

Synthesis and Characterization of Boron-Doped Chitosan-Derived Carbon Quantum Dots: Optimization of Synthesis Time

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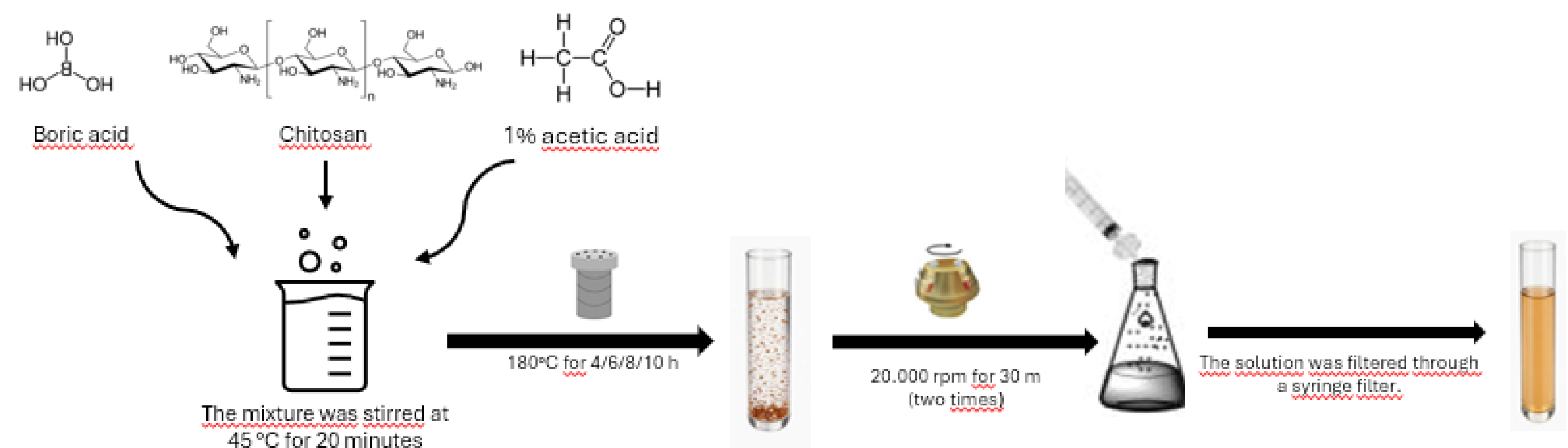
Introduction

Carbon Quantum Dots (CQDs) are carbon nanoparticles smaller than 10 nm. Because of surface passivation, they show good electrical and optical properties. In this study, CQDs with boric acid and chitosan were made. The synthesis times were 4, 6, 8, and 10 hours.

The solution contained boric acid, chitosan, and 1% acetic acid. After heating in the oven for the chosen time, the samples were centrifuged. Then, UV-Vis absorption spectroscopy and photoluminescence (PL) tests were done for characterization. The results showed changes in emission intensity and shifts in absorption bands depending on synthesis time. Chitosan improved the surface properties of CQDs, while boric acid played an important role in their optical behavior.

We thank Konya Technical University and Katip Çelebi University for the opportunities they offered

Experimental



Results and Discussion

PL Results

In the 4 h sample, particle formation is not complete, and the peaks are low and weak. At 6 h, the PL intensity increases and the peaks become clearer. The highest PL intensity is at 8 h, which shows the most efficient synthesis condition. At 10 h, the PL intensity stays high but is more stable and balanced. In short, 8 h gives maximum brightness, while 10 h gives more stable results.

