

RINGKASAN

Penelitian ini bertujuan untuk mensintesis dan mengkarakterisasi komposit karbon aktif/ Fe_3O_4 berbasis cangkang kelapa sawit sebagai adsorben untuk limbah cair yang mengandung zat warna *indigosol blue*. Sintesis dilakukan melalui tahapan preparasi, karbonisasi, aktivasi kimia menggunakan larutan H_3PO_4 10%, serta impregnasi dengan larutan garam besi yang diikuti presipitasi menggunakan NaOH. Hasil uji proksimat menunjukkan bahwa karbon aktif memiliki kadar air 3,19%, kadar abu 3,63%, zat terbang 3,92%, dan kadar karbon terikat 89,26%, yang telah memenuhi standar SNI 06-3730-1995. Spektrum FTIR menunjukkan pita serapan pada 580 cm^{-1} yang merupakan karakterisasi ikatan Fe-O dari Fe_3O_4 . Hasil SEM menunjukkan partikel Fe_3O_4 berdiameter rata-rata 94,22 nm tersebar pada permukaan karbon aktif yang berukuran 9,78 nm, dengan peningkatan luas permukaan dari $300,6\text{ nm}^2$ menjadi $27.883,6\text{ nm}^2$. Data XRD menunjukkan puncak difraksi khas Fe_3O_4 pada sudut $2\theta = 30,21^\circ, 35,69^\circ, 38,31^\circ, 57,51^\circ$, dan $62,81^\circ$, serta puncak lemah pada $21,81^\circ$ yang menunjukkan keberadaan karbon amorf. Hasil UV-Vis DRS menunjukkan nilai *band gap* sebesar 3,18 eV berdasarkan metode *Kubelka-Munk*, yang mengindikasikan sifat semikonduktor. Uji adsorpsi terhadap limbah cair *indigosol blue* menunjukkan efisiensi penyerapan maksimum sebesar 99,95% pada konsentrasi 200 ppm, pH 2-3, waktu kontak 75 menit, dan massa adsorben 0,1 g. Dengan demikian, komposit karbon aktif/ Fe_3O_4 memiliki potensi besar sebagai material adsorben untuk pengolahan limbah cair tekstil yang mengandung zat warna *indigosol blue*.

Kata Kunci: Karbon aktif, Fe_3O_4 , cangkang kelapa sawit, *indigosol blue*, adsorpsi, limbah cair, karakterisasi material.

SUMMARY

This study aims to synthesize and characterize an activated carbon/ Fe_3O_4 composite derived from oil palm shell as an adsorbent for wastewater containing indigosol blue dye. The synthesis process involved preparation, carbonization, chemical activation using 10% H_3PO_4 solution, impregnation with iron salt solution, and precipitation using NaOH. Proximate analysis showed that the activated carbon had a moisture content of 3.19%, ash content of 3.63%, volatile matter of 3.92%, and fixed carbon content of 89.26%, meeting the quality standards of SNI 06-3730-1995. FTIR spectra exhibited a characteristic absorption band at 580 cm^{-1} , indicating the presence of Fe-O bonds, confirming the incorporation of Fe_3O_4 . SEM analysis revealed that Fe_3O_4 particles with an average diameter of 94.22 nm were distributed on the surface of the activated carbon, which originally had an average particle size of 9.78 nm. The surface area increased significantly from 300.6 nm^2 to $27,883.6\text{ nm}^2$. XRD analysis confirmed the presence of crystalline Fe_3O_4 with characteristic peaks at $2\theta = 30.21^\circ$, 35.69° , 38.31° , 57.51° , and 62.81° , and a weak peak at 21.81° indicating the presence of amorphous carbon. UV-Vis DRS analysis showed a band gap value of 3.18 eV calculated using the Kubelka-Munk method, indicating semiconductor properties. Adsorption tests on indigosol blue wastewater showed a maximum removal efficiency of 99.95% at a concentration of 200 ppm, pH 2-3, contact time of 75 minutes, and adsorbent mass of 0.1 g. These results indicate that the activated carbon/ Fe_3O_4 composite has strong potential as an adsorbent material for treating textile wastewater containing indigosol blue dye.

Keywords : Activated carbon, Fe_3O_4 , oil palm shell, indigosol blue, adsorption, wastewater, material characterization