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**Kajian Pengaruh Konsentrasi Logam Dan Ultrasonikasi Dalam Sintesis Katalis Pdâ€“Ni/C Pada Upgrading
Minyak Ko-Pirolisis Fraksi Kerosin Melalui Deoksigenasi Menjadi Bio-Hidrokarbon**
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KAJIAN PENGARUH KONSENTRASI LOGAM DAN ULTRASONIKASI DALAM SINTESIS KATALIS Pd–Ni/C PADA *UPGRADING* MINYAK KO-PIROLISIS FRAKSI KEROSIN MELALUI DEOKSIGENASI MENJADI BIO-HIDROKARBON

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INTISARI

Minyak hasil ko-pirolisis masih memiliki kandungan senyawa teroksigenasi yang tinggi sehingga memerlukan proses *catalytic hydrotreatment*dengan katalis bifungsional logam-asam untuk meningkatkan kualitasnya menjadi bio-hidrokarbon setara bahan bakar aviasi. Penelitian ini bertujuan untuk: (1)mengkaji pengaruh metode preparasi dengan ko-impregnasi basah dengan sekuensial bantuan gelombang ultrasonic; (2) mengevaluasi pengaruh *metal loading* terhadap distribusi logam, morfologi permukaan, dan karakteristik keasaman katalis Pd-Ni/C; serta (3)menganalisis komposisi dan distribusi senyawa hidrokarbon dalam produk minyak ko-pirolisis yang dihasilkan melalui proses *catalytic hydrotreatment*dengan katalis Pd-Ni/CNi/C.

Katalis Pd-Ni/C dengan variasi *metal loading* 1%, 2%, dan 3% (rasio molar Pd:Ni = 1:1) dipreparasi melalui *sequential wet impregnation* pada penyangga karbon aktif, dengan satu varian *metal loading* 2% disintesis tambahan dengan bantuan gelombang ultrasonik (Pd-Ni/C 2%_US), diikuti kalsinasi pada 500 °C dengan gas N_2 dan reduksi pada 350 °C dengan gas H_2. Karakteristik katalis dianalisis menggunakan FTIR, XRD, SEM-EDS, dan NH_3-TPD. Sementara itu, proses *catalytic hydrotreatment*dilakukan dengan perbadingaan katalis terhampan umpan 1:20, pada suhu 250°C selama 4 jam dengan aliran gas H_2 25 bar. Minyak hasil *catalytic hydrotreating* dam dianalisis menggunakan GC-MS ddan FTIR.

Hasil penelitian yang telah berhasil dilakukan menunjukan derajat kristalinitas meningkat seiring *metal loading* sementara itu ukuran kristalin rerata 14,55 nm (1%), 16,04 nm (2%), mengecil ke 12,15 nm (3%). Citra morfologi katalis dengan SEM menunjukan pada katalis 3% mengalami aglomerasi-agregasi paling signifikan dengan kristal baru berbentuk ulir dan pori tidak merata. Keasaman total (NH_3-TPD) menngunakan metode sintesis dengan perbantuan gelombang ultrasonifikasi naik signifikan menjadi 2,4112 mmol/g pada katalis 2%_US. GC-MS produk *hydrotreatment* menujukan senyawa 2,4-dimetil-1-heptena (C_9) dominan di seluruh variasi, dengan perubahan golongan olefine menjadi parrafin diitingi penurunan *yiled* senyawa ini dan menyisakan 6,293% dengan katalis 1% .Distribusi atom karbon bergeser dari C_8 (*loading* 1%) menuju C_{10} (*loading* 3%), sejalan menurunnya intensitas *cracking* akibat aglomerasi. Deoksigenasi paling efektif pada katalis 3%, dengan *yield* oksigenat tersisa terendah (alkohol (2,4,6-trimetilsikloheksil)metanol = 0,1995%), vs katalis 1% yang masih menyisakan fraksi asam karboksilat hingga ~17%. Ultrasonikasi dalam sintesis katalispada 2% mendorong senyawa siklis-aromatik (etilbenzena dengan *yield* 2,183%) dan menekan *overcracking* (1-dekanol, 2-heksil- *yield* 1,870%).

