

SINTESIS SILIKA GEL BERBAHAN DASAR SEKAM PADI DAN APLIKASINYA SEBAGAI ADSORBEN ZAT WARNA KATIONIK KRISTAL VIOLET

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INTISARI

Telah dilakukan sintesis silika gel berbahan dasar sekam padi sebagai adsorben untuk zat warna kationik kristal violet (KV). Tujuan dari penelitian ini adalah melakukan ekstraksi silika dari sekam padi menggunakan HCl sebagai agen *leaching*, mempelajari sintesis silika gel dengan metode *sol-gel* menggunakan silika hasil *acid leaching*, menentukan kondisi optimum adsorpsi zat warna KV oleh silika gel melalui variasi pH, waktu kontak, massa adsorben, dan konsentrasi awal adsorbat, serta melakukan studi kinetika dan isoterm adsorpsi kristal violet oleh silika gel sekam padi.

Proses ekstraksi silika dari sekam padi dilakukan melalui metode *acid leaching* menggunakan larutan HCl 3 M, kemudian dikalsinasi pada suhu 600 °C selama 5 jam. Sintesis silika gel dilakukan dengan metode *sol-gel* menggunakan NaOH 4 M dan HCl 3 M sebagai agen presipitasi. Kemurnian silika ditentukan berdasarkan analisis XRF. Gugus fungsi pada silika gel ditentukan dengan FTIR dan kristalinitas silika gel ditentukan dengan XRD. Proses adsorpsi KV dilakukan secara *batch* dengan memvariasikan pH (3–11), waktu kontak (5–120 menit), massa adsorben (5–150 mg), dan konsentrasi awal adsorbat (5–250 ppm). Analisis konsentrasi KV menggunakan spektrofotometer UV-Vis pada panjang gelombang 590 nm.

Hasil penelitian menunjukkan bahwa proses *acid leaching* efektif dalam menghilangkan pengotor logam sehingga diperoleh silika dengan kemurnian 99,9% dan berwarna putih cerah. Analisis FTIR memperlihatkan keberadaan gugus Si–OH dan Si–O–Si yang menegaskan keberhasilan sintesis silika gel. Analisis XRD memperlihatkan bahwa proses sintesis tidak menyebabkan perubahan pada fase amorf silika. Kondisi optimum adsorpsi diperoleh pada pH 5, waktu kontak 45 menit, massa adsorben 50 mg, dan konsentrasi awal 50 ppm, dengan efisiensi adsorpsi sebesar 95,3% dan kapasitas adsorpsi mencapai 23,847 mg g⁻¹. Proses adsorpsi KV oleh silika gel mengikuti model kinetika orde semu dua dengan konstanta laju (k_2) sebesar 1,3524 g mg⁻¹ menit⁻¹. Adsorpsi sesuai dengan isoterm Freundlich dengan nilai $K_F = 7,81268$ dan $n = 1,2154$. Energi adsorpsi sebesar – 5,147 kJ mol⁻¹ mengindikasikan bahwa proses adsorpsi bersifat fisika.

Kata kunci: adsorpsi, kristal violet, sekam padi, silika gel.

SYNTHESIS OF SILICA GEL BASED ON RICE HUSKS AND ITS APPLICATION AS AN ADSORBENT FOR CRYSTAL VIOLET CATIONIC DYE

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ABSTRACT

Silica gel synthesized from rice husks has been used as an adsorbent for the cationic dye crystal violet (CV). The purpose of this study was to extract silica from rice husks using HCl as a leaching agent, to study the synthesis of silica gel using the sol-gel method with silica obtained from acid leaching, to determine the optimum conditions for KV dye adsorption by silica gel through variations in pH, contact time, adsorbent mass, and initial adsorbate concentration, and to conduct a kinetic and isothermal study of crystal violet adsorption by rice husk silica gel.

The silica extraction process from rice husks was carried out through the acid leaching method using a 3 M HCl solution, then calcined at 600 °C for 5 h. Silica gel synthesis was carried out using the sol-gel method using 4 M NaOH and 3 M HCl as precipitation agents. The purity of silica was determined based on XRF analysis. The functional groups on silica gel were determined by FTIR and the crystallinity of silica gel was determined by XRD. The CV adsorption process was carried out in batches by varying the pH (3–11), contact time (5–120 min), adsorbent mass (5–150 mg), and initial adsorbate concentration (5–250 ppm). CV concentration analysis was performed using a UV-Vis spectrophotometer at a wavelength of 590 nm.

The results showed that the acid leaching process was effective in removing metal impurities, yielding silica with a purity of 99.9% and a bright white color. FTIR analysis revealed the presence of Si–OH and Si–O–Si groups, confirming the success of silica gel synthesis. XRD analysis shows that the synthesis process does not cause changes in the amorphous phase of silica. Optimal adsorption conditions are obtained at pH = 5, contact time of 45 min, adsorbent mass of 50 mg, and initial concentration of 50 ppm, with an adsorption efficiency of 95.3% and adsorption capacity reaching 23.847 mg g⁻¹. The adsorption process of CV by silica gel follows a pseudo-second-order kinetic model with a rate constant (k_2) of 1.3524 g mg⁻¹ min⁻¹. Adsorption is in accordance with the Freundlich isotherm with a K_F value of 7.81268 and $n = 1.2154$. The adsorption energy of -5.147 kJ mol⁻¹ indicates that the adsorption process is physical in nature.

Keywords: adsorption, crystal violet, rice husk, silica gel.