

SINTESIS SILIKA GEL DARI BAHAN DASAR PASIR PANTAI PARANGKUSUMO UNTUK ADSORPSI ZAT WARNA METILEN BIRU

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INTISARI

Sintesis silika gel dengan bahan dasar pasir Pantai Parangkusumo dan aplikasinya pada adsorpsi zat warna metilen biru telah dilakukan. Tujuan penelitian ini adalah sintesis dan karakterisasi silika gel dari pasir Pantai Parangkusumo melalui metode sol gel, serta uji adsorpsinya untuk zat warna metilen biru. Kondisi optimum adsorpsi seperti pH larutan, massa adsorben, waktu kontak, dan konsentrasi awal adsorbat baik menggunakan adsorben pasir pantai teraktivasi (PPA) dan silika gel (SG) telah ditentukan. Dalam penelitian ini juga dipelajari model kinetika dan isoterm adsorpsi metilen biru menggunakan kedua adsorben tersebut.

Penelitian ini diawali dengan preparasi atau pencucian pasir Pantai Parangkusumo, dilanjutkan aktivasi menggunakan HCl. Sintesis silika gel dari pasir pantai teraktivasi dilakukan menggunakan metode sol gel. Material pasir pantai (PP), pasir pantai teraktivasi (PPA), dan silika gel (SG) dikarakterisasi menggunakan XRF, XRD, FT-IR, dan SEM-EDX. Proses adsorpsi zat warna metilen biru dipelajari dengan melakukan variasi pH larutan, massa adsorben, waktu kontak, dan konsentrasi awal adsorbat. Model kinetika adsorpsi ditentukan dari data variasi waktu kontak, sedangkan model isoterm adsorpsi ditentukan berdasarkan data variasi konsentrasi awal adsorbat. Konsentrasi metilen biru sebelum dan sesudah adsorpsi diukur menggunakan spektrofotometer UV-Vis.

Analisis menggunakan XRF, XRD, FT-IR, dan SEM-EDX menunjukkan keberhasilan aktivasi pasir pantai dan sintesis silika gel melalui metode sol gel. Silika gel hasil sintesis memiliki kandungan silika yang tinggi sebesar 93,80% dengan struktur amorf dan bentuk bola berpori. Silika gel memiliki gugus aktif silanol (Si-OH) dan siloksan (Si-O-Si) sehingga dapat digunakan dalam proses adsorpsi. Adsorben PPA dan SG memiliki kondisi optimum adsorpsi pada pH 8, massa adsorben 0,04 g, dan waktu kontak 30 menit. Konsentrasi awal optimum tercapai pada konsentrasi 75 ppm untuk adsorben PPA dan 100 ppm untuk adsorben SG. Proses adsorpsi adsorben PPA dan SG mengikuti model kinetika orde kedua semu dengan nilai konstanta laju reaksi sebesar 0,0854 dan 0,3767 g mg⁻¹ min⁻¹. Proses adsorpsi adsorben PPA dan SG sesuai dengan model Langmuir dengan kapasitas adsorpsi sebesar 5,507 dan 38,462 mg g⁻¹. Energi adsorpsi untuk adsorben PPA dan SG masing-masing sebesar 23,982 dan 33,103 kJ mol⁻¹. Hasil penelitian menunjukkan perubahan pasir pantai menjadi silika gel menaikkan kapasitas adsorpsi secara signifikan yaitu sekitar tujuh kali lipat.

Kata kunci: adsorpsi, metilen biru, pasir pantai, silika gel

SYNTHESIS OF SILICA GEL USING PARANGKUSUMO BEACH SAND AS RAW MATERIAL FOR ADSORPTION OF METHYLENE BLUE DYE

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ABSTRACT

The synthesis of silica gel derived from Parangkusumo beach sand and its application in the adsorption of methylene blue dye were investigated. This study aimed to synthesize and characterize silica gel from Parangkusumo beach sand using the sol gel method and to evaluate its adsorption performance toward methylene blue dye. The optimum adsorption conditions, including solution pH, adsorbent mass, contact time, and initial adsorbate concentration, were determined using activated beach sand (PPA) and silica gel (SG) as adsorbents. In addition, the adsorption kinetics and isotherm models of methylene blue using both adsorbents were also studied.

The research was initiated by washing and preparing Parangkusumo beach sand, followed by activation using HCl. Silica gel was synthesized from the activated beach sand through the sol-gel method. Beach sand (PP), activated beach sand (PPA), and silica gel (SG) were characterized using XRF, XRD, FT-IR, and SEM-EDX analyses. The adsorption process of methylene blue was evaluated by varying solution pH, adsorbent mass, contact time, and initial adsorbate concentration. The adsorption kinetics model was determined from contact time variation data, while the adsorption isotherm model was obtained from initial adsorbate concentration data. The concentration of methylene blue before and after adsorption was measured using a UV-Vis spectrophotometer.

The characterization results confirmed the successful activation of beach sand and the synthesis of silica gel through the sol gel method. The synthesized silica gel exhibited a high silica content of 93.80%, with an amorphous structure and porous spherical morphology. The presence of silanol (Si-OH) and siloxane (Si-O-Si) functional groups enabled the material to be applied as an adsorbent. Both PPA and SG showed optimum adsorption conditions at pH 8, adsorbent mass of 0.04 g, and contact time of 30 min. The optimum initial concentration was obtained at 75 ppm for PPA and 100 ppm for SG. The adsorption processes of PPA and SG followed the pseudo-second-order kinetic model, with rate constants of 0.0854 and 0.3767 g mg⁻¹ min⁻¹, respectively. The adsorption equilibrium data fitted well to the Langmuir isotherm model, with adsorption capacities of 5.507 and 38.462 mg g⁻¹ for PPA and SG, respectively. The adsorption energies of PPA and SG were 23.982 and 33.103 kJ mol⁻¹, respectively. The results indicated that the transformation of beach sand into silica gel significantly increased the adsorption capacity by approximately sevenfold.

Keywords: adsorption, methylene blue, sand beach, silica gel