PL Characterization of Chitosan-CQDs

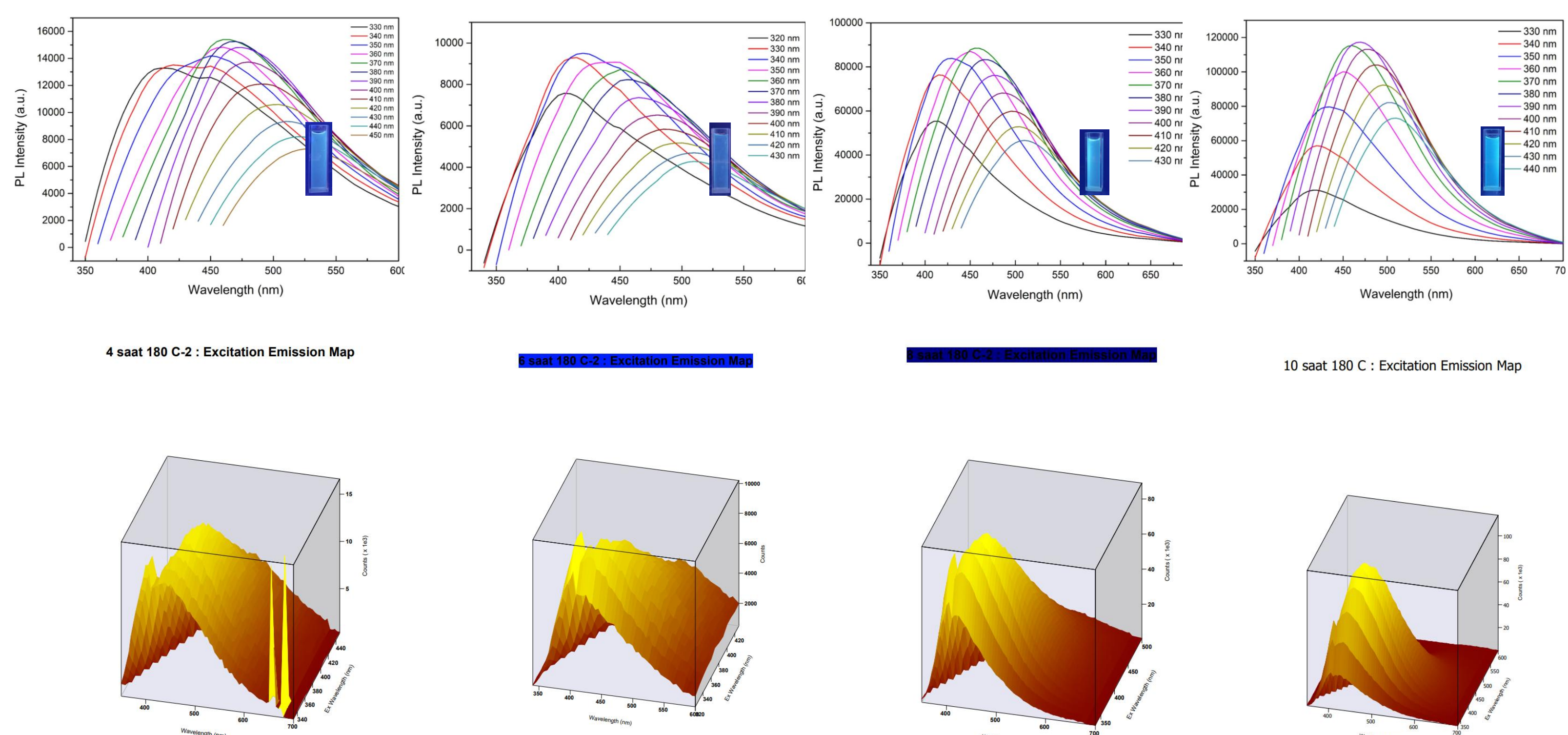


Figure 3. Photoluminescence (PL) spectra and 3D PL map of chitosan/boric acid doped CQDs at different synthesis times

