Microturbulence-assisted Biodiesel Transesterification with the Use of Reticulated Vitreous Carbon

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Abstract

The rising global awareness to move away from the ecologically unsustainable fossil fuel has led to the growing demands for the cleaner and renewable biomass-based biodiesel. While the production of biodiesel has increased nine-folds in the past decade to 33.2 billion litres, biodiesel production methods through transesterification remains inefficient. The present day low mass transfer rates of current reactor design lead to slower reaction. In this study, a microturbulence-assisted transesterification intensification method is investigated through the use of a novel Reticulated Vitreous Carbon (RVC) integrated mechanical stirrer reactor. RVC is a glassy carbon which has favourable material properties, such as superior shearing stress, high surface to volume ratio due to its foamy characteristics, high void volume, extreme chemical tolerance and high-temperature resistance. To improve the mixing of oil and alcohol, thus increasing mass transfer during initial stages of transesterification, four parameters of interest such as agitation speed (100-400 rpm), temperature (40-70 °C), catalyst loading (0.5-1.5 wt%), methanol to oil ratio (4:1-7:1) were investigated. This leads to a comprehensive test matrix of 234 experimental points to quantify the biodiesel conversion rate and final yield, as determined by the EN 14103 standards for quantifying fatty acid methyl esters (FAME). The effects of RVC-induced microturbulence are compared against a baseline mechanical agitator identical in dimensions. The transesterification intensification results using RVC exhibits augmentation in FAME level during the initial physical-limiting mixing stage (0-360 seconds), where the biodiesel conversion surpasses baseline up to 15% for agitation rate studies. This suggest that the microturbulence-induced by the microvoid of RVC, increases the oil-methanol mass transfer. However, as the FAME level saturates, biodiesel conversion slows down since reaction has reached chemical equilibrium. Results reflects that RVC is able to run on lower operating conditions, to achieve the similar yield as high operating conditions when compared with baseline, such as molar ratio and temperature studies, where the maximum
difference in yield is only 3% within the tested range. In conclusion, microturbulence generated from RVC for the novel reactor has the potential to overcome the current low mass transfer-induced physical-limiting barrier, improving the production process of the cleaner biodiesel.