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MECHANICAL AND PHYSICAL PROPERTIES OF FIBERBOARD BONDED BY PALM-BASED POLYURETHANE RESIN AT DIFFERENT EQUIVALENT WEIGHT RATIOS AND HOT PRESSING TEMPERATURES

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AUTHOR'S DECLARATION

I declare that the work in this thesis/dissertation 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 of non-academic institution for any degree or qualification.

I, hereby, acknowledge that I have 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

Medium density fibreboard is normally produced with urea-formaldehyde (UF) and/or phenol-formaldehyde adhesives. However, the former is considerably toxic and environmentally damaging where the formaldehyde emissions are found to cause negative health effects such as cancer. As an alternative, Malaysian Palm Oil Board (MPOB) has developed a new material based binder free from formaldehyde which is based on environmentally friendly vegetable oil-based polymer such as polyurethane (PU). In this study, palm-based PU resin was used as a binder and rubberwood as the fiber in the production of medium density fiberboard (MDF). The palm-based PU resin was prepared by mixing between palm-based polyol and isocyanate at three different equivalent ratios 1:1.5, 1:2.0 and 1:2.5 and dilute in ethyl acetate as solvent. The palm-based PU resin properties were characterized by using back titration of isocyanate (NCO), particle size distribution, Fourier Transform Infrared spectroscopy (FTIR) and thermogravimetry analysis (TGA). In the production of MDF, the palm-based PU resin with different equivalent weight ratios was sprayed at four different percentages of palm-based PU resin 3, 5, 7 and 10% based on weight of rubberwood fibers under high pressure to pulverize the resin for optimal distribution. After cool press, the fibers mats was pressed to 12mm using a hydraulic press heated at different temperatures (100, 150 and 180°C) for 5 minutes. The physical and mechanical properties of MDF were measured by modulus of rupture (MOR), modulus of elasticity (MOE), internal bonding strength (IB), thickness swelling (TS) and moisture content (MC) of MDF based on European Standard (EN 622-5, 2006). The results of characterization palm-based PU resin through back titration of isocyanate showed the free isocyanate of palm-based PU resin produced at ratios of 1:1.5 and 1:2.0 and 1:2.5 are 5.53%, 8.48% and 13.52%. Meanwhile, the degradation processes of palm-based PU resin were started at 340°C in the TGA. The formation of isocyanate (NCO) group was observed at 2270 cm^{-1} in the FTIR spectrum, it clearly showed the presence of isocyanate group in the palm-based PU resin. The averages of particle size of palm-based PU resin showed the single pick indicated that homogeneous distribution of a narrow particle size. However, after one week it was observed the palm-based PU resin was clearly separate two layer. In the first phase study, three types of palm-based PU resin were evaluated with different equivalent ratios between palm-based polyol and isocyanate which were at 1:1.5, 1:2.0 and 1:2.5. It was found that the amount palm-based PU resin as a binder was 7% with equivalent ratios of 1:2.0 which resulted in the better strengths and enough to meet all the minimum and maximum requirements of European Standard (EN 622-5, 2006). The second phase study was determined the effect of hot pressing temperatures in order to assess the minimum temperature that gave the better results and significant reduction in production cost. Three hot pressing temperatures (100, 150 and 180°C) and four different percentages of palm-based resin (3, 5, 7 and 10%) use as a binder were chosen to evaluate the effect on the physical and mechanical properties. It was found that the temperature at 180°C with 7% of palm-based PU resin which resulted in the better strengths and met all minimum and maximum of European Standard (EN 622-5, 2006). In conclusion, the ratio of palm-based PU resin prepared was 1:2.0 required that met all the European Standard requirements (EN 622-5, 2006) was 7% with hot pressing temperature at 180°C.

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CHAPTER ONE
INTRODUCTION

1.1 INTRODUCTION

Wood as biomass resources has many advantages. It is a renewable resource, offering a sustainable and dependable supply. Wood consists of 45% cellulose, 20% hemicelluloses and 25% lignin and thus may be considered as an excellent reservoir of raw materials for the production of chemical and bio-based products (Wigberg and Maunu, 2004). Generally, the wood-based panels, like particleboard (PB), medium density fiberboard (MDF), plywood (PW), oriented strand board (OSB) etc, are produced from byproducts of wood processing like chips, fibres and veneers, adhered together with thermosetting resins such as formaldehyde based. The most common types are urea-formaldehyde, phenol-formaldehyde and melamine-formaldehyde resins. These types are usually synthesized by petrochemical raw materials.

Today, there has been increasing international attention given to the production and use of 'green' adhesives from renewable resources for binding wood-based panels. This interest in these bio-based adhesives has arisen due to a number of drivers such as government legislative changes to minimize the health effects relating to products emissions of volatile organic chemicals (VOC), most notably formaldehyde and the use of renewable materials as a cost effective replacement for petrochemical components of adhesives.

The ideals to use renewable natural materials as a major component of wood adhesives are not new. First Adhesives derived from animal, casein and soy protein were be used and dominated the market till 1940. After 1970, the use of renewable adhesives gradually declined when the petrochemical materials entered the market enabling the synthesis of adhesives with specific properties, constant quality and lower cost (Electra P. *et. al*, 2008).