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Facile single step preparation of carbon nanodots from chitosan by carbonization

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Simple carbonization technique was followed to obtain amino functionalized carbon nanodots. Using chitosan as precursor, different methods were employed to optimise the carbon dots. The X-ray diffraction (XRD) pattern showed a strong carbon peak for carbonised chitosan. Optical property of the as-prepared carbon dots was studied by UV-Visible spectroscopy. The Thermo gravimetric analysis (TGA) revealed the mass change of the carbon dots with respect to the temperature. The study reports the synthesis and characterization of carbon dots from chitosan as a suitable material for multifunctional applications.

Keywords: Chitosan, amino-functionalized carbon dots, carbonization.

Introduction

Nano materials synthesis is the present field of research world wide as it caters to a wide range of applications. From the fabrication of solar cells to sensing hormones the utility of nanomaterials is innumerable[1]. Even though there are a wide range of applications, its harmful effects are not studied. Due to the high reactivity of such quantum sized particles owing to its surface to volume ratio, it is essential that the toxicity be kept minimum.

Taking this into consideration carbon dots or carbon nanodots is gaining wide popularity because of its less toxicity. In biological applications in particular, carbon dots are used in sensing, DNA fibrillation, bioimaging etc. Therefore in the present study a simple carbonization technique is followed to synthesize carbon dots.

Experimental

In the first method, 1 g of chitosan, a natural biopolymer was measured and taken in a crucible. This was subjected to heating in a muffle furnace at 300°C for 2 h. The heating rate of the furnace is 4°C per minute. On cooling, the powder is collected, dispersed in water and centrifuged to obtain carbon nanodots from carbonization. To verify the change in the formation of carbon dots on the application of pressure, a second method was followed for the preparation of carbon dots. Chitosan was well dispersed in 80 mL of water and placed in a Teflon coated autoclave for 24 h at 180°C.

Results and discussion

XRD: The instrument used to obtain X-ray diffraction patterns is GE X-RAY DIFFRACTION SYSTEM-XRD 3003 TT with $CuK_{\alpha 1}$ radiation (λ = 1.5406 Å). The carbon dots prepared by hydrothermal method (second method) showed a chitosan peak at 20.0°[2] but the carbon peak is not evident. Whereas the diffraction data of carbonised chitosan (first method) confirms the presence of carbon from the peak at 25.06°[3]. The interlayer spacing of ~3.56 Å further confirms the formation of carbon dots from the sample subjected to carbonization.

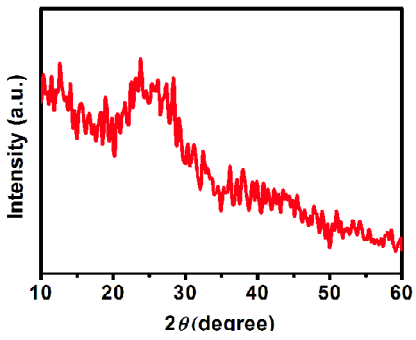

Fig. 1. XRD data of carbon dots from chitosan.

UV-Visible analysis: The data was taken from Perkin-Elmer UV WinLab 6.3.2.0749/2.02.06 Lambda 650 UV/VIS between the range 200–500 nm. The optical properties of the as-prepared carbon dots are shown in Fig. 2. The absorption peak at 230 nm corresponds to the π-π^* transition of C=C in amorphous carbon systems[4]. Due to the presence of NH_2 groups in chitosan the carbon dots obtained are amino functionalised and exhibit absorption peaks at 312, 380 and 450 nm. Similar results are reported by Wang *et al.* 2016[5].

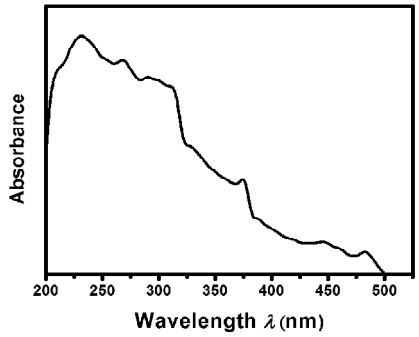

Fig. 2. UV-Vis graph of as-synthesized carbon dots.

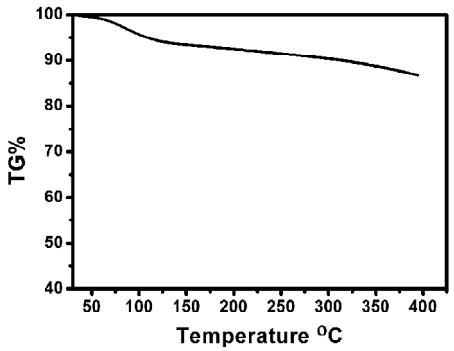

Fig. 3. TGA analysis of the prepared carbon dots.

TGA: The TGA analysis was carried out using NETZSCH STA 2500 STA2500A-0061-N instrument. As seen in Fig. 3, the N doped carbon dots shows considerable stability in the temperature range from 30 to 400°C[6]. Weight loss at 100°C might be due to the removal of water molecules present in the sample. From the graph it is clear that nearly 86% of mass is retained. This shows that the carbon dots are stable upto 400°C.

Conclusions

Amino functionalised carbon dots were prepared from simple carbonization technique. The formation of the as-prepared carbon dots were confirmed from the XRD and UV-Visible studies. The characteristic absorption peak at 380 and 450 nm validated the presence of nitrogen functional groups. The TGA analysis showed that the material is stable till 400°C. Due to their biocompatibility these carbon dots can be used in biomedical applications. The absorption peaks at 312, 380 and 450 nm make it an ideal material to exhibit fluorescent properties. This facilitates its use in bio imaging and as a tracer or marker in targeted drug delivery.

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