UV-Vis Characterization of Modified CQDs

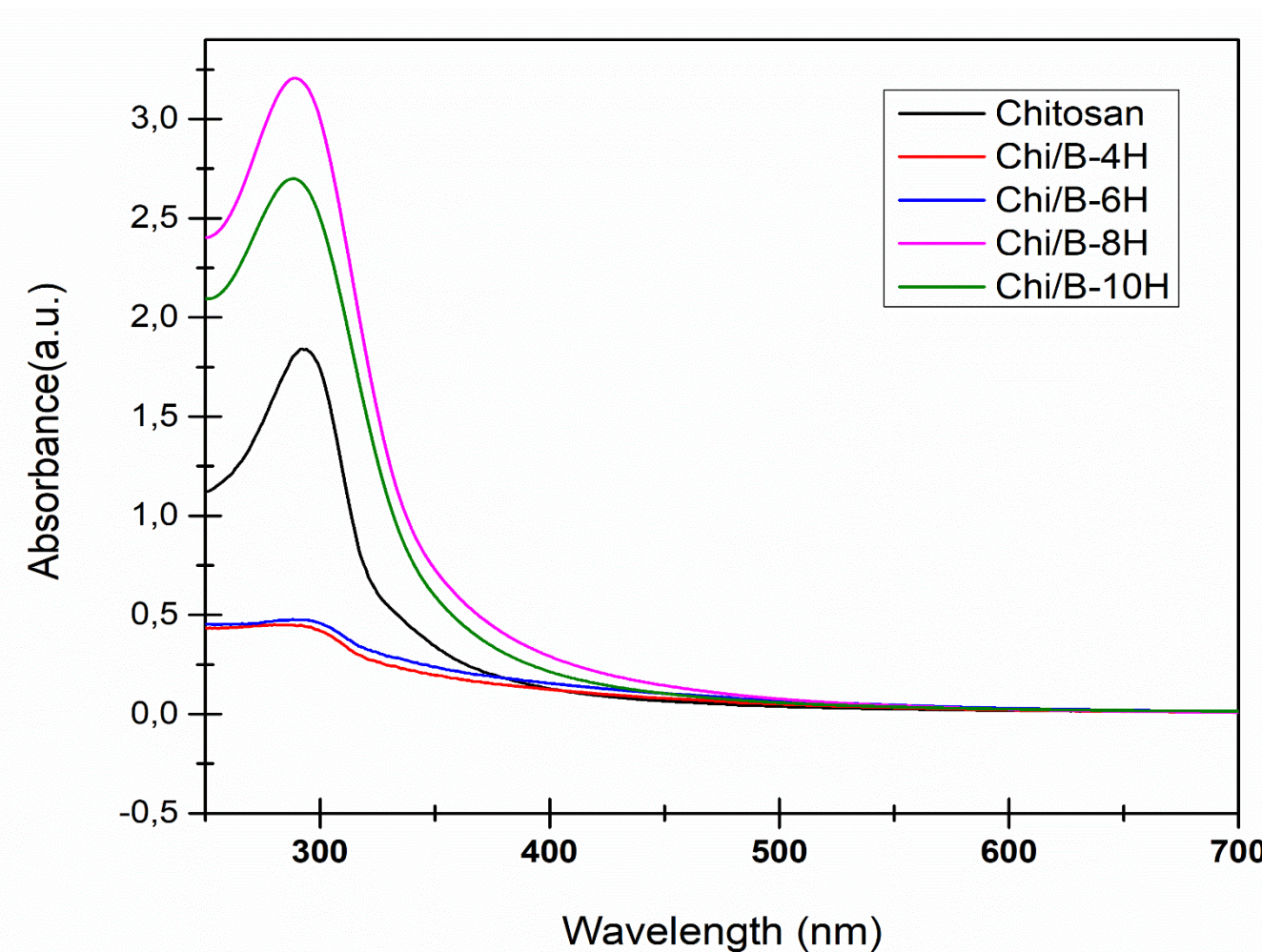


Figure 1. UV-Vis absorption spectra of CQDs at different synthesis times (4, 6, 8, 10 h)

UV-Vis Results

In UV-Vis analysis, changes in absorption bands were seen depending on synthesis time. In the 4 h and 6 h samples, the peaks were wide and weak. At 8 h, the peaks became clearer. At 10 h, the absorption peaks reached the highest intensity. This shows that electronic transitions happened more clearly and the quantum dots became better crystallized.

In summary, the wavelength shifts show that particle size and surface properties change with synthesis time. Also, a blue shift was observed in the peak positions. This shift is directly related to wider band gaps and smaller particle size. The blue shift means that electron transitions move to higher energy levels and the quantum confinement effect becomes stronger.

FTIR Results

In the spectrum, -OH groups appear around 3400 cm⁻¹, C-H stretching at 2900 cm⁻¹, C=O bands at 1650 cm⁻¹, amine/amide signals at 1550–1450 cm⁻¹, C-O vibrations at 1100–1000 cm⁻¹, and metal-oxygen bonds at 600–500 cm⁻¹. When synthesis time increases, the changes in peak intensity and position show better structural order and higher purity.

