

Green Synthesis Nanomaterial Ga₂O₃ via Ekstrak Daun Pepaya Jepang (*Cnidoscolus aconitifolius*) dalam Berbagai Pelarut: Sifat Optik, Struktur, Morfologi, dan Aktivitas Fotokatalitik = Green Synthesis of Ga₂O₃ Nanomaterial via *Cnidoscolus aconitifolius* Leaf Extract in Various Solvents: Optical, Structural, Morphological, and Photocatalytic Activity

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Abstrak

Dalam penelitian ini, green synthesis nanomaterial $\hat{\text{I}}^2\text{-Ga}_2\text{O}_3\text{-M}$, $\hat{\text{I}}^2\text{-Ga}_2\text{O}_3\text{-Hx}$, dan $\hat{\text{I}}^2\text{-Ga}_2\text{O}_3\text{-W}$ via ekstrak daun *Cnidoscolus aconitifolius* telah berhasil dilakukan. Nanomaterial $\hat{\text{I}}^2\text{-Ga}_2\text{O}_3$ dianalisis dengan karakterisasi XRD (X-ray Diffraction), UV-Vis DRS (UV-Vis Diffuse Reflectance Spectroscopy), FTIR (Fourier Transform Infrared), SEM (Scanning Electron Microscopy), EDS (Energy Dispersive X-ray Spectroscopy), dan TEM (Transmission Electron Microscopy). Hasil karakterisasi XRD menunjukkan bahwa sistem kristal $\hat{\text{I}}^2\text{-Ga}_2\text{O}_3\text{-M}$, $\hat{\text{I}}^2\text{-Ga}_2\text{O}_3\text{-Hx}$, dan $\hat{\text{I}}^2\text{-Ga}_2\text{O}_3\text{-W}$ adalah monoklinik dengan grup ruang C12/m1 fasa tunggal. Pengukuran FTIR mengonfirmasi struktur kristal $\hat{\text{I}}^2\text{-Ga}_2\text{O}_3$ berupa serapan karakteristik di 662 cm⁻¹ dan 431 cm⁻¹. Spektroskopi UV-Vis DRS menunjukkan sifat optik $\hat{\text{I}}^2\text{-Ga}_2\text{O}_3\text{-M}$, $\hat{\text{I}}^2\text{-Ga}_2\text{O}_3\text{-Hx}$, dan $\hat{\text{I}}^2\text{-Ga}_2\text{O}_3\text{-W}$ berupa serapan foton di daerah sinar UV dengan bandgap sebesar 4,59 eV, 4,66 eV, dan 4,61 eV, secara berurutan. Karakterisasi SEM-EDS menunjukkan bahwa $\hat{\text{I}}^2\text{-Ga}_2\text{O}_3\text{-M}$, $\hat{\text{I}}^2\text{-Ga}_2\text{O}_3\text{-Hx}$, dan $\hat{\text{I}}^2\text{-Ga}_2\text{O}_3\text{-W}$ memiliki morfologi irregular shape, submicroblock, dan microspindle serta komposisi unsur penyusun yang sesuai secara stoikiometri. Karakterisasi TEM menunjukkan ukuran partikel rata-rata material $\hat{\text{I}}^2\text{-Ga}_2\text{O}_3\text{-M}$, $\hat{\text{I}}^2\text{-Ga}_2\text{O}_3\text{-Hx}$, dan $\hat{\text{I}}^2\text{-Ga}_2\text{O}_3\text{-W}$ sebesar $38,18 \pm 6,58$ nm, $865,85 \pm 165,98$ nm, dan $2926,01 \pm 331,26$ nm. Aktivitas fotokatalitik $\hat{\text{I}}^2\text{-Ga}_2\text{O}_3\text{-M}$, $\hat{\text{I}}^2\text{-Ga}_2\text{O}_3\text{-Hx}$, dan $\hat{\text{I}}^2\text{-Ga}_2\text{O}_3\text{-W}$ pada proses fotodegradasi metilen biru adalah sebesar $92,64 \pm 0,45$ %, $20,07 \pm 0,97$ %, dan $86,70 \pm 0,04$ %, secara berurutan. Kinetika reaksi fotokatalisis $\hat{\text{I}}^2\text{-Ga}_2\text{O}_3\text{-M}$ mengikuti model reaksi orde nol dengan tetapan laju sebesar $4,1 \times 10^{-3}$ M.menit⁻¹ serta $\hat{\text{I}}^2\text{-Ga}_2\text{O}_3\text{-Hx}$ dan $\hat{\text{I}}^2\text{-Ga}_2\text{O}_3\text{-W}$ mengikuti model reaksi orde satu semu dengan tetapan laju sebesar $1,6 \times 10^{-3}$ menit⁻¹ dan $1,64 \times 10^{-2}$ menit⁻¹, secara berurutan.

