# SINTESIS ZEOLIT BERBASIS ABU TERBANG YANG DIMODIFIKASI $ZnO$ dan $Fe_3O_4$ UNTUK ADSORPSI ANTIBIOTIK KLINDAMISIN

**TESIS**

Diajukan untuk memenuhi sebagian syarat untuk memperoleh gelar Magister Sains pada Program Studi Kimia


disusun oleh:

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**KELOMPOK BIDANG KAJIAN MATERIAL**

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# LEMBAR HAK CIPTA

## SINTESIS ZEOLIT BERBASIS ABU TERBANG YANG DIMODIFIKASI ZnO DAN $Fe_3O_4$ UNTUK ADSORPSI ANTIBIOTIK KLINDAMISIN

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Sebuah Tesis yang diajukan untuk memenuhi salah satu syarat memperoleh gelar Magister Sains (M.Si.) pada Program Studi Kimia Fakultas Pendidikan Matematika dan Ilmu Pengetahuan Alam

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## PERNYATAAN

Dengan ini saya menyatakan bahwa tesis dengan judul "**Sintesis Zeolit Berbasis Abu Terbang yang Dimodifikasi ZnO dan $Fe_3O_4$ untuk Adsorpsi Antibiotik Klindamisin**" ini beserta seluruh isinya adalah benar-benar karya saya sendiri. Saya tidak melakukan penjiplakan atau pengutipan dengan cara-cara yang tidak sesuai dengan etika ilmu yang berlaku dalam masyarakat keilmuan. Atas pernyataan ini, saya siap menanggung risiko/sanksi apabila dikemudian hari ditemukan adanya pelanggaran etika keilmuan atau ada klaim dari pihak lain terhadap keaslian karya saya ini.

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Segala upaya telah penulis lakukan dalam penyusunan tesis ini. Akan tetapi, penulis menyadari akan kekurangan karena keterbatasan kemampuan dan pengetahuan penulis. Oleh karena itu, penulis mengharapkan kritik dan saran yang bersifat membangun guna memperbaiki kekurangan tersebut di masa yang akan datang. Penulis berharap dengan adanya tesis ini dapat memberikan manfaat bagi pembaca, penulis, dan terutama peneliti selanjutnya.

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Penulis

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## ABSTRAK

Peningkatan penggunaan antibiotik, seperti klindamisin, telah menyebabkan akumulasi limbah antibiotik di peraiarn yang berkontribusi pada resistensi bakteri. Salah satu metode yang efektif untuk mengatasi permasalahan ini, yaitu adsorpsi. Limbah abu terbang (FA) batu bara merupakan salah satu produk samping industri tekstil yang daur ulangnya masih rendah dan berpotensi menjadi adsorben. Penelitian bertujuan untuk memodifikasi zeolit berbasis abu terbang (ZFA) dengan seng oksida (ZnO) dan magnetit ($Fe_3O_4$) (ZFA/ZnO/$Fe_3O_4$) untuk adsorpsi antibiotik klindamisin. Metode yang digunakan dalam penelitian ini, yaitu sintesis hidrotermal dengan *autoclave* berlapis teflon untuk mendapatkan ZFA/ZnO/$Fe_3O_4$, pengujian adsorpsi menggunakan sistem *batch*, dan pengujian pengambilan kembali zeolit dari larutan dengan batang magnet neodimium. ZFA/ZnO/$Fe_3O_4$ dikarakterisasi lebih lanjut menggunakan X-ray Diffraction (XRD), X-ray Fluorescence (XRF), Fourier Transform Infrared (FTIR), zeta potensial *analyzer*, Brunauer-Emmet-Teller (BET), dan pengujian adsorpsi menggunakan instrumen Ultravioulet-Visible (UV-Vis). Hasil karakterisasi menggunakan XRD memberikan puncak khas untuk zeolit jenis NaP1 dengan sudah tidak ditemukannya puncak untuk mineral mulit dan kuarsa. Modifikasi zeolit dengan ZnO mengakibatkan hilangnya unsur natrium (Na) ketika dianalisis dengan XRF, mengindikasikan bahwa $Zn^{2+}$ menggantikan posisi $Na^{+}$ dalam zeolit. Potensial zeta didapatkan sebesar -92,3000 mengindikasikan permukaan ZFA/ZnO/$Fe_3O_4$ yang negatif. Hasil karakterisasi dengan BET menunjukkan peningkatan luas permukaan dan penurunan diameter pori pada ZFA/ZnO/$Fe_3O_4$ menjadi 24,2540 $m^2$/g dan 6,8313 nm dari 22,5931 $m^2$/g dan 7,3143 nm pada ZFA. Penurunan diameter pori terjadi karena semakin banyak mikropori yang terbentuk, tetapi pori-pori meso dan makro tetap hadir secara merata di permukaan ZFA/ZnO/$Fe_3O_4$ akibat modifikasi dengan ZnO. Modifikasi ini juga menambah situs aktif di permukaan yang berkontribusi pada peningkatan persentase adsorpsi menjadi 94,53% dari 69,23% (ZFA) pada pH 6. Mekanisme adsorpsi terjadi secara monolayer dan multilayer melalui interaksi pada gugus fungsi aktif zeolit, yaitu Si-O yang hasilnya diperkuat dengan analisis serapan gugus fungsi pada FTIR. Data isoterm adsorpsi paling sesuai untuk model Sips dengan regresi kuadrat sebesar 0,982 dan chi kuadrat sebesar 0,210. Penambahan $Fe_3O_4$ teruji meningkatkan sifat magnet dari zeolit yang dibuktikan banyaknya zeolit yang menempel pada permukaan batang magnet neodimium.