FTIR Spectra of CQDs with Boric Acid and Chitosan

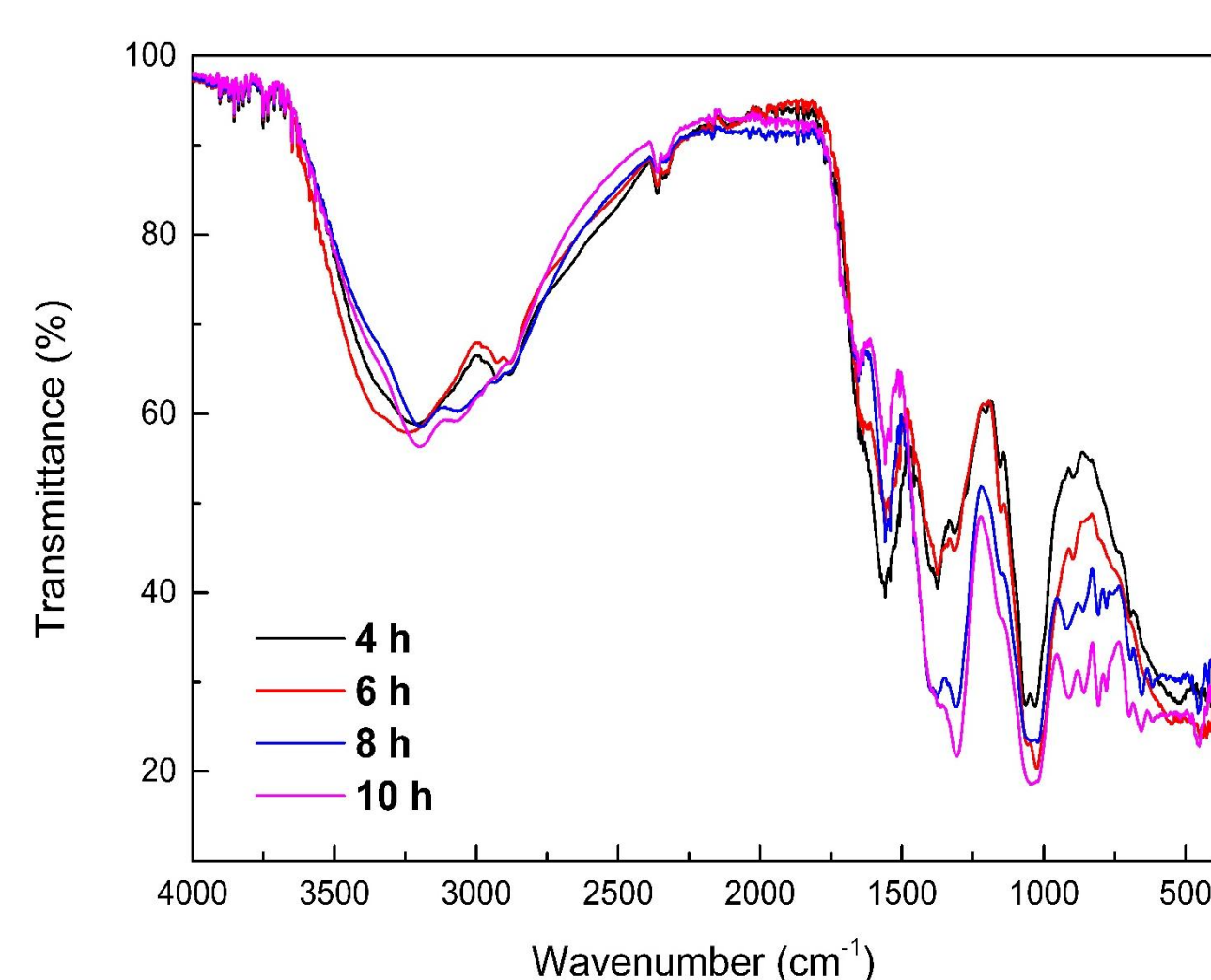


Figure 2. FTIR spectra comparing CQDs synthesized with boric acid and chitosan at different times