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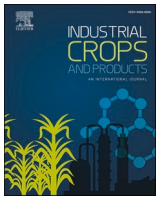

Efficient lignin extraction from oil palm empty fruit bunches using guanidine-based deep eutectic solvents under microwave assistance

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ABSTRACT

The abundance of oil palm empty fruit bunches (OPEFB) in Malaysia necessitates effective waste management strategies. Deep eutectic solvents (DES), particularly chloride-based ones like guanidine hydrochloride (GHCl), offer green and economical pretreatment options for lignocellulosic biomass, enhancing lignin extraction. To the best of current knowledge, no prior investigations have focused on the properties of lignin extracted using this DES system. Therefore, this study investigates the efficient extraction of lignin from oil palm empty fruit bunches (OPEFB) utilizing guanidine-based deep eutectic solvents (GHDES) under microwave assistance. Guanidine hydrochloride (GHCl) is introduced as a hydrogen bond acceptor (HBA) in DES formation, particularly in the GHCl: lactic acid (LA) system. The study systematically investigates the influence of different pretreatment parameters (time and temperature) on the structure and properties of the extracted lignin. Remarkably, guanidine-based DES shows exceptional effectiveness in disrupting the OPEFB structure, resulting in highly efficient lignin extraction. Analyzes show that the DES-extracted lignin has comparable properties to other DES systems, with consistent structural and thermal properties observed at various reaction temperatures and times. Notably, the extracted lignin at 120 °C for 30 min exhibited high yield, minimal impurity content, significant phenolic content, and reduced weight loss. This study not only contributes to the sustainable use of lignin but also highlights the versatility of guanidine-based DES in the utilization of lignocellulosic biomass. The promising results position guanidine-based DES as a viable and innovative candidate for lignin extraction in various applications and promote progress in the utilization of renewable biomass resources.

1. Introduction

The abundance of biomass has sparked interest in the generation of liquid fuels and chemicals in the face of depleting petroleum resources and associated environmental issues. Additionally, it is reported that 14 % of the world's renewable production comes from this renewable resource (Krishnan et al., 2022). Malaysia, as one of the world's major palm oil producers, it is impossible to ignore the abundance of this renewable biomass, particularly oil palm empty fruit bunches (OPEFB). According to Umar et al. (2021), its significant palm oil import is based on its massive oil palm plantation of over 5.4 million hectares, which accounts for nearly 90 % of Malaysia's lignocellulosic biomass waste (Umar et al., 2021). If not appropriately managed, this abundance of biomass waste will lead to environmental issues despite being a resource for high-value applications (Harun et al., 2021). Therefore, there is a need to find a better solution to handle this abundance of OPEFB, especially for producing value-added products.

The composition of OPEFB can be divided into three main constituents: cellulose (42–63 %), hemicellulose (20.27–33 %) and lignin (10–36.6 %) (Yaakob et al., 2021). These three constituents in OPEFB give an advantage in producing value-added products. For instance, Ichwan et al. (2023) demonstrated that integrating OPEFB nanocellulose into aligned electrospun cellulose acetate butyrate nanofiber networks can improve the interlaminar fracture durability of a carbon fiber epoxy resin laminate (Ichwan et al., 2023). However, lignin remains underutilized among these three constituents due to the difficulties of

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