

SINTESIS KATALIS KALSIUM OKSIDA TERIMPREGNASI MOLIBDENUM DAN TERFUNGSIONALISASI AMINOSILAN UNTUK KONVERSI MINYAK NYAMPLUNG MENJADI BIODIESEL MELALUI ESTERIFIKASI-TRANSESTERIFIKASI

Firanti Zulkarnain
22/502758/PA/21581

INTISARI

Sintesis katalis kalsium oksida terimpregnasi molibdenum dan terfungsionalisasi aminosilan untuk konversi minyak nyamplung menjadi biodiesel telah berhasil dilakukan. Penelitian ini bertujuan untuk mensintesis dan mengkarakterisasi katalis Mo/CaO-APTMS, mengevaluasi performa katalis, mengoptimasi kondisi reaksi menggunakan metode *Response Surface Methodology* (RSM), serta menguji kemampuan *reusability* katalis. Impregnasi Mo dilakukan melalui metode *ultrasound-assisted spray impregnation*, sedangkan fungsionalisasi 3-APTMS dilakukan melalui metode *ultrasound-assisted grafting*. Katalis dikarakterisasi menggunakan FTIR, XRD, NH₃-TPD, CO₂-TPD, SAA, SEM-EDX Mapping, dan XPS. Optimasi dilakukan menggunakan RSM berbasis *Central Composite Design* (CCD) dengan waktu reaksi, konsentrasi katalis, dan rasio molar metanol sebagai variabel bebas, serta *yield* biodiesel sebagai variabel respons.

Hasil penelitian menunjukkan bahwa katalis Mo/CaO-APTMS memiliki gugus hidroksil (-OH), ion karbonat (CO₃²⁻), serta ikatan logam-oksigen (M-O) yang mengindikasikan keberhasilan modifikasi permukaan katalis. Katalis ini memiliki ukuran kristal sebesar 27,76 nm, luas area spesifik 5,799 m²/g, volume pori total 0,063 cm³/g, dan diameter pori rata-rata 43,82 nm. Selain itu, total keasaman dan kebasaan katalis Mo/CaO-APTMS masing-masing sebesar 2,4379 dan 3,5405 mmol/g, lebih tinggi dibandingkan CaO dan Mo/CaO. Hasil tersebut menunjukkan bahwa modifikasi Mo dan APTMS mampu menghasilkan katalis dengan karakter permukaan yang lebih baik dibandingkan katalis sebelum modifikasi. Pada konversi minyak nyamplung menjadi biodiesel dengan kondisi reaksi yang sama, katalis Mo/CaO-APTMS menghasilkan *yield* tertinggi sebesar 82,00%. Optimasi menggunakan RSM berbasis CCD memberikan kondisi optimum pada waktu reaksi 1,17 jam, konsentrasi katalis 2,34%, dan rasio molar metanol:minyak 12:1, dengan *yield* biodiesel sebesar 68,40%. Katalis Mo/CaO-APTMS juga masih dapat digunakan kembali hingga tiga siklus reaksi dengan *yield* berturut-turut sebesar 68,40; 64,99; 59,83%, sehingga masih mampu mempertahankan aktivitas katalitiknya dalam produksi biodiesel.

Kata kunci: biodiesel, kalsium oksida, minyak nyamplung, *reusability*, *Response Surface Methodology* (RSM)

SYNTHESIS OF MOLYBDENUM-IMPREGNATED AND AMINOSILANE-FUNCTIONALIZED CALCIUM OXIDE CATALYST FOR THE CONVERSION OF NYAMPLUNG OIL INTO BIODIESEL THROUGH ESTERIFICATION-TRANSESTERIFICATION

Firanti Zulkarnain

22/502758/PA/21581

ABSTRACT

The synthesis of molybdenum-impregnated and aminosilane-functionalized calcium oxide catalyst for the conversion of nyamplung oil into biodiesel was successfully carried out. The objective of this study was to synthesize and characterize the Mo/CaO-APTMS catalyst, evaluate its catalytic performance, optimize the reaction conditions using Response Surface Methodology (RSM), and investigate its reusability. Mo impregnation was performed using the ultrasound-assisted spray impregnation method, while 3-APTMS functionalization was carried out through the ultrasound-assisted grafting method. The catalyst was characterized using FTIR, XRD, NH_3 -TPD, CO_2 -TPD, SAA, SEM-EDX mapping, and XPS. The reaction conditions were optimized using RSM based on Central Composite Design (CCD), with reaction time, catalyst loading, and methanol to oil molar ratio as independent variables, and biodiesel yield as the response variable.

The results showed that the Mo/CaO-APTMS catalyst contained hydroxyl group (-OH), carbonate ions (CO_3^{2-}), and metal-oxygen (M-O) bonds, indicating successful surface modification of the catalyst. The catalyst had a crystallite size of 27.76 nm, a specific surface area of 5.799 m^2/g , a total acidity and basicity of Mo/CaO-APTMS were 2.4379 and 3.5405 mmol/g, respectively, which were higher than those of CaO and Mo/CaO. These results indicate that Mo impregnation and APTMS functionalization improved the surface properties of the catalyst compared with the unmodified catalyst. Under the same reaction conditions, Mo/CaO-APTMS produced the highest biodiesel yield of 82.00%. The RSM-CCD optimization gave the optimum conditions at a reaction time of 1.17 h, catalyst loading of 2.34%, and methanol to oil molar ratio 12:1, resulting in a biodiesel yield of 68.40%. The Mo/CaO-APTMS catalyst could also be reused for up to three reaction cycles, with yield of 68.40; 64.99; and 59.83%, respectively, indicating that the catalyst was still able to maintain its catalyst activity in biodiesel production.

Keywords: biodiesel, calcium oxide, nyamplung oil, reusability, Response Surface Methodology (RSM)