Kata kunci: bio-hidrokarbon, *catalytic hydrotreatment*, katalis Pd-Ni/C, *metal loading*, ultrasonikasi, minyak ko-pirolisis, minyak sawit

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STUDY OF THE EFFECTS OF *METAL LOADING* AND ULTRASONICATION IN THE SYNTHESIS OF Pd–Ni/C CATALYST FOR *UPGRADING* KEROSENE-FRACTION BIO-OIL CO-PYROLYSIS VIA DEOXYGENATION INTO BIOHYDROCARBONS

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ABSTRACT

The oil produced by co-pyrolysis still contains high levels of oxygenated compounds, requiring a *catalytic hydrotreatment* process using a bifunctional *metal*-acid catalyst to improve its quality to that of aviation-grade biohydrocarbons. This study aims to: (1) investigate the effect of varying *metal loading*s (1%, 2%, and 3%) on the characteristics of the Pd-Ni/C catalyst prepared via ultrasonic-assisted wet impregnation; (2) evaluate the effect of *metal loading* on the *metal* distribution, surface morphology, and acidity characteristics of the Pd-Ni/C catalyst; and (3) analyze the composition and distribution of hydrocarbon compounds in the co-pyrolysis oil product resulting from *catalytic hydrotreatment*with the Pd-Ni/C catalyst.

Pd-Ni/C catalysts with *metal loading*s of 1%, 2%, and 3% (Pd:Ni molar ratio = 1:1) were prepared via sequential wet impregnation on an activated carbon support; one variant with a 2% *metal loading* was additionally synthesized using ultrasonic waves (Pd-Ni/C 2%_US), followed by calcination at 500 °C in N_2 gas and reduction at 350 °C in H_2 gas. The catalyst characteristics were analyzed using FTIR, XRD, SEM-EDS, and NH_3-TPD. Meanwhile, the *catalytic hydrotreatment* process was carried out with a catalyst-to-feed ratio of 1:20, at 250 °C for 4 hours with a hydrogen gas flow of 25 bar. The oil resulting from the *catalytic hydrotreatment* was analyzed using GC-MS and FTIR.

The results of the successful study show that the degree of crystallinity increases with *metal loading*, while the average crystal size is 14.55 nm (1%), 16.04 nm (2%), and decreases to 12.15 nm (3%). SEM images of the catalyst morphology show that the 3% catalyst exhibits the most significant agglomeration and aggregation, with new spiral-shaped crystals and uneven pores. Total acidity (NH_3-TPD) using the synthesis method aided by ultrasonication increased significantly to 2.4112 mmol/g in the 2%_US catalyst. GC-MS analysis of the hydro*treatment* products showed that the 2,4-dimethyl-1-heptene (C_9) compound was dominant across all variations; the shift from olefins to paraffins was accompanied by a decrease in the yield of this compound, leaving 6.293% with the 1% catalyst. The carbon atom distribution shifted from C_8 (1% *loading*) to C_{10} (3% *loading*), in line with the decrease in *cracking* intensity due to agglomeration. Deoxygenation is most effective with the 3% catalyst, yielding the lowest residual oxygenate content (2,4,6-trimethylcyclohexyl)methanol = 0.1995%), compared to the 1% catalyst, which still leaves a carboxylic acid fraction of up to ~17%. Ultrasonication assisted on synthesis catalyst at 2% promotes cyclic-aromatic compounds (ethylbenzene with yield 2.183%) and suppresses over*cracking* (1-decanol, 2-hexyl- yield 1.870%).

Keywords: *biohydrocarbons, catalyst Pd-Ni/C,catalytic hydrotreatment,metal loading, ultrasonification*