composition, lignin, cellulose and homocellulose were higher in core fibre for both acids. While ash content and alpha cellulose were higher in core fibre. Epoxy weight uptake of a single fibre was highest at 1:1.5 epoxy to acetone ratio at 15 minutes wetting time; and the highest fibre strength was found at 1:1.75 epoxy to acetone ratio. For the kenaf/epoxy composite, the N,N-dimethylethyldiamine curing system at 1:5 kenaf to epoxy ratio showed the highest tensile, flexural and impact properties, The composite with boron trifluorohydride curing system at 1:4 kenaf to epoxy ratio demonstrated the lowest value in the mechanical properties. Different types of curing system did not impart significantly on density of the composites.

ACKNOWLEDGEMENT

Firstly, I wish to thank Allah for giving me the opportunity to embark on my PhD and for completing this long and challenging journey successfully. My gratitude and thanks go to my supervisor Assoc Prof Dr Ahmad Zafir bin Romli, who have helped, supervised and guided me through this PhD journey. My deepest appreciation goes to Dr Ahmad Faiza bin Mohd for his suggestions and constant advice throughout the research.

Special thanks to my colleagues and faculty members who were supportive throughout this research work.

Finally, this thesis is dedicated to my loving husband and children, for the support, encouragement and vision to educate me. This piece of victory is dedicated to all of you. Alhamdulillah.

TABLE OF CONTENTS

Page

CHAPTER ONE
INTRODUCTION

1.1 Research Background

Recently, there has been a growing interest in the use of natural fibres as reinforcing fillers in both thermoplastics and thermoset materials. Natural fibres such as kenaf, hemp, flax, sisal, coir, jute, banana and pineapple leaf have the potential to be used as a replacement of conventional reinforcing materials in composite (Matthew P Westman et al., 2010). The increasing number of study using natural fibre is due to the benefits that it offers such as environmental friendly, biodegradability and renewability. Apart from the environmental concerns, composites made of natural fibre also have benefits of producing high toughness, low density, light weight product and; reducing wear and cost during processing (Nishino et al., 2003). Another reason for using natural fibres is that they have a higher specific strength than glass fibre and a similar specific modulus (Faruk et al., 2012). Basically, natural fibres offer acceptable specific strengths and modulus, at a lower cost (Huda et al., 2008).

As one of the warm season annual fiber crop which closely related to cotton and jute, kenaf had been used as a cordage crop to produce twine, rope and sackcloth ages ago. However, as the rapid development of technology goes on, more and various application for kenaf also revolve such as paper product, building materials, absorbents and animal feeds (Mohd Edeerozey et al., 2007). Kenaf had been acknowledged as environmentally friendly because of its ability to accumulates carbon dioxide at a significantly high rate and it also absorb nitrogen and phosphorus from the soil (Zampaloni et al., 2007).