PENGEMBANGAN SENSOR FLUORESENSI BERBASIS *CARBON DOTS* TERDOPING NITROGEN DAN FOSFOR (N,P-CDs) MENGGUNAKAN IRADIASI GELOMBANG MIKRO UNTUK DETEKSI ION Cu(II)

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INTISARI

Pengembangan sensor fluoresensi berbasis *carbon dots* (CDs) untuk deteksi ion Cu(II) telah berhasil dilakukan pada penelitian ini. CDs yang terdoping nitrogen (N) dan fosfor (P) (N,P-CDs) disintesis melalui metode *one-step microwave-assisted synthesis*, menggunakan glukosa sebagai sumber karbon, diamonium fosfat (DAP) sebagai dopan P, dan etilendiamin (EDA) sebagai dopan N. Doping N dan P bertujuan untuk memodifikasi struktur elektronik serta meningkatkan sifat optik CDs. Proses penelitian mencakup sintesis N,P-CDs, karakterisasi, kajian sifat optik, serta uji aplikasinya sebagai sensor fluoresensi untuk deteksi Cu(II). Optimasi sintesis dilakukan dengan memvariasikan daya dan waktu iradiasi *microwave*, serta konsentrasi DAP dan EDA. Karakterisasi dilakukan menggunakan *Fourier Transform Infrared* (FT-IR), *Transmission Electron Microscopy* (TEM), spektrofotometer UV-Vis, dan spektrofluorometer. Stabilitas fotokimia N,P-CDs dievaluasi berdasarkan pengaruh pH dan waktu penyimpanan terhadap intensitas fluoresensinya. Uji aplikasi sebagai sensor fluoresensi meliputi selektivitas terhadap ion logam Cd^{2+}, Co^{2+}, Cr^{3+}, Cr^{6+}, Cu^{2+}, Fe^{2+}, Fe^{3+}, Mn^{2+}, Ni^{2+}, Pb^{2+}, dan Zn^{2+}, uji anti-interferensi, serta analisis sensitivitas untuk menentukan *Limit of Detection* (LOD) dan *Limit of Quantification* (LOQ).

Hasil penelitian menunjukkan bahwa kondisi sintesis optimum diperoleh pada daya iradiasi 500 Watt selama 60 detik, dengan persentase DAP dan EDA masing-masing 50% berat/berat prekursor glukosa. Keberhasilan sintesis dan doping dikonfirmasi melalui spektra FT-IR, yang menunjukkan keberadaan ikatan C=C dari karbon inti serta gugus fungsi amina dan fosfat pada permukaan N,P-CDs. Hasil karakterisasi TEM mengungkapkan bahwa N,P-CDs memiliki morfologi kuasi-sferis dengan ukuran partikel rata-rata 2-3 nm. Studi sifat optik menunjukkan bahwa N,P-CDs memiliki panjang gelombang eksitasi 405 nm dengan emisi pada 495 nm, yang berada dalam rentang cahaya tampak dan menghasilkan warna hijau-kebiruan. Pada aplikasi sebagai sensor fluoresensi, N,P-CDs menunjukkan selektivitas tinggi dan ketahanan terhadap interferensi dalam mendeteksi Cu(II) pada kondisi basa (pH 8). Sensor ini memiliki rentang linear 0-99,87 ppm, dengan nilai LOD sebesar 0,759 ppm dan LOQ sebesar 2,513 ppm.

Kata kunci: Cu(II), fluoresensi, *microwave*, N,P-CDs, sensor.

DEVELOPMENT OF FLUORESCENCE SENSOR-BASED ON NITROGEN AND PHOSPHORUS CO-DOPED CARBON DOTS (N,P-CDs) USING MICROWAVE IRRADIATION FOR Cu(II) ION DETECTION

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ABSTRACT

The development of a fluorescence sensor based on carbon dots (CDs) for the detection of Cu(II) ions was successfully achieved in this study. N,P-CDs were synthesized via a one-step microwave-assisted method using glucose as the carbon source, diamonium phosphate (DAP) as the phosphorus dopant, and ethylenediamine (EDA) as the nitrogen dopant. The incorporation of N and P aimed to modulate the electronic structure and enhance the optical properties of the CDs. The research encompassed the synthesis, characterization, optical property analysis, and evaluation of N,P-CDs as a fluorescence sensor for Cu(II) detection. Optimization of the synthesis parameters was conducted by varying the microwave irradiation power and duration, as well as the concentrations of DAP and EDA. Structural and optical characterization was performed using Fourier Transform Infrared (FT-IR) spectroscopy, Transmission Electron Microscopy (TEM), UV-Vis spectrophotometry, and spectrofluorometry. The photochemical stability of N,P-CDs was assessed by examining the influence of pH and storage duration on fluorescence intensity. The sensor's performance was evaluated through selectivity tests against metal ions (Cd^{2+}, Co^{2+}, Cr^{3+}, Cr^{6+}, Cu^{2+}, Fe^{2+}, Fe^{3+}, Mn^{2+}, Ni^{2+}, Pb^{2+}, and Zn^{2+}), anti-interference studies, and sensitivity analysis to determine the Limit of Detection (LOD) and Limit of Quantification (LOQ).

The results demonstrated that the optimal synthesis conditions were attained at a microwave power of 500 W for 60 seconds, with 50% (w/w) DAP and EDA relative to the glucose precursor. The successful synthesis and heteroatom doping were confirmed through FT-IR spectral analysis, revealing the presence of C=C bonds characteristic of the carbon core, along with amine and phosphate functional groups on the surface of N,P-CDs. TEM imaging confirmed the quasi-spherical morphology of N,P-CDs, with an average particle diameter of 2–3 nm. Optical studies indicated that N,P-CDs exhibited an excitation wavelength of 405 nm and an emission wavelength of 495 nm, producing a greenish-blue fluorescence. As a fluorescence-based sensor, N,P-CDs demonstrated high selectivity and strong resistance to interference for Cu(II) detection under alkaline conditions (pH 8). The sensor exhibited a linear detection range of 0–99.87 ppm, with an LOD of 0.759 ppm and an LOQ of 2.513 ppm.

Keywords: Cu(II), fluorescence, microwave, N,P-CDs, sensor.