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**Pengaruh Penambahan g-C3N4 terhadap Kinerja Fotokatalis g-C3N4/Co/TiO2â€“HAp untuk Fotodegradasi
Malachite Green di Bawah Iradiasi Sinar Tampak**
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PENGARUH PENAMBAHAN g-C_3N_4 TERHADAP KINERJA FOTOKATALIS g-C_3N_4/Co/TiO_2–HAp UNTUK FOTODEGRADASI *MALACHITE GREEN* DI BAWAH IRADIASI SINAR TAMPAK

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INTISARI

Sintesis komposit g-C_3N_4/Co/TiO_2–HAp sebagai fotokatalis untuk fotodegradasi *malachite green* di bawah iradiasi sinar tampak telah dilakukan. Penelitian ini bertujuan untuk mempelajari pengaruh variasi konsentrasi g-C_3N_4 terhadap aktivitas fotodegradasi *malachite green* dan menentukan kondisi optimum reaksi yang meliputi pH larutan, massa katalis, serta konsentrasi awal larutan *malachite green*. Penelitian ini juga bertujuan untuk mengevaluasi kemampuan penggunaan ulang (*reusability*) fotokatalis hingga tiga kali siklus.

Material fotokatalis disintesis melalui metode *sol-gel* dengan melarutkan titanium(IV) tetraisopropoksida (TTIP) ke dalam etanol absolut. Suspensi HAp dan Co sebesar 5% dicampurkan ke dalam larutan TTIP, kemudian ditambahkan g-C_3N_4 dengan variasi konsentrasi 10, 20, dan 30% terhadap Co/TiO_2–HAp. Campuran yang diperoleh disentrifugasi, diambil endapannya, kemudian dikeringkan dan dikalsinasi pada temperatur 500 °C. Komposit yang terbentuk dikarakterisasi menggunakan XRD, FTIR, DRUV-Vis, FESEM–EDX, dan TEM–SAED. Selain itu juga dilakukan optimasi pH larutan, massa katalis, dan konsentrasi awal *malachite green*. Uji kinetika fotokatalis dilakukan dengan waktu iradiasi 0, 1, 2, 3, 4, 5, 10, 20, 30, 40, 50, 60, 70, 80, 90, dan 100 menit di bawah sinar tampak. Konsentrasi *malachite green* setelah fotodegradasi diukur menggunakan spektrofotometer UV-Vis pada panjang gelombang 618 nm. Selain itu, dilakukan uji *reusability* fotokatalis sebanyak tiga kali pemakaian pada kondisi optimum.

Hasil menunjukkan bahwa komposit g-C_3N_4/Co/TiO_2–HAp memiliki gugus fungsi khas Ti–O–Ti, PO_4^{3-}, OH, dan C–N dari analisis FTIR. Karakterisasi XRD mengonfirmasi terbentuknya TiO_2 anatase, HAp, dan g-C_3N_4 tanpa adanya fase pengotor baru. Analisis FESEM menunjukkan morfologi homogen dan teraglomerasi, sedangkan EDX mendeteksi unsur utama Ti, O, Ca, P, C, N, dan Co. Analisis TEM–SAED menunjukkan struktur komposit polikristalin dengan dispersi TiO_2 pada HAp dan interaksi dengan g-C_3N_4. Hasil DRUV-Vis menunjukkan bahwa komposit g-C_3N_4 10%/Co/TiO_2–HAp memiliki *band gap energy* terendah sebesar 2,09 dan mampu mendegradasi *malachite green* hingga 99,13% pada kondisi optimum pH 5, massa katalis 20 mg, konsentrasi awal 10 mg/L, dan waktu iradiasi 70 menit dengan konstanta laju reaksi sebesar 0,0594 menit^{-1}.

Kata kunci: fotodegradasi, g-C_3N_4, HAp, *malachite green,* sinar tampak.

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EFFECT OF g-C_3N_4 ADDITION ON THE PHOTOCATALYTIC PERFORMANCE OF g-C_3N_4/Co/TiO_2–HAp FOR MALACHITE GREEN PHOTODEGRADATION UNDER VISIBLE LIGHT IRRADIATION

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ABSTRACT

Synthesis of g-C_3N_4/Co/TiO_2–HAp composite as a photocatalyst for malachite green photodegradation under visible light irradiation has done. This research aimed to study the effect of g-C_3N_4 concentrations on the photodegradation activity of malachite green and to determine the optimum reaction conditions, including solution pH, catalyst mass, and initial malachite green concentration. In addition, this research also aimed to evaluate the reusability of the photocatalyst for up to three cycles.

The photocatalyst was synthesized using the sol–gel method by dissolving titanium(IV) tetraisopropoxide (TTIP) in absolute ethanol. HAp and 5% Co were added to the TTIP solution, followed by the addition of g-C_3N_4 at concentrations of 10, 20, and 30% relative to Co/TiO_2–HAp. The suspension mixture was centrifuged, and the precipitate was dried and calcined at 500 °C. The composites were characterized using XRD, FTIR, DRUV-Vis, FESEM–EDX, and TEM–SAED. Optimization studies were conducted on the solution pH, catalyst mass, and initial concentration of malachite green. Photocatalytic kinetic were performed of 0, 1, 2, 3, 4, 5, 10, 20, 30, 40, 50, 60, 70, 80, 90, and 100 minutes under visible light at optimum conditions. The concentration of malachite green was measured using a UV-Vis spectrophotometer at a wavelength of 618 nm. The reusability of the photocatalyst was evaluated for three cycles under optimum conditions.

The results showed that the g-C_3N_4/Co/TiO_2–HAp composite exhibited characteristic functional groups of Ti–O–Ti, PO_4^{3-}, OH, and C–N based on FTIR analysis. XRD characterization confirmed the formation of anatase TiO_2, HAp, and g-C_3N_4 without the formation of any impurity phases. FESEM analysis appeared relatively homogeneous and agglomerated, while EDX analysis confirmed the presence of Ti, O, Ca, P, C, N, and Co. TEM–SAED analysis indicated a polycrystalline composite structure with TiO_2 dispersed on HAp and interacting with g-C_3N_4. The absorption edge analysis of DRUV-Vis resulted that the g-C_3N_4 10%/Co/TiO_2–HAp composite had the lowest band gap energy of 2.09 eV, indicating composite can be active under visible light irradiation. The composite was able to degrade malachite green by 99.13% efficiency under optimum conditions of pH 5, catalyst dosage of 20 mg, initial concentration of 10 mg/L, and irradiation time of 70 minutes, with a reaction rate constant of 0.0594 min^{-1}.

Keywords: g-C_3N_4, HAp, malachite green, photodegradation, visible light.