

ABSTRAK

GREEN SYNTHESIS NANOKOMPOSIT MnFe₂O₄/Cdots UNTUK FOTODEGRADASI RHODAMINE B DI BAWAH SINAR ULTRAVIOLET, VISIBLE LIGHT DAN SUNLIGHT

Oleh:

Naqwa Mumtazah Purba
24/546734/PPA/06851

Nanokomposit MnFe₂O₄/Cdots (MFC) berhasil difabrikasi melalui metode *green synthesis* menggunakan larutan *Moringa oleifera* sebagai agen pereduksi ion Mn²⁺/Fe³⁺ dan kulit semangka sebagai sumber karbon. Proses penggabungan dilakukan dengan bantuan sonikasi dan diperoleh MFC1, MFC2, MFC3, MFC4, dan MFC5 berdasarkan variasi volume Cdots sebesar 10, 15, 20, 25, dan 30 mL. Hasil uji *X-ray diffraction* menunjukkan bahwa seluruh sampel memiliki struktur kristal *spinel kubik* dengan penurunan ukuran kristalit MnFe₂O₄ akibat penambahan Cdots yaitu (8,0 ± 0,2), (7,8 ± 0,1) dan (7,6 ± 0,1) nm untuk MnFe₂O₄, MFC1 dan MFC4. Citra *transmission electron microscopy* memperlihatkan morfologi *spherical* dengan ukuran rata-rata 12,7 ± 2,2 nm dan dispersi yang baik, sedangkan hasil *scanning electron microscopy-energy dispersive X-ray* dan *mapping* unsur mengonfirmasi distribusi homogen Mn, Fe, O, dan C tanpa impuritas. Analisis *Fourier transform infra-red* menunjukkan pita serapan khas Fe–O serta gugus C=O dan C–O–C dari Cdots. Hasil pengujian *vibrating sample magnetometer* memperlihatkan karakteristik superparamagnetik dengan nilai magnetisasi saturasi menurun dari 20,4 menjadi 14,0 emu/g seiring peningkatan Cdots. Sifat magnetik tersebut mendukung proses pemisahan katalis secara eksternal serta menunjukkan kemampuan *reusability* tanpa penurunan efisiensi yang signifikan. Spektrum *UV–Vis diffuse reflectance* menunjukkan pergeseran serapan ke daerah tampak dengan energi celah pita 2,40–2,20 eV yang menandakan peningkatan penyerapan foton visible. Uji fotokatalitik terhadap larutan *rhodamine B* menunjukkan efisiensi degradasi meningkat dari 79,7% (MFC1) menjadi maksimum 98,5 % pada MFC4, kemudian menurun menjadi 82,1% (MFC5) akibat efek *shielding*. Aktivitas optimum MFC4 juga diamati pada penyinaran UV, visible light, dan sunlight dengan efisiensi berturut-turut 98,5%, 76,8%, dan 85,7%, serta mempertahankan efisiensi di atas 90 % setelah tiga siklus penggunaan ulang. Dengan stabilitas tinggi, sifat magnetik menengah, dan kinerja fotokatalitik yang konsisten, nanokomposit MFC hasil *green synthesis* ini berpotensi digunakan sebagai fotokatalis ramah lingkungan untuk degradasi pewarna organik dan pengolahan air berkelanjutan sesuai prinsip SDGs 6.

Kata kunci: Nanokomposit MnFe₂O₄/Cdots, *Moringa oleifera*, *green synthesis*, Fotokatalisis, *Rhodamine B*.

ABSTRACT

GREEN SYNTHESIS OF MnFe₂O₄/Cdots NANOCOMPOSITE FOR PHOTODEGRADATION OF RHODAMINE B UNDER ULTRAVIOLET, VISIBLE LIGHT, AND SUNLIGHT IRRADIATION

Oleh:

Naqwa Mumtazah Purba
24/546734/PPA/06851

MnFe₂O₄/Cdots (MFC) nanocomposites were successfully fabricated through a *green synthesis* approach using *Moringa oleifera* extract as a reducing agent for Mn²⁺/Fe³⁺ ions and watermelon peel as a carbon source. The composite formation was assisted by sonication, producing MFC1, MFC2, MFC3, MFC4, and MFC5 based on Cdots volume variations of 10, 15, 20, 25, and 30 mL, respectively. *X-ray diffraction* results confirmed that all samples exhibited a cubic spinel crystal structure, with the crystallite size of MnFe₂O₄ decreasing due to Cdots addition, namely (8.0 ± 0.2), (7.8 ± 0.1) dan (7.6 ± 0.1) nm for MnFe₂O₄, MFC1, and MFC4, respectively. *Transmission electron microscopy* images revealed spherical morphology with an average particle size of 12.7 ± 2.2 nm and good dispersion, while *scanning electron microscopy–energy dispersive X-ray* and elemental mapping confirmed homogeneous distributions of Mn, Fe, O, and C without impurities. *Fourier transform infrared spectroscopy* analysis showed characteristic absorption bands of Fe–O and functional groups of C=O and C–O–C from Cdots. *Vibrating sample magnetometer* measurements indicated superparamagnetic behavior, with saturation magnetization values decreasing from 20.4 to 14.0 emu/g as Cdots content increased. This magnetic property supports external catalyst separation and demonstrates reusability without a significant reduction in efficiency. The *UV–Vis diffuse reflectance* spectra exhibited a red shift toward the visible region, with E_g energies ranging from 2.40 to 2.20 eV, indicating enhanced visible-light photon absorption. Photocatalytic tests against Rhodamine B solution revealed that the degradation efficiency increased from 79.7% (MFC1) to a maximum of 98.5% for MFC4, then slightly decreased to 82.1% (MFC5) due to the *shielding* effect. The optimal activity of MFC4 was also observed under UV, visible, and sunlight irradiation, with efficiencies of 98.5%, 76.8%, dan 85.7% respectively, while maintaining above 90% after three reuse cycles. With high structural stability, moderate magnetic properties, and consistent photocatalytic performance, the green-synthesized MFC nanocomposite shows strong potential as an environmentally friendly photocatalyst for organic dye degradation and sustainable water treatment in accordance with SDG 6 principles.

Keywords: MnFe₂O₄/Cdots nanocomposite, *Moringa oleifera*, green synthesis, photocatalysis, Rhodamine B.