.....In this research, green synthesis of $\hat{\text{I}}^2\text{-Ga}_2\text{O}_3\text{-M}$, $\hat{\text{I}}^2\text{-Ga}_2\text{O}_3\text{-Hx}$, dan $\hat{\text{I}}^2\text{-Ga}_2\text{O}_3\text{-W}$ nanomaterials via *Cnidoscolus aconitifolius* leaf extract has been successfully carried out. $\hat{\text{I}}^2\text{-Ga}_2\text{O}_3$ nanomaterials are characterized by XRD (X-ray Diffraction), UV-Vis DRS (UV-Vis Diffuse Reflectance Spectroscopy), FTIR (Fourier Transform Infrared), SEM (Scanning Electron Microscopy), EDS (Energy Dispersive X-ray Spectroscopy), dan TEM (Transmission Electron Microscopy). XRD characterization results showed that $\hat{\text{I}}^2\text{-Ga}_2\text{O}_3\text{-M}$, $\hat{\text{I}}^2\text{-Ga}_2\text{O}_3\text{-Hx}$, and $\hat{\text{I}}^2\text{-Ga}_2\text{O}_3\text{-W}$ are single phased and adopted monoclinic crystal system with C12/m1 space group. FTIR measurement confirmed the $\hat{\text{I}}^2\text{-Ga}_2\text{O}_3$ crystal structure, which showed characteristic absorption in 662 cm⁻¹ and 431 cm⁻¹. UV-Vis DRS spectroscopy showed optical properties of $\hat{\text{I}}^2\text{-Ga}_2\text{O}_3\text{-M}$, $\hat{\text{I}}^2\text{-Ga}_2\text{O}_3\text{-Hx}$, and $\hat{\text{I}}^2\text{-Ga}_2\text{O}_3\text{-W}$ which absorbs photon in UV region with bandgap value of 4,59 eV, 4,66 eV, dan 4,61 eV, respectively. SEM-EDS results showed that morphological shape of $\hat{\text{I}}^2\text{-Ga}_2\text{O}_3\text{-M}$, $\hat{\text{I}}^2\text{-Ga}_2\text{O}_3\text{-Hx}$, and $\hat{\text{I}}^2\text{-Ga}_2\text{O}_3\text{-W}$ are irregular shape, submicroblock, and microspindle, also elemental composition that corresponds stoichiometrically. TEM characterization results showed that $\hat{\text{I}}^2\text{-Ga}_2\text{O}_3\text{-M}$, $\hat{\text{I}}^2\text{-Ga}_2\text{O}_3\text{-Hx}$, and $\hat{\text{I}}^2\text{-Ga}_2\text{O}_3\text{-W}$ have average particle size of $38,18 \pm 6,58$ nm, $865,85 \pm 165,98$

nm, and $2926,01 \pm 331,26$ nm. Photocatalytic activity of $\hat{\text{I}}^2\text{-Ga}_2\text{O}_3\text{-M}$, $\hat{\text{I}}^2\text{-Ga}_2\text{O}_3\text{-Hx}$, and $\hat{\text{I}}^2\text{-Ga}_2\text{O}_3\text{-W}$ in methylene blue photodegradation are $92,64 \pm 0,45$ %, $20,07 \pm 0,97$ %, dan $86,70 \pm 0,04$ %, respectively. Photocatalysis kinetics of $\hat{\text{I}}^2\text{-Ga}_2\text{O}_3\text{-M}$ followed the zeroth order reaction model with rate constant of $4,1 \times 10^{-3} \text{M}\cdot\text{min}^{-1}$ while $\hat{\text{I}}^2\text{-Ga}_2\text{O}_3\text{-Hx}$ and $\hat{\text{I}}^2\text{-Ga}_2\text{O}_3\text{-W}$ followed the pseudo first order reaction model with rate constant value of $1,6 \times 10^{-3} \text{min}^{-1}$ and $1,64 \times 10^{-2} \text{min}^{-1}$, respectively.