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Oxidant-assisted adsorption using lignocellulosic biomass-based activated carbon

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ABSTRACT

The present study aimed to synthesize adsorbent from palm kernel shell (PKS) namely, activated carbon (AC) impregnated with magnesium oxide (AC-PKS-Mg) via hydrothermal process for palm oil effluent treatment. The structure and the morphology of biomass-based activated carbons were studied in detail using Brunauer-Emmett-Teller-Barrett-Joyner-Halenda (BET-BJH), X-ray Diffraction (XRD), Fourier-Transform Infrared Spectroscopy (FTIR), and Scanning Electron Microscopy/Energy-Dispersive X-ray Spectroscopy (SEM/EDX) techniques. The biosorbents were tested for treating palm oil effluent using iron oxide/peroxide-assisted adsorption. The FTIR analysis confirmed the presence of hydroxyl groups and C—H stretching attributed to the lignocellulose characteristics of the bio sorbents. The iron oxide/peroxide-assisted adsorption confirmed that activated carbon-palm kernel shell-magnesium oxide (AC-PKS-Mg) achieved a highest color removal of 94.5 % and 83 % of chemical oxygen demand (COD) at pH 3 within 10 min using 1.1 g/L of adsorbent, 250 mg/L of oxidant and 130 mg/L of iron oxide compared to AC-PKS. The pseudo-second-order model described the adsorption kinetics for AC-PKS-Mg, indicating that chemisorption is predominant. Also, the results of the regeneration capacity test clearly show that the adsorption capacity of AC-PKS-Mg has not been significantly weakened after four adsorption–desorption processes, which indicates that the adsorbent is a promising material in the field of adsorption.

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1. Introduction

Malaysia is the second largest producer of crude palm oil after Indonesia, with a total production of approximately 26 million metric tons in 2021 [1]. However, massive plantation and over-exploitation of palm oil also contribute to about 90 % of overall lignocellulosic biomass waste generation, which causes huge disposal problems [2]. Accordingly, more than 70 % of empty fruit bunches (EFB), oil palm trunks (OPT), oil palm fronds (OPF), palm pressed fibers (PPF), and palm kernel shells (PKS) are discarded as waste and disposed into landfills [3]. On the other hand, producing palm oil also generates around 60 % of palm oil mill effluent (POME). It should be noted that 1 million tonnes of crude palm oil produce approximately 2.76 million tonnes of POME [4].

The conversion of carbonaceous agricultural wastes into sustainable adsorbents has created a novel insight into developing green adsorbents with low-cost but high efficiency. In the past few years, the utilization of agricultural biomass such as sugarcane bagasse [5], palm kernel shell (PKS) [6], rice husk [7] and banana peel [8], to synthesize activated carbon has attracted many researchers. Moreover, agricultural wastes also have higher porous structure and contains oxygenated functional groups such as hydroxyl, ether, and carbonyl groups and other reactive groups such as methyl groups, which can bind pollutants through hydrogen bonding, electrostatic attraction, and π-π interaction and increase the adsorption property of the adsorbent [9]. Among the agricultural wastes, high lignin (53.85 %), carbon (51.6 %), and low ash (1.12 %) contents are the desired properties of PKS to be converted into activated carbon [10]. The literature studies

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