SINTESIS ZEOLIT MAGNETIK DARI LIMBAH ABU LAYANG BATUBARA DAN LUMPUR MERAH UNTUK ADSORPSI ANTIBIOTIK CIPROFLOXACIN

SKRIPSI

diajukan untuk memenuhi sebagian syarat untuk memperoleh gelar Sarjana Sains pada Program Studi Kimia

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ABSTRAK

Pencemaran air oleh antibiotik ciprofloxacin (CP) menimbulkan risiko resistensi mikroba. Penelitian ini bertujuan mensintesis zeolit magnetik dari limbah abu layang batubara dan lumpur merah melalui metode alkali fusi-hidrotermal dalam sistem batch sebagai adsorben ciprofloxacin. Sintesis dengan waktu hidrotermal 9 jam dan suhu 160℃ menghasilkan zeolit magnetik bertipe cancrinite (ZM-CAN). Karakterisasi XRF menunjukkan kandungan utama Si, Al, dan Fe sebagai unsur pembentuk kerangka zeolit dan komponen magnetik. Hasil XRD mengonfirmasi dominasi fasa kristalin cancrinite, sedangkan sifat magnetik terdeteksi melalui uji menggunakan magnet neodimium. Spektrum FTIR memperlihatkan keberadaan gugus fungsional O–H, Si–O–Al, dan Fe–O. Morfologi hasil pengamatan SEM-EDS menunjukkan bentuk heksagonal dengan distribusi unsur O, Si, Al, Na, Ca, dan Fe. Zeolit magnetik ini memiliki luas permukaan yang cukup besar, muatan permukaan negatif yang stabil, serta menunjukkan efisiensi optimum dalam proses adsorpsi ciprofloxacin pada kondisi zwiterionik. Model isoterm adsorpsi yang digunakan menunjukkan kesesuaian baik, sementara uji regenerasi dengan larutan NaCl jenuh membuktikan bahwa material ini dapat digunakan kembali dengan efisiensi yang tinggi. Secara keseluruhan, zeolit magnetik hasil sintesis berpotensi besar sebagai adsorben efektif, bersifat magnetik, dan dapat digunakan ulang untuk pengolahan limbah antibiotik.

Kata kunci: abu layang, adsorpsi, cancrinite, ciprofloxacin, lumpur merah, regenerasi, zeolit magnetik.

ABSTRACT

Water pollution caused by the antibiotic ciprofloxacin (CP) poses a significant risk of microbial resistance. This study aimed to synthesize magnetic zeolite from coal fly ash and red mud waste via an alkali fusion–hydrothermal method in a batch system as an adsorbent for ciprofloxacin. Synthesis under hydrothermal conditions at 160 °C for 9 hours yielded cancrinite-type magnetic zeolite (ZM-CAN). XRF characterization revealed Si, Al, and Fe as the major elements responsible for forming the zeolite framework and magnetic components. XRD analysis confirmed the dominance of crystalline cancrinite, while magnetic properties were detected using a neodymium magnet test. FTIR spectra indicated the presence of O–H, Si–O–Al, and Fe–O functional groups. SEM-EDS analysis showed a hexagonal morphology with elemental distribution of O, Si, Al, Na, Ca, and Fe. The synthesized magnetic zeolite exhibited a relatively large surface area, stable negative surface charge, and optimum adsorption efficiency for ciprofloxacin under zwitterionic conditions. Adsorption isotherm modeling demonstrated a good fit, while regeneration tests using saturated NaCl solution confirmed that the material can be effectively reused.Overall, the synthesized magnetic zeolite demonstrates strong potential as an effective, magnetic, and reusable adsorbent for antibiotic wastewater treatment.

Keywords*: adsorption; cancrinite; ciprofloxacin; fly ash; magnetic zeolite; red mud; regeneration.*

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