Realization of solid-state red fluorescence and concentration-induced multicolor emission from N, B co-doped carbon dots

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Supplementary material

Optimization of reaction conditions

Here, CDs were synthesized by a facile one-step microwave method. The reaction conditions were optimized by using the single factor variable method (Fig. S1). First, the molar ratio of phloroglucinol, ethylenediamine, and boric acid was fixed at 2 : 0.15:0.5, and the reaction solvent was changed. When obtained in water, CDs exhibit double emission centered at 487 and 602 nm, as seen from the inset of Fig. S1(a). Then, the reaction solvent was replaced by DMF. It can be seen from Fig. S1(a) that CDs exhibit one luminescence peak at 644 nm. This is because DMF is conducive to the dehydration and carbonization of raw materials, which endows CDs with a large sp^2 conjugated region and causes redshift of their luminescence wavelength [S1]. However, the fluorescence intensity of CDs is very low, which may be due to the excessive carbonization [S2]. Therefore, the mixture of DMF and water was used as reaction solvent to prepare CDs. For a balance between the redshift of emission and the enhancement of fluorescence intensity, the mixture of water and DMF with a volume ratio of 9.5 : 0.5 was selected as the reaction solvent, where the optimal luminescence peak of CDs is at 630 nm.

Then, in order to further optimize the fluorescence intensity of CDs, the reaction time and the content of additives were regulated. As shown in Figs. S1(b)–S1(d), with the extension of reaction time, optimal emission of CDs gradually redshifts but their fluorescence intensity gradually decreases. When reacted for 5 min, CDs exhibit emission centered at 613 nm, belonging to orange emission. When reacted for more than 11 min, CDs show emission peak at 635 nm with very low fluorescence intensity. Thus, the reaction time was fixed as 8 min, where the emission peak of CDs is at 623 nm.

Furthermore, the contents of ethylenediamine and boric acid were optimized. The molar ratio of phloroglucinol and boric acid was fixed at 2 : 0.5, and the ratio of ethylenediamine was changed from 0.05 to 0.45. From Fig. S1(c), it can be seen that with the increase of the N content, the emission wavelength gradually redshifts, and the fluorescence intensity first increases and then decreases, and reaches the highest value at the molar ratio of 0.2, so the ratio of ethylenediamine was selected as 0.2.

Then, the molar ratio of phloroglucinol to ethylenediamine was fixed at 2 : 0.2, and the amount of boric acid was changed from 0.05 to 0.50. As can be seen from Fig. S1(d), as the boric acid content gradually increases from 0.05 to 0.50, the fluorescence intensity first increases and then decreases, and reaches the maximum at the ratio of 0.15. Therefore, the synthesis conditions of CDs were optimized as follows: the volume ratio of water to DMF is 9.5 : 0.5, the reaction time is 8 min, and the molar ratio of phloroglucinol, ethylenediamine, and boric acid is 2 : 0.2:0.15.

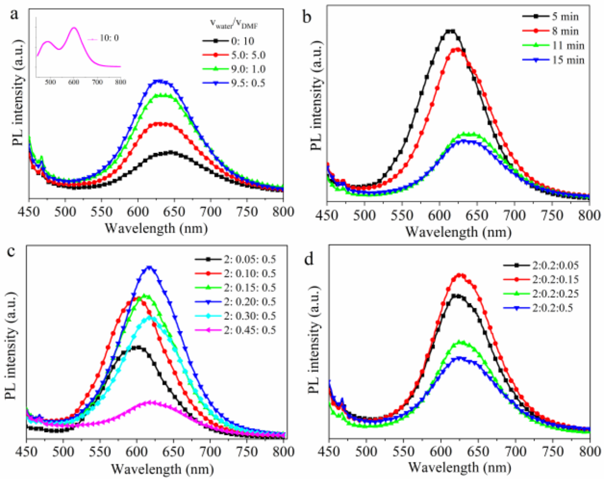

Fig. S1 PL spectra of CDs prepared at different conditions: **(a)** solvent; **(b)** reaction time; **(c)** ethanediamine; **(d)** boric acid.

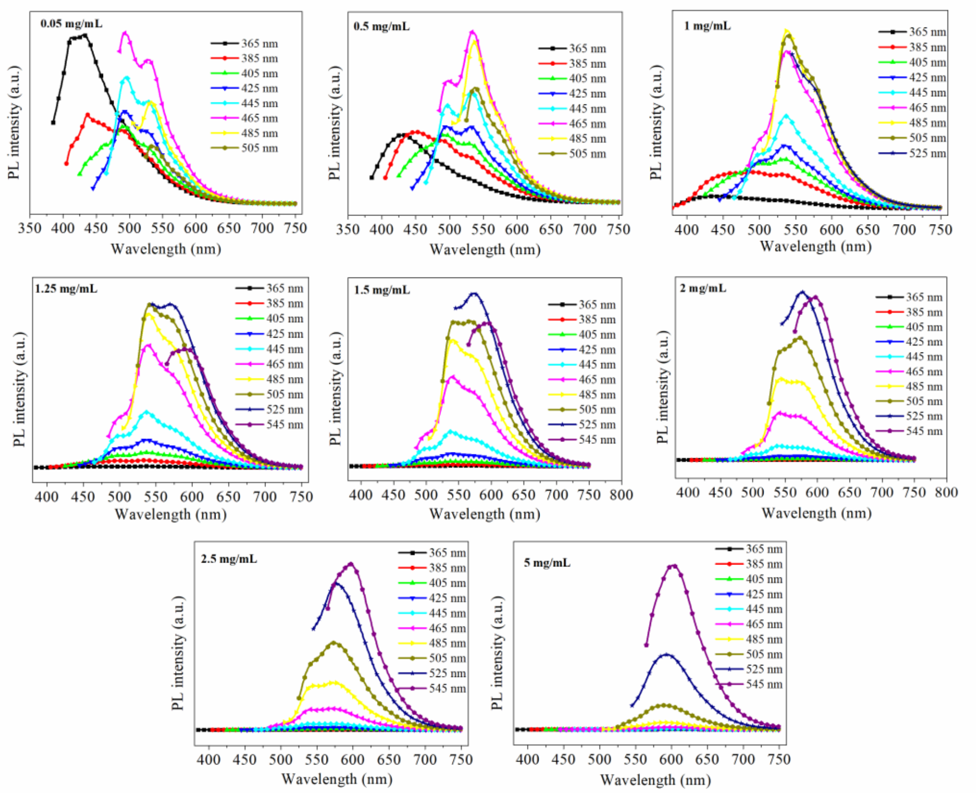

Fig. S2 PL spectra of CD DMSO solution with different concentrations and under different excitation wavelengths.

References

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