SINTESIS KARBON DOT TERDOPING NITROGEN DAN FLUORIN (N,F-CDs) BERBANTUAN GELOMBANG MIKRO SEBAGAI SENSOR FLUORESENSI UNTUK DETEKSI ION Fe^{3+} DI LINGKUNGAN PERAIRAN

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INTISARI

Sintesis sensor fluoresensi berbasis karbon dot terdoping nitrogen dan fluorin (N,F-CDs) telah dilakukan dengan metode gelombang mikro yang dapat digunakan sebagai sensor untuk mendeteksi Fe^{3+} di lingkungan perairan. N,F-CDs disintesis dengan prekursor asam sitrat sebagai sumber C dan amonium fluorida sebangai sumber N dan F. Sintesis dilakukan dengan metode gelombang mikro dengan berbagai optimasi kondisi reaksi. Optimasi dilakukan dengan memvariasikan daya, waktu, dan massa dopan. Daya iradiasi divariasikan dari 100-800 W, waktu iradiasi divariasikan dari 20-100 detik, dan massa dopan divariasikan dari 0-100 mg. N,F-CDs yang telah disintesis dari kondisi optimum dievaluasi stabilitas intensitas fluoresensinya dengan berbagai parameter, yaitu stabilitas terhadap perubahan pH, paparan sinar UV, serta waktu simpan di suhu ruang dan suhu ±4 °C. Dilakukan uji selektivitas dan sensitivitas N,F-CDs terhadap ion Fe^{3+} serta dievaluasi pengaruh interferensi ion logam lainnya. N,F-CDs dengan kondisi terbaik diaplikasikan untuk mendeteksi ion Fe^{3+} di perairan.

Hasil penelitian menunjukkan bahwa sintesis N,F-CDs memiliki kondisi optimum sintesis pada daya 450 W dengan waktu 80 detik dan 50 mg masa dopan. Spektra FTIR menunjukkan bahwa atom N dan F telah terpasivasi pada permukaan CDs yang ditunjukkan dengan adanya vibrasi ikatan karakteristik seperti N-H, C-N, dan C-F. Analisis dengan TEM menunjukkan bahwa N,F-CDs berbentuk kuasi-sferis dengan diameter rata-rata 1,67 nm. N,F-CDs memiliki stabilitas yang baik pada rentang pH 4-9, paparan sinar UV hingga 90 menit, dan waktu penyimpanan pada suhu ±4 °C selama 7 hari. Sensor berbasis N,F-CDs ini secara selektif mampu mendeteksi Fe^{3+}. N,F-CDs dapat mendeteksi Fe^{3+} dengan *Limit of Detection* (LoD) sebesar 0,0087 ppm dan *Limit of Quantification* (LoQ) sebesar 0,0291 ppm. N,F-CDs telah berhasil diaplikasikan sebagai sensor fluoresensi untuk mendeteksi Fe^{3+} pada sampel air lingkungan dengan tingkat presisi yang tinggi, ditunjukkan dengan nilai *Relative Standard Deviation* (RSD) <5%.

Kata kunci: Fe^{3+}, fluoresensi, karbon dot, N,F-CDs, sensor logam berat

MICROWAVE-ASSISTED SYNTHESIS OF NITROGEN AND FLUORINE-DOPED CARBON DOTS (N,F-CDs) AS FLUORESCENT SENSOR FOR DETECTION OF Fe^{3+} IONS IN THE WATER ENVIRONMENT

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ABSTRACT

The synthesis of a fluorescent sensor based on nitrogen and fluorine co-doped carbon dots (N,F-CDs) has been carried out using a microwave-assisted method for the detection of Fe^{3+} ions in aquatic environments. N,F-CDs were synthesized using citric acid as a carbon source and ammonium fluoride as the source of nitrogen and fluorine. Optimization was carried out by varying power, time, and dopant mass. Irradiation power was varied from 100-800 W, irradiation time was varied from 20-100 s, and dopant mass was varied from 0-100 mg. The N,F-CDs synthesized under optimal conditions were evaluated for the stability of their fluorescence intensity under various parameters, namely stability against pH changes, UV irradiation, and storage time at room temperature and ±4 °C. Selectivity and sensitivity tests of N,F-CDs toward Fe^{3+} ions were conducted, and the interference effect of other metal ions was evaluated. The N,F-CDs with the best condition were applied to detect Fe^{3+} ions in water.

The results demonstrated that the optimal synthesis conditions for N,F-CDs were achieved at 450 W microwave power, 80 s irradiation time, and 50 mg dopant mass. FTIR spectra confirmed successful surface passivation with nitrogen and fluorine atoms, indicated by the presence of characteristic vibrational bands such as N-H, C-N, and C-F. TEM analysis revealed that the synthesized N,F-CDs were quasi-spherical with an average diameter of 1.67 nm. The N,F-CDs exhibited good fluorescence stability across a pH range of 4-9, under UV irradiation up to 90 minutes, and after storage at ±4 °C for 7 days. The N,F-CDs-based sensor demonstrated high selectivity toward Fe^{3+} ions and was capable of detecting Fe^{3+} with a limit of detection (LoD) of 0.0087 ppm and a limit of quantification (LoQ) of 0.0291 ppm. The sensor was successfully applied for Fe^{3+} detection in environmental water samples with high precision, as indicated by a relative standard deviation (RSD) of less than 5%.

Keyword: carbon dots, Fe^{3+}, fluorescence, heavy metal sensors, N,F-CDs