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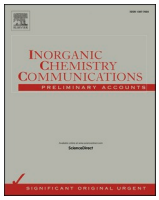

Transforming waste into multifunctional nanomaterials: Mg-doped carbon dots from cow dung for Y(III) detection and biomedical applications

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ABSTRACT

Rare earth metal Yttrium (Y^{3+}) plays a vital role in many electronic devices however, discarding these devices eventually contaminates the environmental sources. Herein, we have developed a Mg-doped carbon dots (M-CDs) as a fluorescent probe for selective and sensitive determination of Y^{3+} in water bodies. The M-CDs having maximum emission at 420 nm upon 310 nm excitation with 20 % quantum yield and which was synthesized from upcycling of agricultural waste i.e., cow dung by simple carbonization followed by hydrothermal method. M-CDs were confirmed using different analytical and characterization techniques as well as stable in different pH and ionic strength solutions. The M-CDs was highly selective towards Y^{3+} ions over different metal ions with significant blue shift. This fluorescent probe performs a good linear relationship between the different concentrations of Y^{3+} ion and fluorescence intensity ($R^2 = 0.99$) within the range of 0.2 to 20 μg/mL with a detection limit of 0.019 μg/mL. The study indicates quenching of Y^{3+} was result of dynamic quenching and the Inner Filter Effect (IFE) effect. Also, the cytotoxicity of M-CDs was checked via CAM assay and significant growth in blood vascularization with healthy growth of chick embryo confirmed the M-CDs were biocompatible. The nontoxic M-CDs was employed for MCF-7 breast cancer cell imaging which gives bright blue fluoresce under UV light excitation. Further, aiming to a circular economy approach the residual carbon remaining after hydrothermal was used as reactivated carbon for the abatement of environmental pollutants. The sustainable, cost-effective and agricultural waste-derived Mg-doped CDs have potential applications in analytical, environmental, forensic as well as biomedical fields.

1. Introduction

Yttrium (Y) is a widely used rare earth element in many electronic devices such as microwave filters, and LEDs in the production of phosphorescence materials which are used in cell phones and large display screens, leasers as well as in radars. However, after discarding these devices; yttrium is eventually contaminates environmental sources such as soil and water which leads to negative effects on aquatic animals and human beings as well as on photosynthesis and plant growth [1]. According to the guidelines of the US EPA and WHO the permissible concentration of yttrium in drinking water should be 6.4 μg/L [2]. Therefore, it is a major concern to maintain contamination of groundwater, rivers, and other water bodies from such hazardous heavy metals like yttrium. Scientist around the world have been developing various methods such as ICP-OES, AAS, ICP-MS, FES, and XRF for the detection of heavy metal ions; however, their expensive instrumentation, delicacy, and high maintenance affect their wide applicability [3–7]. Until now some research groups have developed selective sensing platforms for Y^{3+} ion in aqueous media by using various sensing techniques. Previously, Salicylaldehyde Acylhydrazone, Cyclen=1,4,7,10-tetraazacyclododecane, CNTs, N-CDs have utilized as Y^{3+} sensor [8–11]. However, to the best of our knowledge cow dung derived carbon dots were first time used for sensing of Y^{3+} ions in this report.

Carbon dots (CDs) are one of the members of carbon family shows excellent photoluminescent properties as well as great biocompatibility, water solubility and colloidal as well as photostability [12,13]. These

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