KAJIAN KINETIKA, ISOTERM DAN TERMODINAMIKA ADSORPSI ZAT WARNA KATIONIK KRISTAL VIOLET MENGGUNAKAN ABU LAYANG BATUBARA TERAKTIVASI

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INTISARI

Penelitian kajian kinetika, isoterm dan termodinamika adsorpsi zat warna kationik kristal violet menggunakan abu layang batubara teraktivasi yang berasal dari PLTU Muara Enim Palembang telah dilakukan. Tujuan dari penelitian ini adalah mengaktivasi abu layang batubara serta melakukan adsorpsi zat warna kationik kristal violet menggunakan abu layang batubara tanpa aktivasi dan teraktivasi. Parameter yang dipelajari meliputi pengaruh pH, massa adsorben, penentuan kinetika dan energi aktivasi, isoterm adsorpsi dan termodinamika adsorpsi ($\Delta G°$, $\Delta H°$, dan $\Delta S°$), serta aplikasi adsorpsi zat warna kristal violet dalam sampel buatan.

Penelitian ini diawali dengan proses aktivasi abu layang batubara oleh HCl 6 M. Karakterisasi abu layang batubara tanpa aktivasi dan teraktivasi dilakukan dengan menggunakan Spektrofotometer Serapan Atom (AAS), *X-Rays Fluorescence* (XRF), Spektroskopi Inframerah (FT-IR), Difraksi Sinar-X (XRD), dan *Scanning Electron Microscope Energy Dispersive X-ray Spectroscopy* (SEM-EDX).

Hasil penelitian menunjukkan bahwa abu layang batubara teraktivasi memiliki kemampuan adsorpsi yang lebih baik daripada tanpa aktivasi. Adsorpsi zat warna kristal violet mencapai optimum pada pH 8 dengan massa adsorben 0,40 g. Adsorpsi zat warna kristal violet menggunakan abu layang batubara tanpa aktivasi dan teraktivasi pada berbagai temperatur mengikuti model kinetika pseudo orde dua Ho dan McKay dengan model isoterm Langmuir. Nilai K_L mengalami kenaikan fungsi linier dengan kenaikan temperatur, yang menunjukkan proses adsorpsi bersifat endotermis. Nilai energi aktivasi (E_a) adsorpsi zat warna kristal violet menggunakan abu layang batubara tanpa aktivasi dan teraktivasi masing-masing sebesar 26,90 kJ/mol dan 20,60 kJ/mol. Kajian termodinamika adsorpsi menunjukkan nilai energi bebas standar Gibbs untuk abu layang batubara tanpa aktivasi ($-\Delta G°$) pada temperatur 290, 300, 310, dan 320 K sebesar 24,63; 25,96; 27,01; dan 28,08 kJ/mol, sedangkan untuk teraktivasi adalah 25,36; 26,72; 27,83; dan 28,29 kJ/mol. Nilai perubahan entalpi standar ($\Delta H°$) pada rentang temperatur tersebut sebesar +8,42 kJ/mol untuk abu layang tanpa aktivasi dan +9,23 kJ/mol untuk teraktivasi. Nilai perubahan entropi standar ($\Delta S°$) masing-masing sebesar +114,23 kJ/mol dan +119,50 kJ/mol. Hal ini mengindikasikan bahwa proses adsorpsi dipicu oleh faktor entropi. Aplikasi adsorpsi zat warna kristal violet dalam sampel buatan menunjukkan bahwa abu layang batubara efektif dalam mengadsorpsi zat warna tersebut.

Kata kunci: abu layang batubara, kristal violet, isoterm, kinetika, termodinamika.

KINETIC, ISOTHERM AND THERMODYNAMIC STUDIES ON THE ADSORPTION OF CATIONIC CRYSTAL VIOLET USING ACTIVATED COAL FLY ASH

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ABSTRACT

Research on isotherm, kinetics, and thermodynamics of adsorption of cationic crystal violet dye using activated coal fly ash from PLTU Muara Enim Palembang has been carried out. The purpose of this study was to activate coal fly ash and to adsorb cationic crystal violet dye with inactivated and activated coal fly ash. The parameters studied included the effect of pH, adsorbent mass, determination of kinetics and activation energy, adsorption isotherms, and thermodynamics adsorption (ΔG°, ΔH°, and ΔS°), as well as the adsorption application of crystal violet dye in artificial samples.

This study begins with the activation process of coal fly ash by 6 M HCl. Characterization of inactivated and activated coal fly ash was carried out using Atomic Absorption Spectrophotometer (AAS), X-Rays Fluorescence (XRF), Infrared Spectroscopy (FT-IR), X-Ray Diffraction (XRD), and Scanning Electron Microscope Energy Dispersive X-ray Spectroscopy (SEM-EDX).

The results showed that activated coal fly ash had a better adsorption ability than without activation. The adsorption of crystal violet dye reached its optimum at pH 8 with an adsorbent mass of 0.40 g. The adsorption of crystal violet dye using coal fly ash was inactivated and activated at various temperatures following the Ho and McKay pseudo-second-order kinetic model with the Langmuir isotherm model. The value of K_L has a linear function increase with increasing temperature, which indicates the adsorption process is endothermic. The value of activation energy (E_a) for adsorption of crystal violet dye using inactivated and activated coal fly ash was 26.90 kJ/mol and 20.60 kJ/mol, respectively. The study of adsorption thermodynamics showed that the Gibbs standard free energy values for coal fly ash without activation (-ΔG°) at temperatures of 290, 300, 310, and 320 K were 24.63; 25.96; 27.01; and 28.08 kJ/mol, while for the activated it is 25.36; 26.72; 27.83; and 28.29 kJ/mol. The standard enthalpy change value (ΔH°) in that temperature range is +8.42 kJ/mol for fly ash without activation and +9.23 kJ/mol for activated. The standard entropy change values (ΔS°) were +114.23 kJ/mol and +119.50 kJ/mol, respectively. This indicates that the adsorption process is triggered by the entropy factor. The application of crystal violet dye adsorption in artificial samples showed that coal fly ash was effective in the adsorption of the dye.

Keywords: coal fly ash, crystal violet, isotherm, kinetics, thermodynamics.