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A green synthesis, characterization of highly luminescent carbon dots from *Moringa oleifera* gum application as an efficient potentiometric sensor for Hg^{2+} toxic metal ions

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In this study, synthesis of highly luminescent carbon dots (CDs) is one of the hot research areas in the present-day context C-dots synthesis from *Moringa oleifera* gum is a green materials. The C-dots synthesis using hydrothermal method using 180°C for 24 h reaction. We have synthesized highly luminescent CDs in a green way which can be adopted for large-scale production of luminescent CDs. In the newly synthesized C-dots characterizations including UV-Vis, FT-IR, Raman, PL and FE-SEM etc. The newly prepared CCPE was using C-dots and potentiometric heavy toxic metal ions sensing. We have demonstrated the CDs as a sensitive and selective potentiometric sensor for the determination of Hg^{2+} ions which is a well-known environmental toxic pollutant.

Keywords: Carbon dots (CDs), composite carbon paste electrode (CCPE), potentiometer, toxic metal ions.

Introduction

Carbon dots (CDs) as a new member of carbon nanomaterials have drawn a great deal of attention, owning to their chemical stability, excellent water solubility, tuneable fluorescence properties, low cost, low toxicity, good biocompatibility and environmental friendliness materials[1,2]. In recently, the newly synthesis of fluorescent CDs without using organic chemicals in a simple, economical and environmentally friendly way is of great interest, which is so-called the green chemistry concept[3]. Some green synthetic routes have been developed for the synthesis of CDs by using inexpensive and renewable resources as starting waste materials, like natural gums, watermelon peels, orange juice, chicken eggs, and gelatin etc.[4–6].

To this end, a green method using precursors directly from nature is a very promising solution and would be of great benefit to large scale synthesis and widespread applications in the present work most use in hydrothermal method, we present a totally facile and green approach toward the synthesis of fluorescent carbon dots. Carbon dots (C-dots) are a recently developed material belonging to the *Moringa oleifera* gum[7] and have attracted considerable attention in various research areas. The synthesis C-dots can serve as an effective sensor for sensitive and selective determination of mercury(II) ions. The excellent chemical and photochemical stability of CDs together with their biocompatibility give a clear advantage in the context of biological applications, and thus making them a legitimate competitor to the conventional CDs with comparable or even better performance[8].

Experimental

Synthesis of carbon dots (CDs):

The *Moringa oleifera* gum were collected from my Pancharai village and washed several times under tap water to remove dirt and other impurity's present in the *Moringa oleifera* gum. (1 g) of *Moringa oleifera* gum was accurately weighed and dispersed in 100 ml ultrapure water and sonicated for 15 min. The whole solutions transferred to autoclave and kept muffle furnace at 180°C for 24 h. The resulting collect the solution was filtered through Whatman 40 grade filter paper followed by centrifugation (REMI) at 20.000 rpm for 20 min to remove larger particles. The resulting settled particles, the settled particles was collected and dried under vacuum using Equitron-Roteva, India. We get a carbon dots as a black fine powder. The resultant CDs was collected and

stored in an airtight container and were characterized by various analytical techniques.

Results and discussion

To study the optical properties of the CDs, UV-Vis spectrum were carried out in detail. The absorption spectrum (Fig. 1(a)) showed a characteristic weak absorption peak at 282 nm, which was related to the electron transition in the oxygen containing the bagasse derived CDs and can be attributed to the n $\rightarrow \pi^*$ transition of the CDs.

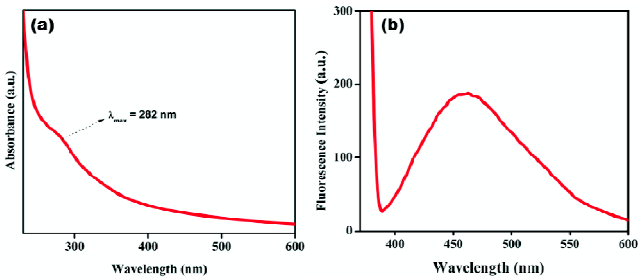

Fig. 1. (a) Ultraviolet-Visible (UV-Vis) and (b) photoluminescence spectrum of C-dots.

The C-dots were investigated for its fluorescent property in presence of UV light. The CDs possessed the strongest fluorescence emission band located at 462 nm.

The Raman spectra Fig. 2(b) of C-dots clearly show two superimposed broad peaks of D-band (Sp^3) and G-band (Sp^2) at around 1337 and 1552 cm^{-1}. The presences of D and G bands in C-dots further support the Sp^2 graphitic defect sites in Sp^3 amorphous carbon. The intensity ratio is $I_D/I_G = 0.7957$.

The FTIR spectrum showed Fig. 2(a) that the C-dots obtained from *Moringa oleifera* gum exhibited a strong characteristic absorption at 3414 cm^{-1} which was due to O-H stretching vibration mode. The band at 2954 cm^{-1} corresponds to the CH stretching vibration mode, the peak at 2494 cm^{-1} is due the stretching vibration mode of CH_2, another medium stretching vibration mode was observed at 1593 cm^{-1} and also at 1433 cm^{-1} which indicated the presence of C-C band. A small C-O stretching vibration mode was also observed at 1049 cm^{-1}. All above the peaks conformed the CDs.

