

**ISOTHERM, KINETIKA, DAN TERMODINAMIKA ADSORPSI ZAT
WARNA MALACHITE GREEN MENGGUNAKAN ABU LAYANG
BATUBARA TERAKTIVASI ASAM KLORIDA**

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INTISARI

Penelitian tentang isotherm, kinetika, dan termodinamika adsorpsi zat warna *malachite green* menggunakan abu layang batubara dari Pembangkit Listrik Tenaga Uap (PLTU) Tanjung, Muara Enim, Sumatra Selatan telah dilakukan. Tujuan penelitian ini adalah menentukan isotherm, kinetika, dan parameter termodinamika adsorpsi zat warna *malachite green* menggunakan abu layang batubara teraktivasi asam klorida. Proses aktivasi abu layang batubara menggunakan HCl 6 M dan hasilnya dikarakterisasi menggunakan SSA, XRF, FT-IR, dan XRD. Parameter adsorpsi yang dievaluasi dalam penelitian ini meliputi pengaruh pH larutan, pengaruh massa adsorben, kinetika adsorpsi, energi aktivasi, isotherm adsorpsi dan parameter termodinamika adsorpsi (ΔG° , ΔH° dan ΔS°). Konsentrasi zat warna *malachite green* dalam larutan sebelum dan sesudah adsorpsi ditentukan menggunakan spektrofotometer UV-Vis.

Hasil penelitian menunjukkan bahwa abu layang batubara teraktivasi (ALBT) memiliki kemampuan adsorpsi yang lebih baik dari abu layang batubara tanpa aktivasi (ALB). Kinetika adsorpsi zat warna *malachite green* oleh ALB dan ALBT pada berbagai temperatur mengikuti kinetika *pseudo* orde dua Ho dan McKay dan mengikuti isotherm Langmuir. Harga K_L mengalami kenaikan seiring dengan meningkatnya temperatur, menunjukkan bahwa adsorpsi bersifat endotermis. Nilai energi aktivasi adsorpsi (E_a) zat warna *malachite green* oleh ALB dan ALBT berturut-turut sebesar 88,74 dan 72,11 kJ mol⁻¹. Pada penentuan parameter termodinamika adsorpsi diperoleh nilai perubahan energi bebas Gibbs standar (ΔG°) pada temperatur 293, 303, 313 dan 323 K untuk ALB dan ALBT semakin meningkat seiring dengan penambahan temperatur. Nilai perubahan entalpi standar (ΔH°) pada rentang temperatur tersebut untuk ALB dan ALBT berturut-turut sebesar +18,54 dan +14,77 kJ mol⁻¹, sedangkan untuk nilai perubahan entropinya (ΔS°) masing-masing sebesar +148,57 dan +137,96 J mol⁻¹ K⁻¹ yang mengindikasikan bahwa proses adsorpsi bersifat spontan dan dipicu oleh faktor entropi. Aplikasi adsorpsi pada sampel buatan menunjukkan bahwa kadar *malachite green* dalam sampel (>300 ppm) dapat diturunkan menjadi < 5 ppm dengan 3 kali adsorpsi secara berurutan.

Kata kunci: abu layang batubara, *malachite green*, isotherm, kinetika, termodinamika adsorpsi

***ISOTHERM, KINETIC AND THERMODYNAMIC ADSORPTION OF
MALACHITE GREEN DYE USING COAL FLY ASH ACTIVATED WITH
HYDROCHLORIC ACID***

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ABSTRACT

Research on the isotherm, kinetics, and thermodynamics of malachite green dye adsorption using coal fly ash from the Tanjung Steam Power Plant (PLTU), Muara Enim, South Sumatra, was carried out. The aim of this study was to determine the isotherm, kinetic, and thermodynamic parameters of malachite green dye adsorption using hydrochloric acid activated coal fly ash. The coal fly ash activation process used 6 M HCl, and the results were characterized using AAS, XRF, FT-IR, and XRD. The adsorption parameters evaluated in this study included the effect of solution pH, the effect of adsorbent mass, adsorption kinetics, activation energy, adsorption isotherm, and adsorption thermodynamic parameters (ΔG° , ΔH° , and ΔS°). The concentration of malachite green dye in the solution before and after adsorption was determined using a UV-Vis spectrophotometer.

The results showed that activated coal fly ash had a better adsorption ability than unactivated coal fly ash. The adsorption kinetics of malachite green dye by unactivated coal fly ash and activated coal fly ash at various temperatures followed the pseudo-second-order Ho and McKay kinetics and followed the Langmuir isotherm. The value of K_L increases with increasing temperature, indicating that the adsorption is endothermic. The adsorption activation energy (E_a) of malachite green dye by unactivated coal fly ash and activated coal fly ash was 88.74 and 72.11 kJ mol⁻¹, respectively. The determination of the adsorption thermodynamic parameter, the value of the standard Gibbs free change (ΔG°) at temperatures of 293, 303, 313 and 323 K for unactivated coal fly ash and activated coal fly ash increases with increasing temperature. The value of the standard enthalpy change (ΔH°) in that temperature range for coal fly ash without and with activation is +18.54 and +14.77 kJ mol⁻¹ while the entropy change value (ΔS°) is +148.57 and +137.96 J mol⁻¹ K⁻¹, respectively, which indicates that the adsorption process is spontaneous and triggered by the entropy factor. The adsorption application on artificial samples showed that the malachite green content in the sample (> 300 ppm) could be reduced to < 5 ppm with 3 consecutive adsorption times.

Keywords: coal fly ash, isotherm, kinetics, malachite green, thermodynamics adsorption