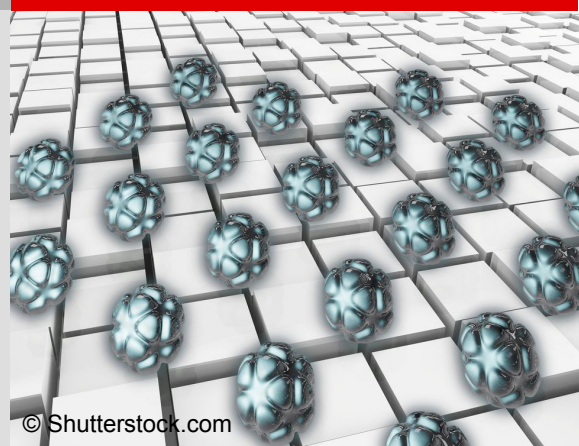




Carbon Nitride Quantum Dots for Mercury Detection

Quantum dots are usually fluorescent nanocrystals with quantum mechanical properties. They received a lot of attention due to their promising properties in a broad field of applications, such as bioimaging, biosensing, photocatalysis, ion detection, etc. Herein a new method for the detection of mercury is presented.¹



1 Introduction

The big disadvantage of quantum dots is the toxicity of heavy metals. Consequently, a lot of effort has been made during the last years in order to find safe but still effective alternative fluorescent nanomaterials.

Carbon nitride turned out to be a promising material, however the preparation requires a high temperature pyrolysis process. A further drawback is the fact that the resulting material generally shows large particle sizes, poor luminescent properties and poor water-solubility.

Herein a simple synthesis of effective carbon nitride quantum dots (CNQDs) is described. The use of microwave heating enables convenient heating to elevated temperatures and efficient stirring, highly beneficial for the generation of small and homogeneous particle sizes.

2 Equipment

The synthesis of CNQDs was performed in a Monowave microwave reactor, using G30 reaction vials.

For analysis, UV- and fluorescence spectrophotometry has been used as well as transmission electron microscopy (TEM), FTIR spectrometry, X-ray photoelectron spectroscopy, x-ray diffraction and NMR spectroscopy.

3 Reaction Conditions / Experimental

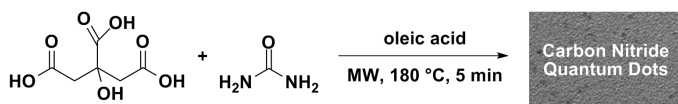


Fig. 1 Synthesis of carbon nitride quantum dots

In a typical experiment, 0.5 g citric acid monohydrate, 0.5 g urea and 10 mL oleic acid were filled in a reaction vial and processed in a Monowave reactor under the following conditions.

No.	Step	Temp (°C)	Time (hh:mm:ss)	Stirrer Speed (rpm)
1	Heat as fast as possible	180 A		1200 A
2	Hold Time		00:05:00 A	1200 A
3	Cooling	55 A		1200 A

After cooling, the black precipitate was separated and washed with *n*-hexane. Subsequently, it was dispersed in ultra-pure water and centrifuged at 6000 rpm for separation of larger particles.

4 Results

Thanks to the efficient stirring of the microwave reactor the resulting quantum dots turned out to be uniform spheric particles with a narrow size distribution of 1 to 5 nm (Figure 2).

Further analysis suggested that the crystallinity of the CNQDs is not pronounced. The nanoparticles might contain various functional groups (-COOH, -OH, -NH₂) which are responsible for the water-solubility.

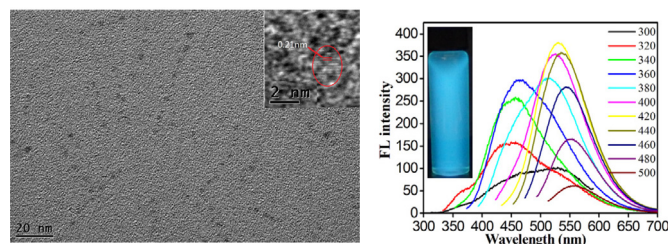


Fig. 2 TEM image and excitation-dependent emission spectrum. The as-prepared quantum dots show strong fluorescence under 365 nm UV light.

The quantum yield of the prepared quantum dots was calculated to be 27.1% using Rhodamin 6G as a reference.

After preparation of the CNQDs they were used to evaluate the selectivity towards metal ions. Therefore a solution was prepared with different metal ions, and fluorescence spectra were recorded subsequently under excitation at 423 nm.

As can be seen in Figure 3A the fluorescence intensity significantly decreases whenever Hg^{+2} ions are present in the solution.

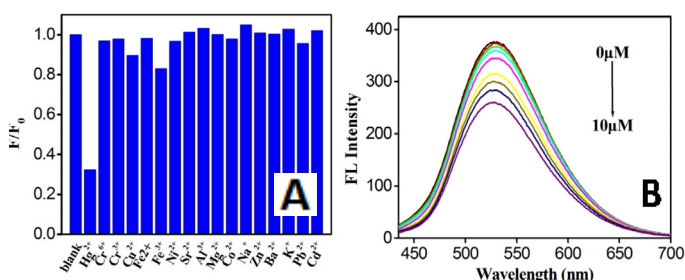


Fig. 3 (A) Normalized fluorescence intensity of aqueous solution in the presence of different metal ions. (B) Fluorescence emission spectra of the CNQDs upon addition of various concentrations of Hg^{+2} .

A concentration study using different molar ratios of Hg^{+2} and CNQDs was performed. Figure 3B shows that the photoluminescence intensity gradually decreases with increasing the concentration of Hg^{+2} ions.

The photoluminescence stability of the CNQDs was tested using green beans. Figure 4 shows the result of growth experiments with usual water as well as with an aqueous concentration of 0.3 mg/mL CNQDs.

The beans cultured with the CNQDs solution showed bright blue color emission under 365 nm UV beam after 100 h of growth. This result suggest good biocompatibility as well as negligible biotoxicity.

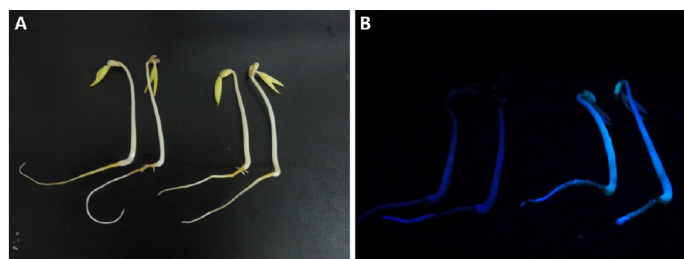


Fig. 4 Green beans cultured with pure water (left, under daylight) and CNQDs solution after 100 h of growth (under 356 nm UV beam).

5 Conclusion

Fluorescent carbon nitride quantum dots were easily prepared via microwave assisted heating at 180 °C for 5 minutes. Besides the handling convenience the big advantages of microwave assistance were the stirring efficiency and the accurate parameter control including the possibility to instantly switch the heating on and off.

The size of the uniform spherical dots was 1-5 nm with a quantum yield of 27.1%. Furthermore they show high selectivity in the detection of Hg^{+2} ions as well as negligible biotoxicity and good biocompatibility.

6 References

- [1] X. Cao et al.,
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