Eco-sustainable pretreatment for biodiesel production in a green chemistry perspective

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Synthetic fuels, along with biofuels such as biodiesel, are crucial for transitioning to a decarbonized energy system. Biodiesel serves as a flexible solution, with various production technologies that offer distinct advantages and disadvantages depending on different factors, including specific applications. The process of producing biodiesel from waste cooking oils (WCO) through alkaline transesterification is well-established. Nonetheless, the quality of this raw material can fluctuate depending on its source, usage, and storage conditions. Elevated levels of free fatty acids (FFA) beyond current standards can impede the efficiency of the transesterification process, necessitating deacidification. Particularly, if the oil has a high content of FFAs, typically exceeding 1-2.5%, it is essential to reduce them prior to transesterification through various chemical or physical processes. Chemical methods encompass basic neutralization, chemical or enzymatic esterification, neutralization using ion exchange resins, and biotreatment. Conversely, physical treatments involve the distillation of fatty acids in a steam stream, adsorption, membrane separation, and extraction using solvents or supercritical fluids. Adsorption is a cost-effective and straightforward method for pretreatment. Consequently, recent innovations in biodiesel production have explored the potential of various adsorbents to mitigate the acidity of waste cooking oils. Industrial waste has shown the most effective performance, achieving notable reductions in acidity. A detailed study further explored how temperature and the oil-to-adsorbent ratio (O/A) influence deacidification efficiency. The highest adsorption rate was achieved after six hours at 40 °C with an O/A ratio of 8, resulting in an adsorption of 34.3 mg/g. A kinetic analysis was performed using the collected experimental data, incorporating the primary kinetic models in both linear and non-linear forms to refine the pretreatment process. Results were then compared with commercial materials like Magnesol and Miroil Fry Powder, utilized for oil regeneration and as stabilizers in restaurants and fast food establishments. Finally, the proposed pretreatment strategy was assessed from a green chemistry viewpoint by calculating several green metrics. The balance of green chemistry gauges the reaction’s environmental friendliness, represented by the average value of the selected normalized green metrics, with the optimal value nearing 1 (or 100%).

Keywords: *waste cooking oil, deacidification, adsorption, industrial waste, green chemistry.*