

INTISARI

FABRIKASI *BEADS* KOMPOSIT KITOSAN/KARBON AKTIF DARI AMPAS KOPI DENGAN SODIUM ALGINAT UNTUK ADSORPSI METILEN BIRU

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Metilen biru (MB) merupakan zat pewarna sintetis kationik yang berpotensi mencemari lingkungan perairan akibat sifatnya yang toksik dan sulit terurai secara alami. Material adsorben berbasis biopolimer berupa komposit kitosan/karbon aktif (KKA) dari ampas kopi dan sodium alginat (SA) menjadi salah satu pendekatan yang menjanjikan karena efisien, ramah lingkungan, dan berbiaya rendah. Karbon aktif disintesis melalui aktivasi kimia dengan impregnasi ZnCl_2 15% dan aktivasi fisika pada suhu 500°C . Penelitian ini bertujuan untuk menganalisis pengaruh rasio komposit KKA:SA dan massa *beads* komposit terhadap persentase adsorpsi MB. *Beads* difabrikasi melalui metode *ionic crosslinking* menggunakan CaCl_2 4% dengan variasi rasio massa KKA:SA yaitu 1:0, 1:1, 2:1, dan 3:1. Kondisi optimum dicapai pada rasio KKA:SA 1:1, selanjutnya divariasikan massa *beads* sebesar 0,02 g, 0,04 g, dan 0,06 g. Uji adsorpsi dilakukan secara *batch* menggunakan larutan MB 10 ppm selama 60 menit, dengan pengukuran konsentrasi sisa menggunakan *Ultraviolet-Visible Spectrophotometry* pada $\lambda = 664\text{ nm}$. Karakterisasi *Scanning Electron Microscopy* menunjukkan morfologi permukaan *beads* yang berongga dan berpori, mengindikasikan luas permukaan aktif yang tinggi. Karakterisasi *Fourier Transform Infrared* mengkonfirmasi kehadiran gugus fungsi O-H, N-H, dan C=O yang berperan dalam mekanisme pengikatan MB melalui interaksi elektrostatik dan ikatan hidrogen. Kapasitas adsorpsi optimum sebesar 47,51 mg/g dicapai pada massa *beads* 0,02 g dengan persentase adsorpsi MB tertinggi sebesar 91,95%. Analisis kinetika menunjukkan bahwa adsorpsi MB mengikuti model *Pseudo Second Order* dengan nilai $R^2 = 0,99$, sedangkan model *Pseudo First Order* menghasilkan $R^2 = 0,02$, mengindikasikan bahwa mekanisme adsorpsi didominasi oleh interaksi kimia (*chemisorption*) sebagai tahap penentu laju. Hasil ini menunjukkan bahwa *beads* komposit KKA/SA memiliki potensi signifikan sebagai adsorben MB dan dapat dikembangkan lebih lanjut untuk aplikasi pengolahan limbah cair.

Kata kunci: Karbon aktif, Kitosan, Sodium alginat, Adsorpsi, Metilen biru

ABSTRACT

FABRICATION OF CHITOSAN/ACTIVATED CARBON COMPOSITE BEADS FROM COFFEE GROUNDS WITH SODIUM ALGINATE FOR METHYLENE BLUE ADSORPTION

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Methylene blue (MB) is a cationic synthetic dye that poses a significant threat to aquatic environments due to its toxic nature and resistance to natural degradation. A biopolymer-based composite adsorbent consisting of chitosan/activated carbon (CAC) derived from coffee grounds and sodium alginate (SA) represents a promising approach owing to its efficiency, environmental compatibility, and low cost. Activated carbon was synthesized via chemical activation through impregnation with 15% ZnCl_2 solution followed by physical activation at 500 °C. This study aimed to investigate the effect of CAC:SA composite ratio and beads mass on the adsorption efficiency of MB. Composite beads were fabricated through ionic crosslinking using 4% CaCl_2 solution, with CAC:SA mass ratio variations of 1:0, 1:1, 2:1, and 3:1. The optimum condition was established at a CAC:SA ratio of 1:1, upon which beads mass further varied at 0.02 g, 0.04 g, 0.06. Adsorption tests were conducted in batch mode using a 10 ppm MB solution for 60 minutes, with residual concentration measured by UV-Vis spectrophotometry at $\lambda = 664 \text{ nm}$. Scanning Electron Microscopy characterization revealed a porous and cavitated surface morphology, indicating a high active surface area. Fourier Transform Infrared characterization confirmed the presence of O-H, N-H, and C-O functional groups, which facilitate MB binding through electrostatic interactions and hydrogen bonding. The optimum adsorption capacity of 47.51 mg/g was achieved at a bead mass of 0.02 g, corresponding to a maximum adsorption efficiency of 91.95%. Kinetic analysis demonstrated that MB adsorption confirmed to the Pseudo Second Order model with $R^2 = 0.99$, while the Pseudo First Order model yielded $R^2 = 0.02$, indicating that the adsorption mechanism is predominantly governed by chemisorption as the rate-determining step. These findings suggest that CAC/SA composite beads hold significant potential as MB adsorbents and warrant further development for practical wastewater treatment applications.

Keywords: Activated carbon, Chitosan, Sodium alginate, Adsorption, Methylene blue