

N,S-KARBON DOT TERMODIFIKASI TEMBAGA(II) (N,S-CDs/Cu²⁺) SEBAGAI SENSOR FLUORESENSI UNTUK DETEKSI RESIDU GLIFOSAT PADA KENTANG

Arif Rahmanul Azmi
21/480623/PA/20887

INTISARI

Fluoresen nanosensor berbasis karbon dot terdoping ion tembaga(II) (Cu²⁺) (N,S-CDs/Cu²⁺) telah dikembangkan untuk mendeteksi residu pestisida glifosat pada produk agrikultural berupa kentang. Karbon dot dilakukan sintesis metode *microwave* dengan prekursor asam sitrat sebagai sumber C dan L-glutathione sebagai sumber N dan S. Optimasi sintesis karbon dot dilakukan dengan memvariasikan waktu iradiasi, daya *microwave*, serta massa L-glutathione dengan perbandingan b/b% asam sitrat. Waktu iradiasi dilakukan dalam rentang waktu 1–7 menit, sedangkan daya *microwave* dilakukan pada rentang 100–800 watt. Dopan heteroatom juga dilakukan optimasi untuk menentukan massa dopan yang optimum dengan perbandingan 0–100% (b/b asam sitrat). Kondisi optimum sintesis dilanjutkan untuk menyintesis karbon dot yang dilanjutkan penambahan ion logam Cu²⁺ pada material karbon dot yang berhasil disintesis. Material yang terbentuk di karakterisasi kemudian diuji stabilitasnya terhadap faktor lingkungan seperti pH, paparan sinar UV, dan lama waktu penyimpanan. Selain itu juga dilakukan pengujian selektivitas, interferensi ion dan senyawa lain, dan sensitivitas N,S-CDs/Cu²⁺ dalam mendeteksi senyawa glifosat.

Berdasarkan intensitas fluoresensi kondisi sintesis yang optimal adalah perbandingan 1:1 antara asam sitrat dan L-glutathione pada daya *microwave* 450 watt dengan waktu sintesis selama 6 menit. Keberhasilan sintesis material dapat ditunjukkan melalui spektra FTIR dan citra TEM. Pada spektra FTIR, keberhasilan N dan S pada karbon dot ditunjukkan dengan munculkan vibrasi dari ikatan N–H, C–N, dan S–H. Distribusi ukuran partikel yang ditemukan pada N,S-CDs berada pada ukuran $4,067 \pm 0,369$ nm. Selektivitas ion logam terbaik terhadap deteksi senyawa glifosat berupa ion Cu²⁺ dengan ditunjukkan *enhancement* intensitas fluoresensi. N,S-CDs memiliki fotostabilitas yang baik pada rentang pH 2–12, paparan sinar UV 180 menit dan penyimpanan dalam suhu ± 4 °C selama 28 hari. N,S-CDs sebagai sensor berbasis fluoresensi memiliki rentang linear 0–3 ppm dengan nilai batas deteksi (LoD) 0,0888 ppm dan batas kuantisasi (LoQ) 0,296 ppm.

Kata kunci: asam sitrat, ion logam Cu²⁺, karbon dot, L-glutathione, sintesis *microwave*

N,S-CARBON DOTS MODIFIED WITH COPPER(II) (N,S-CDs/Cu²⁺) AS FLUORESCENCE SENSOR FOR DETECTING GLYPHOSATE RESIDUES IN POTATOES

Arif Rahmanul Azmi

21/480623/PA/20887

ABSTRACT

A copper(II) ion doped carbon dot (N,S-CDs/Cu²⁺) based fluorescent nanosensor has been developed for the detection of glyphosate pesticide residues in agricultural products such as potatoes. The carbon dots were synthesised via a microwave-assisted method using citric acid as the carbon source and L-glutathione as the nitrogen and sulfur sources. Optimization of the carbon dot synthesis was performed by varying irradiation time, microwave power, and the mass of L-glutathione relative to citric acid (w/w%). Irradiation time was varied from 1 to 7 minutes, while microwave power ranged from 100 to 800 watts. Optimization of the heteroatom dopant was also carried out to determine the optimal dopant mass within the range of 0–100% (w/w relative to citric acid). The optimal synthesis conditions were then applied to produce the carbon dots, followed by incorporation of Cu²⁺ ions into the synthesized carbon dot material. The resulting material was characterized and stability against environmental factors such as pH, UV irradiation, and storage duration. In addition, selectivity tests, ion and molecular interference studies, and sensitivity evaluation of the N,S-CDs/Cu²⁺ system toward glyphosate detection were conducted.

Based on fluorescence intensity, the optimal synthesis conditions were achieved using a 1:1 ratio of citric acid to L-glutathione at 450 watts of microwave power for 6 minutes. Successful material synthesis was confirmed by FTIR spectra and TEM imaging. The FTIR spectra indicated successful N and S doping by the appearance of vibrational bands corresponding to N–H, C–N, and S–H bonds. The particle size distribution of the N,S-CDs was determined to be 4.067 ± 0.369 nm. Among the tested metal ions, Cu²⁺ exhibited the best selectivity for glyphosate detection, as evidenced by fluorescence intensity enhancement. The N,S-CDs demonstrated excellent photostability across a pH range of 2–12, UV exposure for 180 minutes, and storage at approximately 4 °C for 28 days. As a fluorescence-based sensor, the N,S-CDs displayed a linear detection range of 0–3 ppm, with a limit of detection (LOD) of 0.0888 ppm and a limit of quantification (LOQ) of 0.296 ppm.

Keywords: citric acid, ionic metal Cu²⁺, carbon dots, L-glutathione, microwave synthesis