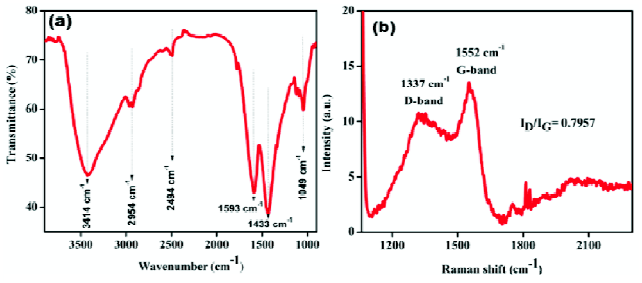

Fig. 2. (a) FT-IR and (b) Raman spectrum of C-dots.

The FE-SEM microscopy image in (Fig. 3(a, b)). The FE-SEM images showed spherical morphology of CDs and uniform particles size.

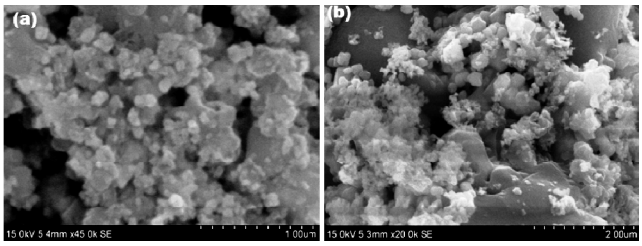

Fig. 3. (a, b) FE-SEM microscopy image of C-dots.

The potentiometric sensing of different metals ions Cd^{2+}, Cu^{2+}, Hg^{2+}, Zn^{2+}, Pb^{2+} ions (10^{-3} *M*) was carried out using composite carbon paste electrode (CCPE) as the working electrode and saturate calomel electrode (SCE) as the reference electrode in the presence of KCl electrolyte (10^{-3} *M*) results presented in the Fig. 4(a). The figure clearly indicates that though all the metals ions responded to the sensing but the sensing of Hg^{2+}, which is a clear indication of Hg^{2+} responded well at the concentration of 10^{-3} *M*, where as other metal ions like Cd^{2+}, Cu^{2+}, Zn^{2+} and Pb^{2+} ions in the concentration 10^{-3} *M* does not responded well as equivalent to the Hg^{2+} ion. The potentiometric sensing was also carried out with the same experimental conditions, but with different anions of mercury salts (chloride, sulphate and acetate salt) (Fig. 4(b), (c) and (d)).

The potentiometric sensing results of mercuric chloride, mercury sulphate and mercury acetate with CCPE in different pH solutions (pH 1–10) and KCl electrolyte (10^{-3} *M*) results was observed in Fig. 4(b), 4(c) and 4(d). The other experimental conditions remain the same as above. The curves indicated that both with chloride anion and acetate anion are almost the same at all pHs but the sensing with chloride salt is very clear and distinct, accurate and expressive. Hence the above sensing with mercuric chloride is highly recommended.

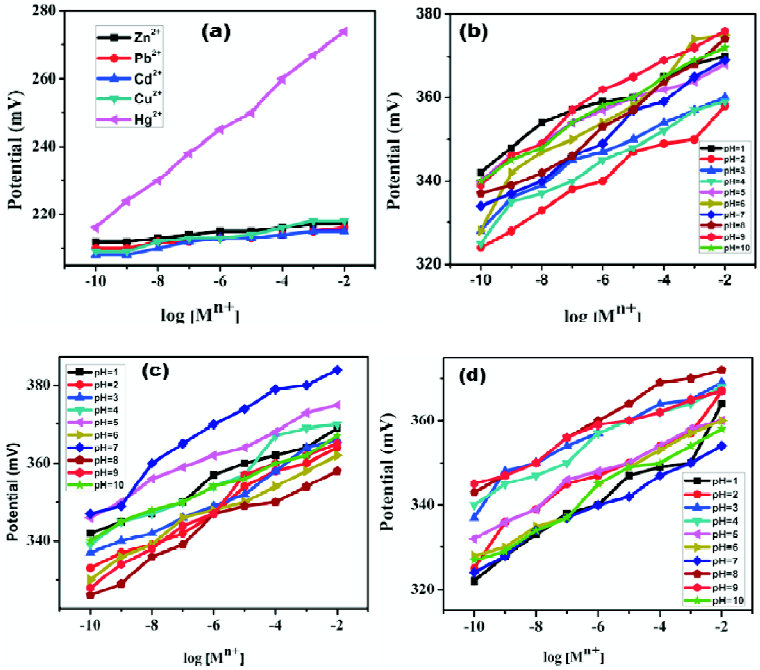

Fig. 4. (a) Potentiometric sensing of different metals ions, (b) mercury chloride, (c) mercury sulphate and (d) mercury acetate in different pH solutions (pH 1–10)) in the presence of KCl electrolyte.

Conclusions

In summary, the CDs were synthesized under the hydrothermal condition (in an aqueous medium at 180°C) using a *Moringa oleifera* gum as the precursor. *Moringa oleifera* gum CDs has been proven to be an effective strategy for producting flurescent CDs. The potentiometric sensing of composite carbon paste electrode shows better selectivity to mercury ion. However, the mercury response CCPE has a minor dependence on the pHs a shorter response time. C-dots exhibited different behavior with respect to that of different buffer solutions.

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