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ORIGINAL RESEARCH

Novel natural rubber latex/lignin-based bio-adhesive: synthesis and its application on medium density fiber-board

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Abstract

The phenolic content in lignin makes it a potential substitute for formaldehyde-based synthetic wood adhesives. In the present work, lignin isolated from Hevea brasiliensis was treated with laccase enzyme to obtain active lignin. The activated lignin (NaOH treated) was further formulated with natural rubber latex (NR-latex) to prepare bio-adhesive. Complementary analysis such as modulus of rupture (MoR), modules of elasticity (MoE), internal bonding (IB), Fourier transform infrared (FTIR) spectroscopy, thickness swelling (TS), and scanning electron microscopy (SEM) were applied to characterize a medium density fibre-board (MDF) prepared based on bio-adhesive formulation. It was found that bio-adhesive formulation of 10 g NR-latex with 10 g of lignin has the highest MoR of 16 MPa, while the formulation of 15 g NR-latex with 5 g lignin showed the highest MoE of 15 MPa. The TS result showed that there is a weight gain on MDFs with a lower proportion of NR-latex content which consequently increases the density of the composites. The FTIR analysis of formulated bio-adhesive revealed the significant difference in chemical composition with different proportions of lignin and NR-latex in bio-adhesive. Finally, SEM examination of the interfaces of formulated bio-adhesive and wood fibre material showed the better dispersion with no adhesive lumps.

Keyword Bio-adhesive · Lignin · Natural rubber latex · Medium density fibre-board · Bending strength · Internal bonding · Synthetic-adhesive

Introduction

The global wood-adhesive industry is supported by the petrochemical derived resins due to their superior ability to yield high performance [1, 2]. Being an industrially preferred material for high profit, these resins are strongly associated with the emission of carcinogenic gases [3, 4]. The formaldehyde bearing adhesives have been confirmed to possess chronic toxic risks to both human health and the environment [5, 6], which spurred the development of regulations for formaldehyde emission standards of composite wood products by The United States Environment Protection Agency as well as subsequent bans on these harmful resins by developing countries such as China, Japan and Europe [7]. In addition, the over-dependency on synthetic resins derived from petroleum sources has been a red flag alert at the same time. This is mainly because petroleum shortage has been an interesting topic of concern globally with aligning peaking demands on the non-renewable sources [8, 9]. Consequently, after a thorough consideration of the environmental and threat to users' health issues manifested in "legally restricted applications of the finite non-renewable materials for adhesives in composite wood products' manufacturing", a vivid and extravaganza transition of interests from these synthetic materials to biomaterials have been reported among researchers [10, 11]. Therefore, various attempts have been undertaken to find a novel wood adhesive formulations from renewable resources [12, 13].

NR latex is a milky fluid that contains small particles of rubber from the *Hevea brasiliensis* tree and is dispersed in aqueous form [14]. As Malaysia owns one of the largest rubber plantations in the world, the raw material supply is abundant so the rubber-based industries are developed in this

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