**Kata kunci:** ZFA/ZnO/$Fe_3O_4$, adsorpsi, magnetik, klindamisin, zeolit

## *ABSTRACT*

*The increased use of antibiotics, such as clindamycin, has led to the accumulation of antibiotic waste in waterways that contribute to bacterial resistance. One effective method to overcome this problem is adsorption. Coal fly ash (FA) waste is one of the textile industry by-products whose recycling is still low and has the potential to be an adsorbent. The research aims to modify fly ash-based zeolite (ZFA) with zinc oxide (ZnO) and magnetite ($Fe_3O_4$) (ZFA/ZnO/$Fe_3O_4$) for clindamycin antibiotic adsorption. The methods used in this research are hydrothermal synthesis with a Teflon-coated autoclave to obtain ZFA/ZnO/$Fe_3O_4$, adsorption testing using the batch system, and zeolite retrieval testing from solution with a neodymium magnetic rod. ZFA/ZnO/$Fe_3O_4$ characterize using X-ray Diffraction (XRD), X-ray Fluorescence (XRF), Fourier Transform Infrared (FTIR), zeta potential analyzer, Brunauer-Emmet-Teller (BET), and adsorption testing using Ultravioulet-Visible (UV-Vis) instruments. Characterization results using XRD gave typical peaks for NaP1-type zeolite, with no peaks found for mullite and quartz minerals. Modifying zeolite with ZnO resulted in the loss of sodium (Na) element when analyzed by XRF, indicating that $Zn^{2+}$ replaced the $Na^{+}$ position in the zeolite. The zeta potential was -92.3000, indicating an opposing ZFA/ZnO/Fe3O4 surface. BET characterization results showed an increase in surface area and a decrease in pore diameter in ZFA/ZnO/$Fe_3O_4$ to 24.2540 $m^2$/g and 6.8313 nm from 22.5931 $m^2$/g and 7.3143 nm in ZFA. The decrease in pore diameter occurs because more micropores form, but meso and macro pores remain evenly present on the surface of ZFA/ZnO/$Fe_3O_4$ due to modification with ZnO. This modification also increased the active sites on the surface, which contributed to an increase in the adsorption percentage from 94.53% to 69.23% (ZFA) at pH 6. The adsorption mechanism occurs in a monolayer and multilayer manner through interactions on the active functional groups of zeolite, namely Si-O, the results of which are reinforced by functional group absorption analysis on FTIR. The adsorption isotherm data best fit the Sips model with a quadratic regression of 0.982 and chi-squared of 0.210. The addition of the $Fe_3O_4$ test increases the magnetic properties of zeolites, as evidenced by the number of zeolites attached to the surface of neodymium magnetic rods.*


***Keywords**: ZFA/ZnO/$Fe_3O_4$, adsorption, magnetic, clindamycin, zeolite*

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# DAFTAR GAMBAR

# DAFTAR TABEL

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