ABSTRAK

Ali Hamzah Lubis, NIM 4221210009 (2026) Sifat Kinetika dan Termodinamika Adsorpsi Cu(II) oleh Komposit Polimer Berpori $Cu(TAC)_2$ Berbasis Limbah Plastik dengan Karbon Aktif Tandan Kosong Kelapa Sawit.

Penelitian ini dilakukan untuk mengkaji sifat kinetika dan termodinamika adsorpsi ion Cu(II) menggunakan komposit karbon aktif tandan kosong kelapa sawit (TKKS) yang dimodifikasi dengan *Metal Organic Frameworks* (MOFs) $Cu(TAC)_2$ berbasis ligan asam tereftalat hasil depolimerisasi limbah plastik PET. Sintesis komposit KA-$Cu(TAC)_2$ dilakukan melalui metode refluks menggunakan rasio logam, ligan, dan karbon aktif sebesar 1:2:3. Hasil karakterisasi XRD menunjukkan bahwa MOFs $Cu(TAC)_2$ dan komposit KA-$Cu(TAC)_2$ memiliki fase kristal triklinik dan monoklinik, sedangkan hasil SEM menunjukkan morfologi karbon aktif berlapis dan tidak beraturan dengan partikel kristalin MOFs yang terdispersi pada permukaan dan sebagian pori karbon aktif. Pengujian adsorpsi dilakukan terhadap ion Cu(II) melalui variasi massa adsorben, konsentrasi awal larutan, waktu kontak, dan suhu adsorpsi. Konsentrasi ion Cu(II) sebelum dan sesudah proses adsorpsi dianalisis menggunakan AAS. Hasil penelitian menunjukkan bahwa kondisi optimum adsorpsi diperoleh pada massa adsorben 1 g, konsentrasi awal 180 ppm, waktu kontak 30 menit, dan suhu 303 K dengan kapasitas adsorpsi sebesar 9,64 mg/g. Analisis isoterm menunjukkan bahwa proses adsorpsi lebih representatif mengikuti model Freundlich dengan nilai koefisien determinasi (R^2) sebesar 0,9457, sedangkan analisis kinetika menunjukkan bahwa proses adsorpsi lebih sesuai mengikuti model *pseudo-second-order* dengan nilai R^2 sebesar 0,9826. Hasil analisis termodinamika menunjukkan nilai $\Delta H°$ sebesar -2,848 kJ/mol, $\Delta S°$ sebesar -28,75364 J/mol·K, serta nilai $\Delta G°$ positif pada rentang suhu 303–353 K. Hasil tersebut menunjukkan bahwa proses adsorpsi berlangsung secara eksoterm, disertai penurunan ketidakteraturan sistem, serta cenderung kurang spontan pada suhu yang lebih tinggi.

Kata kunci: adsorpsi, Cu(II), karbon aktif, MOFs $Cu(TAC)_2$, kinetika, termodinamika.

ABSTRACT

Ali Hamzah Lubis, NIM 4221210009 (2026) Kinetic and Thermodynamic Properties of Cu(II) Adsorption by a Porous Polymer Composite $Cu(TAC)_2$ Based on Plastic Waste with Oil Palm Empty Fruit Bunch Activated Carbon.

This study aimed to investigate the kinetic and thermodynamic properties of Cu(II) ion adsorption using an activated carbon composite derived from oil palm empty fruit bunches (EFB), modified with $Cu(TAC)_2$ Metal Organic Frameworks (MOFs) based on terephthalic acid ligands obtained from the depolymerization of PET plastic waste. The KA-$Cu(TAC)_2$ composite was synthesized using a reflux method with a metal-to-ligand-to-activated carbon ratio of 1:2:3. XRD characterization showed that the $Cu(TAC)_2$ MOFs and KA-$Cu(TAC)_2$ composite exhibited triclinic and monoclinic crystal phases, while SEM analysis revealed a layered and irregular activated carbon morphology with crystalline MOF particles dispersed on the surface and within some of the pores of the activated carbon. Adsorption experiments were conducted using Cu(II) ions by varying the adsorbent mass, initial solution concentration, contact time, and adsorption temperature. Cu(II) ion concentrations before and after the adsorption process were analyzed using AAS. The results showed that the optimum adsorption conditions were obtained at an adsorbent mass of 1 g, an initial concentration of 180 ppm, a contact time of 30 minutes, and a temperature of 303 K, with an adsorption capacity of 9.64 mg/g. Isotherm analysis showed that the adsorption process was more representatively described by the Freundlich model, with a coefficient of determination (R^2) of 0.9457, while kinetic analysis indicated that the adsorption process was better described by the pseudo-second-order model, with an R^2 value of 0.9826. Thermodynamic analysis yielded $\Delta H°$ of −2.848 kJ/mol, $\Delta S°$ of −28.75364 J/mol·K, and positive $\Delta G°$ values over the temperature range of 303–353 K. These results indicate that the adsorption process was exothermic, accompanied by a decrease in system disorder, and tended to become less spontaneous at higher temperatures.

Keywords: adsorption, Cu(II), activated carbon, MOFs $Cu(TAC)_2$, kinetics, thermodynamics.