Fluorescent recognition of Fe3+ in acidic environment by enhanced-quantum yield N-doped carbon dots: optimization of variables using central composite design

ABSTRACT

A versatile synthetic approach for development of highly fuorescent nitrogen-doped carbon dots (N-CDs) from carboxymethylcellulose in the presence of linear polyethyleneimine (LPEI) has been developed. According to single factor method, central composite design incorporated with response surface methodology matrix was applied to fnd and model optimal conditions for the temperature (220–260 °C), duration (1–3 h) and LPEI weight (0.5–1.5%). The statistical results show that duration was the most signifcant parameter for efcient carbonization conversion rate in comparison with temperature and LPEI weight. The reduced cubic model (R2 = 0.9993) shows a good correlation between the experimental data and predicted values. The optimal variables were temperature of 260 °C, duration of 2 h and LPEI weight of 1%. Under these conditions, quantum yield of up to 44% was obtained. The numerically optimized N-CDs have an average size of 3.4 nm with graphitic nature owing to the abundant amino species incorporated into the carbon core framework. The blue-green N-CDs possess emission dependent upon the solvent polarity, wide pH stability with enhanced emission in an acidic environment. Impressively, the N-CDs show long-shelf-life for up to 1 year with no noticeable precipitation. The N-CDs were able to recognize a high concentration of -Fe3+ ions with a detection limit of 0.14 μM in acidic solution owing to the special coordination for Fe3+ to be captured by electron-donating oxygen/ amino groups around N-CDs. Moreover, the N-CDs can also be used as a new kind of fuorescent ink for imaging applications.