UNIVERSITI TEKNOLOGI MARA

DEVELOPMENT AND CHARACTERIZATION OF ADHESIVES FROM SODA BAMBOO LIGNIN

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

Faculty of Applied Sciences

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CONFIRMATION BY PANEL OF EXAMINERS

I certify that a Panel of Examiners has met on 8th February 2018 to conduct the final examination of Syaiful Bin Osman in his **Doctor of Philosophy** thesis entitled "Development and Characterization of Adhesives from Soda Bamboo Lignin" in accordance with Universiti Teknologi MARA Act 1976 (Akta 173). The Panel of Examiner recommends that the student be awarded the relevant degree. The Panel of Examiners was as follows:

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AUTHOR'S DECLARATION

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

I, hereby, acknowledge that I have been 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

Bamboo has great potential to be utilized for various purposes. It has always been associated with traditional way of Malaysian rural lifestyle. Nevertheless, time is changing and sustainability issue has increased the popularity of bamboo as sustainable supply for valuable chemical that are mostly derived from non-renewable resources nowadays. The aims of current study were, (1) to evaluate the physicochemical characteristic of four Malaysian bamboo species that is Semantan (*Gigantochloa scortechinii*), Beting (*Gigantochloa levis*), Lemang (*Schizostachyum brachyladum*) and Akar (*Bambusa vulgaris*) (2) to determine the properties lignin extracted from Malaysian bamboo and subsequently (3) to develop lignin phenol formaldehyde adhesive resins and characterize its physical, chemical and mechanical properties. Lignin was obtained from bamboo via soda pulping method using autoclave at elevated temperature and pressure. For the synthesis of lignin phenol formaldehyde, two types of bamboo lignin namely Semantan and Beting bamboo were chosen with percentage of lignin to phenol replacement were 5%, 10%, 15% and 20%. Results indicated that there was little variation in terms of extractive and major chemical composition regardless of differences in terms of species studied although there were significant differences in Et-OH extractive content, holocellulose and alpha-cellulose content among Malaysian bamboo studied. The ash content value of Malaysian bamboo is 5.43% to 8.50%. Malaysian bamboo has fiber crystallinity of 44.4%, 43.2%, 42% and 43.3% respectively for Semantan, Beting, Lemang, and Akar. Three major ash forming elemental composition was potassium (K), calcium (Ca) and magnesium (Mg). All bamboo lignin exhibit high degree of similarity to each other in terms of functional groups that exist. Bamboo lignin mainly composed of Guaiacyl (G) and Syringyl (S) type lignin. The thermal study shows that bamboo has generally low glass temperature (T_g) and high stability at high temperature (800◦C). In the final part of this study, lignin-phenol-formaldehyde (LPF) adhesive resin was synthesized in laboratory using Semantan and Beting lignin. The physical, chemical and mechanical properties of the LPF were characterized and compared with the pure phenol formaldehyde (PF) used as control. Results obtained in this study revealed the potential of bamboo lignin as partial replacement of phenol in the synthesis of PF adhesives without compromising the properties of adhesives. Both PF and lignin phenol formaldehyde have comparable physical properties with high similarity in terms of functional groups that exist. Incorporation of lignin as partial phenol replacement was found to increase the viscosity faster over time compared to pure PF. Mechanical characterization based on dry lap shear strength indicated that all LPF yield satisfactory results surpassed the requirement for relevant International Standard such as Chinese National Standard (GB/T 14732). Results obtained in this study manifest the potential of bamboo lignin as partial replacement of phenol during the synthesis of PF adhesives without compromising the properties of adhesives itself. This research has touch some critical subjects on bamboo that contributes to the significant comprehensive understanding in terms of properties of the selected Malaysian bamboo and subsequently the properties of lignin from bamboo and its application in bio based green adhesives.

TABLE OF CONTENTS