ENCAPSULATION OF MAGNETIC-LUMINESCENT Fe_3O_4/CARBON QUANTUM DOT NANOCOMPOSITES USING ZIF-8 METAL-ORGANIC FRAMEWORK (MOF)

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ENKAPSULASI NANOKOMPOSIT MAGNETIK-LUMINISENSI Fe_3O_4/CARBON QUANTUM DOT DENGAN KERANGKA LOGAM ORGANIK ZIF-8

ABSTRAK

Nanokomposit magnetik-luminisensi Fe_3O_4/CQD berpotensi sebagai material bioimaging karena menggabungkan sifat magnetik dan fluoresensi dalam satu sistem. Namun, penggabungan Fe_3O_4 dan CQD memiliki keterbatasan, yaitu terjadinya efek quenching yang menyebabkan penurunan intensitas fluoresensi serta stabilitas dispersi yang belum optimal dalam medium berair maupun biologis. Oleh karena itu, diperlukan modifikasi permukaan nanokomposit Fe_3O_4/CQD melalui enkapsulasi menggunakan material biodegradable, yaitu Zeolitic Imidazolate Framework-8 (ZIF-8). Penelitian ini bertujuan untuk mensintesis nanokomposit Fe_3O_4/CQD@ZIF-8 melalui metode in situ self-assembly serta mengkaji pengaruh variasi prekursor Zn^{2+}:2-Hmim terhadap intensitas fluoresensi dan stabilitas dispersi. Keberhasilan sintesis nanokomposit Fe_3O_4/CQD@ZIF-8 dikarakterisasi menggunakan X-Ray Diffraction (XRD), Fourier Transform Infrared Spectroscopy (FTIR), dan Atomic Force Microscopy (AFM). Stabilitas dispersi dianalisis melalui pengukuran potensial zeta, sedangkan intensitas fluoresensi dianalisis menggunakan spektrofotometer fluoresensi. Hasil karakterisasi XRD, FTIR, dan AFM menunjukkan bahwa ZIF-8 berhasil mengenkapsulasi nanokomposit Fe_3O_4/CQD. Enkapsulasi menggunakan ZIF-8 meningkatkan intensitas fluoresensi, dengan intensitas tertinggi diperoleh pada rasio prekursor 0,75 g Zn^{2+}:1,65 g 2-Hmim. Sementara itu, sampel dengan rasio prekursor 0,1 g Zn^{2+}:0,22 g 2-Hmim menunjukkan stabilitas dispersi terbaik dengan nilai potensial zeta sebesar −39,2 mV. Hasil penelitian menunjukkan bahwa enkapsulasi nanokomposit Fe_3O_4/CQD menggunakan ZIF-8 berhasil dilakukan pada seluruh variasi rasio prekursor yang diteliti. Peningkatan rasio prekuorsor Zn^{2+} terhadap 2-Hmim menigkatkan intensitas fluoresensi, tetapi menurunkan stabilitas dispersi. Oleh karena itu, diperlukan optimasi rasio prekursor untuk memperoleh nanokomposit Fe_3O_4/CQD dengan intensitas fluoresensi tinggi dan stabilitas dispersi yang baik.

Kata kunci: bioimaging, Fe_3O_4/CQD, intensitas fluoresensi, nanokomposit magnetik luminisensi, stabilitas dispersi, ZIF-8.

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ABSTRACT

Fe_3O_4/CQD magnetic-luminescent nanocomposites have potential as bioimaging materials because they combine magnetic and fluorescent properties in a single system. However, the combination of Fe_3O_4 and CQDs has limitations, namely the occurrence of a quenching effect that causes a decrease in fluorescence intensity, as well as limited dispersion stability in both aqueous and biological media. Therefore, surface modification of the Fe_3O_4/CQD nanocomposite is required through encapsulation using a biodegradable material, namely Zeolitic Imidazolate Framework-8 (ZIF-8). This study aims to synthesize Fe_3O_4/CQD@ZIF-8 nanocomposites via the in situ self-assembly method and to investigate the effect of variations in the Zn^{2+}:2-Hmim precursor on fluorescence intensity and dispersion stability. The successful synthesis of the Fe_3O_4/CQD@ZIF-8 nanocomposite was characterized using X-ray diffraction (XRD), Fourier transform infrared spectroscopy (FTIR), and atomic force microscopy (AFM). Dispersion stability was analyzed by measuring the zeta potential, while fluorescence intensity was analyzed using a fluorescence spectrophotometer. The results of XRD, FTIR, and AFM characterization showed that ZIF-8 successfully encapsulated the Fe_3O_4/CQD nanocomposites. Encapsulation using ZIF-8 increased the fluorescence intensity, with the highest intensity obtained at a precursor ratio of 0.75 g Zn^{2+}:1.65 g 2-Hmim. Meanwhile, the sample with a precursor ratio of 0.1 g Zn^{2+}:0.22 g 2-Hmim exhibited the best dispersion stability with a zeta potential of -39.2 mV. The results indicate that the encapsulation of Fe_3O_4/CQD nanocomposites using ZIF-8 was successfully achieved across all investigated precursor ratios. Increasing the Zn^{2+}-to-2-Hmim precursor ratio increased the fluorescence intensity but decreased the dispersion stability. Therefore, optimization of the precursor ratio is necessary to obtain Fe_3O_4/CQD nanocomposites with high fluorescence intensity and good dispersion stability.

Keywords: bioimaging, dispersion stability, Fe_3O_4/CQD, fluorescence intensity, luminescent magnetic nanocomposites, ZIF-8