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Simulation and Experimentation of Volatile Fatty Acid Extraction Using Ion Exchange Resins During Food Waste Biomethanation

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Abstract

Biomethanation is a promising technology for valorizing organic wastes, including food waste, which produces methane-rich biogas and organic fertilizer (Nwabunwanne Nwokolo et al., 2020). Various intermediate products will be formed during the biomethanation process. Enhanced food waste biomethantion is achieved by removing excess volatile fatty acids (VFA) formed due to the presence of readily hydrolyzable organic compounds (Hui Geng et al., 2022). Utilizing ion exchange resin for VFA removal is more advantageous, as it has higher adsorption efficiency than other carbon conductive materials. Modern synthetic resins such as lewatit, amberlyst, and amberlite provide unique advantages for VFA removal (A. Kaushik et al., 2018). However, the development and boundary conditions of ion exchange systems in biomethantion are least explored. Hence, accurate modeling of the ion exchange process could significantly enhance its applicability to biomethanation and reduces the time and cost involved in laboratory testing. The models Thomas, Yoon-Nelson, and Solid Film Mass Transfer can be used to estimate the saturation time, ion exchange capacity, and sizing variables of a fixed bed column of ion exchange resin. Kinetic modeling can be performed using Intraparticle Diffusion and External Liquid Film Mass Transfer models. In addition, the Aspen adsorption software tool can be used to evaluate the influence of the ion exchange resin's bed height on removing VFA and estimating performance parameters (Andrezza et al., 2021). The overall adsorption efficiency of VFA is found to be 40.85, 27.72, and 76.4 for lewatit, amberlyst, and amberlite resins, respectively. The Aspen adsorption model represents the best fit compared to the experimental data with regression value, R2 >0.99. Thus, implementing the ion exchange resin adsorption method would maintain optimal conditions for increased food waste biomethanation, contributing to increased production of methane-rich biogas. The VFA can be desorbed from the ion exchange resin, which can be regenerated and reused to replace the VFA conventionally produced from crude oil. VFAs are used as chemical building blocks, substrates for bioplastics production, and biofuels. The market value for VFA is expected to reach around 700 to 800 million USD by 2026 (Swarnima et al., 2022). Hence the ion exchange process for

VFA removal has a dual role of efficient food waste treatment and ensuring a circular economy, both leading to a sustainable environment.

Keywords: Food waste Biomethantion, Volatile Fatty Acid, Modelling, Intraparticle Diffusion Model, Value-added Products.

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