ABSTRAK

Pencemaran air oleh zat warna sintetis memerlukan material multifungsi yang mampu menggabungkan proses adsorpsi dan fotodegradasi secara efektif. Penelitian ini bertujuan mensintesis, mengkarakterisasi, dan mengevaluasi kinerja material α-Fe_2O_3·SiO_2 mesopori berbasis biosilika sekam padi terhadap penghilangan metilen biru (MB). Material disintesis melalui metode hidrotermal menggunakan *template cetyltrimethylammonium bromide* (CTAB), kemudian dimodifikasi dengan $Fe(NO_3)_3$ melalui impregnasi pada konsentrasi 0,2; 0,4; dan 0,6 M. Karakterisasi menggunakan FTIR, GSA, XRD, UV-Vis DRS, dan SEM-EDX menunjukkan terbentuknya material α-Fe_2O_3·SiO_2 berstruktur mesopori dengan kristalinitas hematit yang meningkat serta penurunan energi *band gap* dari 2,92 menjadi 1,96 eV seiring peningkatan konsentrasi Fe. Material α-Fe_2O_3·SiO_2 0,2 M memberikan efisiensi adsorpsi tertinggi sebesar 78,92 ± 0,85 %, sedangkan α-Fe_2O_3·SiO_2 0,4 M menghasilkan efisiensi penghilangan total MB tertinggi sebesar 94,01 ± 0,76 %. Proses adsorpsi mengikuti model kinetika pseudo orde dua, sedangkan fotodegradasi mengikuti model pseudo orde satu. Adsorpsi juga mengikuti isoterm Langmuir dengan kapasitas maksimum 74,63 mg g^{-1} serta berlangsung secara spontan dan eksotermik. Hasil penelitian menunjukkan bahwa material α-Fe_2O_3·SiO_2 mesopori berbasis biosilika berpotensi sebagai adsorben dan fotokatalis ramah lingkungan untuk pengolahan limbah zat warna.

Kata kunci: α-Fe_2O_3·SiO_2; biosilika; adsorpsi; fotodegradasi

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ABSTRACT

Water pollution caused by synthetic dyes requires the development of multifunctional materials capable of effectively integrating adsorption and photodegradation processes. This study aimed to synthesize, characterize, and evaluate the performance of mesoporous α-Fe_2O_3·SiO_2 derived from rice husk biosilica for methylene blue (MB) removal. The material was synthesized via a hydrothermal method using cetyltrimethylammonium bromide (CTAB) as a template, followed by impregnation with $Fe(NO_3)_3$ at concentrations of 0.2, 0.4, and 0.6 M. Characterization using FTIR, GSA, XRD, UV–Vis DRS, and SEM–EDX confirmed the formation of mesoporous α-Fe_2O_3·SiO_2 with increased hematite crystallinity and a reduced band gap energy from 2.92 to 1.96 eV as the Fe concentration increased. The α-Fe_2O_3·SiO_2 0.2 M material exhibited the highest adsorption efficiency (78.92 ± 0.85 %), whereas α-Fe_2O_3·SiO_2 0.4 M achieved the highest total MB removal efficiency (94.01 ± 0.76 %). Adsorption followed the pseudo-second-order kinetic and Langmuir isotherm models, with a maximum adsorption capacity of 74.63 mg g^{-1}, and occurred spontaneously and exothermically, whereas photodegradation followed the pseudo-first-order kinetic model. These findings demonstrate that mesoporous α-Fe_2O_3·SiO_2 derived from rice husk biosilica has strong potential as an environmentally friendly adsorbent and photocatalyst for dye wastewater treatment.

Kata kunci: α-Fe_2O_3·SiO_2; biosilica; adsorption; photodegradation

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