UNIVERSITI TEKNOLOGI MARA

DEVELOPMENT OF TRANSPARENT WOOD FROM TROPICAL SPECIES: EFFECTS OF LIGNIN REMOVAL AND EPOXY RESIN INFUSION ON MERANTI MERAH, MEMPISANG AND KEDONDONG

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ABSTRACT

In Malaysia, buildings contribute approximately 66% of national energy consumption. In response, the government enacted the Energy Efficiency and Conservation Act (EECA) to enhance energy efficiency and promote sustainable practices by 2050. Transparent wood (TW), an emerging material with low light scattering and thermal insulation properties, offers potential for sustainable construction in line with EECA goals. This study investigates the fabrication of TW from three tropical species—meranti merah, mempisang, and kedondong—through chemical delignification and subsequent epoxy resin impregnation. Four delignification durations (3, 6, 9 and 12 hours) were tested to determine optimal lignin removal. Meranti merah and mempisang showed optimal lignin content at 6 hours (18.76 and 21.95%), while kedondong peaked at 12 hours (21.44%). Meranti merah exhibited the highest tensile strength (113.4 MPa at 3h), while mempisang showed stable performance. Optical transmittance improved in all TW samples compared to delignified wood, with the highest values recorded for mempisang (57%) and meranti merah (56%). Post-treatment density increases confirmed successful polymer infiltration. Among the three species, meranti merah demonstrated the best combination of mechanical strength and optical clarity, making it a strong candidate for TW applications in sustainable construction.

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TABLE OF CONTENTS

CHAPTER ONE
INTRODUCTION

1.1 Background of Study

The first experimental realization of transparent wood (TW), by Siegfrieg Fink in 1992 described the colouration of an object effecting the transmission of light. He explained that light is absorbed more by the darker colour if compared to the bright colour of wood. In his research (Fink, 1992) focused on the theory and method to produce a TW that is capable for a light passing through. The study made had not discussed further on mechanical properties of TW.

In recent years, researchers have investigated varieties on approaches of making TW. Between years 2015 up till 2023, the number of investigations grows rapidly. The studies had been made to fulfil different demand. The core principle of TW fabrication involves the removal of lignin, a light-absorbing component in wood that gives it colour and rigidity. There are several types of chemical variations, steps and rates used to attain the result. The delignification process is commonly followed by infusing a polymer into delignified wood (DW) to enhance the mechanical properties and to attain desire light transmittance. Lignin functioned to strengthen the wood structure where it owns about 30% of wood tissue and gives colour to wood (Li et al., 2017). The lignin removal impacts support of the shape and strength of DW. Since the strength of wood was reduced by the delignification process, resin infusion or impregnation could be done to replace the lignin position and function in wood. For example, epoxy resin helps to improve mechanical and optical properties of material (Li et al., 2018).

Despite these advancements, most TW studies have been conducted on softwood or temperate hardwood species such as balsa, poplar, and birch. Tropical hardwoods, which are more abundant and denser in regions like Malaysia, have been less explored. Given that the building sector in Malaysia accounts for about 66% of national energy consumption, there is a growing interest in developing energy-efficient materials using local resources. This opens an opportunity to explore native Malaysian species such as meranti merah, mempisang, and kedondong, which differ in lignin content, density, and anatomical structure.

The interesting findings showed that 90% light could pass through this medium