

**KATALIS HETEROGEN  $\text{SO}_4/\text{ZrO}_2$  DAN  $\text{Na}_2\text{O}/\text{ZrO}_2$ : PREPARASI, KARAKTERISASI, DAN APLIKASINYA UNTUK KONVERSI LOW GRADE CRUDE PALM OIL MENJADI BIODIESEL**

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**INTISARI**

Katalis  $\text{SO}_4/\text{ZrO}_2$  dan  $\text{Na}_2\text{O}/\text{ZrO}_2$  telah berhasil disintesis dan diaplikasikan pada tahap esterifikasi dan transesterifikasi untuk mengonversi *Low Grade Crude Palm Oil* (LGCP O) menjadi biodiesel. Katalis asam dan basa heterogen tersebut disintesis menggunakan metode impregnasi basah dengan variasi konsentrasi (0,3; 0,5; dan 0,7 M  $\text{H}_2\text{SO}_4$  dan 1, 2, 3, dan 4 M NaOH) dan temperatur kalsinasi (400, 500, 600, 700, dan 800 °C) untuk memperoleh katalis dengan total keasaman dan kebasaan tertinggi. Karakterisasi katalis meliputi FTIR, XRD, metode gravimetri untuk menentukan total keasaman, metode indikator Hammett untuk menentukan total kebasaan, SEM yang dikombinasikan dengan EDX, dan *surface area analyzer*. Karakterisasi hasil transesterifikasi meliputi FTIR, GC-MS, dan  $^1\text{H-NMR}$ .

Hasil karakterisasi katalis menunjukkan bahwa katalis  $\text{SO}_4/\text{ZrO}_2$  memiliki total keasaman tertinggi yakni 5,51 mmol  $\text{g}^{-1}$  pada konsentrasi 0,7 M  $\text{H}_2\text{SO}_4$  dan temperatur kalsinasi 500 °C. Katalis  $\text{Na}_2\text{O}/\text{ZrO}_2$  memiliki total kebasaan tertinggi yakni 1,70 mmol  $\text{g}^{-1}$  pada konsentrasi 3 M NaOH dan temperatur kalsinasi 700 °C. Pada tahap esterifikasi, katalis 0,7 M  $\text{SO}_4/\text{ZrO}_2$ -500 dapat menurunkan kadar FFA LGCP O sebesar 54,33% dari 1,28% menjadi 0,58% pada kondisi optimum 5% berat katalis, 1:9 rasio mol LGCP O:metanol, dan 20 menit waktu reaksi. Pada tahap transesterifikasi, katalis 3 M  $\text{Na}_2\text{O}/\text{ZrO}_2$ -700 berhasil mengonversi LGCP O menjadi biodiesel sebesar 63,49%. Terbentuknya biodiesel dibuktikan dengan adanya puncak yang sesuai dengan puncak metil oleat (42,93%), metil palmitat (41,01%), metil linoleat (11,10%), metil stearat (2,88%), metil miristat (1,50%), dan metil laurat (0,59%).

Kata kunci: katalis  $\text{SO}_4/\text{ZrO}_2$ , katalis  $\text{Na}_2\text{O}/\text{ZrO}_2$ , biodiesel, esterifikasi, transesterifikasi

**HETEROGENEOUS CATALYSTS OF  $\text{SO}_4/\text{ZrO}_2$  AND  $\text{Na}_2\text{O}/\text{ZrO}_2$ : PREPARATION, CHARACTERIZATION, AND THEIR APPLICATIONS TO CONVERT LOW GRADE CRUDE PALM OIL BECOME BIODIESEL**

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**ABSTRACT**

The  $\text{SO}_4/\text{ZrO}_2$  and  $\text{Na}_2\text{O}/\text{ZrO}_2$  catalysts had been synthesized and applied to esterification and transesterification reactions to convert Low Grade Crude Palm Oil (LGCP O) become biodiesel. The heterogeneous acid and base catalysts were synthesized using wet impregnation method with variation of concentrations (0.3, 0.5, and 0.7 M  $\text{H}_2\text{SO}_4$  and 1, 2, 3, and 4 M NaOH) and calcination temperatures (400, 500, 600, 700, and 800 °C) to obtain catalyst with the highest total acidity and basicity. Characterization of catalysts included FTIR, XRD, gravimetric method to determine total acidity, Hammett indicator method for total basicity determination, SEM combined with EDX, and surface area analyzer. Characterization of transesterification product included FTIR, GC-MS, and  $^1\text{H-NMR}$ .

The results of catalyst characterization showed that the  $\text{SO}_4/\text{ZrO}_2$  catalyst had the highest total acidity of  $5.51 \text{ mmol g}^{-1}$  at 0.7 M  $\text{H}_2\text{SO}_4$  concentration and 500 °C calcination temperature. The  $\text{Na}_2\text{O}/\text{ZrO}_2$  catalyst had the highest total basicity of  $1.70 \text{ mmol g}^{-1}$  at 3 M NaOH concentration and 700 °C calcination temperature. In esterification reaction, 0.7 M  $\text{SO}_4/\text{ZrO}_2$ -500 catalyst could decrease the FFA content of LGCP O by 54.33% from 1.28% to 0.58% under optimum condition of 5% catalyst weight, 1:9 mol ratio of LGCP O:methanol, and 20 minutes reaction time. In transesterification reaction, 3 M  $\text{Na}_2\text{O}/\text{ZrO}_2$ -700 catalyst succeeded in converting LGCP O to biodiesel by 63.49%. The formation of biodiesel was confirmed by the presence of peaks corresponding to the peaks of methyl oleate (42.93%), methyl palmitate (41.01%), methyl linoleic (11.10%), methyl stearate (2.88%), methyl myristate (1.50%), and methyl laurate (0.59%).

**Keywords:**  $\text{SO}_4/\text{ZrO}_2$  catalyst,  $\text{Na}_2\text{O}/\text{ZrO}_2$  catalyst, biodiesel, esterification, transesterification