Hydrothermal Synthesis of Xylose-Based Carbon Dots: Evaluation of Reaction Conditions and Purification Steps

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Carbon dots (CDs) are 0-dimensional photoluminescent species mainly composed of carbon atoms which have recently attracted research interest because of their unique properties (biocompatibility, low toxicity, etc.) [1]. Such advantageous characteristics make them great candidates for replacing conventional fluorescent materials in a wide range of application fields, including catalysis, anticounterfeiting systems, or non-invasive sensing [2].

This broad applicability, as well as the possibility of synthesizing the structures by cheap and sustainable methods, has boosted the scientific production related to the topic. The rapid pace of publication since the discovery of CDs in 2004 [3], has resulted in a huge variety of data which includes conflicting information, errors, and misconceptions [4]. From our perspective, this problem arises from the lack of fundamental studies regarding the chemistry involved in the CDs' synthesis process. We think the unawareness of this key factor leads to the incomprehension of the CDs' formation mechanism [5] and the composition of the final solution product [6]. The former keeps scientists unable to precisely control the growth of the nanoparticles while the latter prevents them from choosing the appropriate purification procedure due to the ignorance of the formed byproducts and their interaction with CDs.

In this communication, we try to fill part of the presented knowledge gap with a preliminary study of the effects of the synthesis parameters on the nanoparticle size. Using commercial xylose as a single precursor, we performed both conventional and microwave-assisted hydrothermal synthesis and tuned the reaction temperature and time, the reactant concentration, the solvent composition, and the reactor filling volume to evaluate how their variation affected the CDs' size and check if the formation mechanism agreed with any of those few proposed in literature [5]. On the other hand, we paid special attention to the purification method. We combined a mechanic filtration with a dialysis step (using membranes of different molecular weight cut-offs) with the aim of optimizing the separation of CDs from the rest of possible fluorophores and luminescent components contained in the matrix which can mask the spectroscopic response of CDs (Figure 1).

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Figures

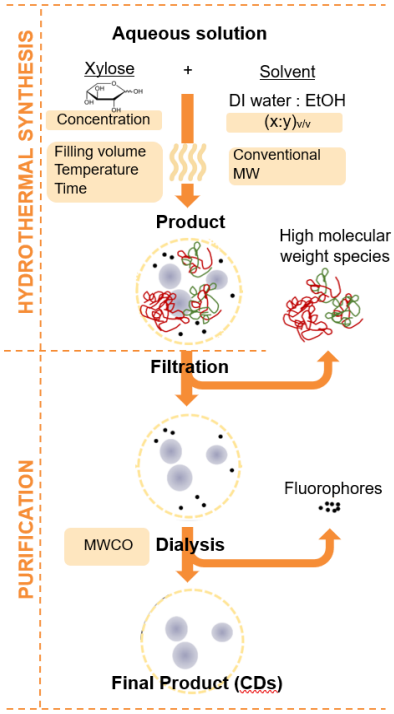

Figure 1. Schematic of the synthesis and purification processes of CDs. Studied parameters are highlighted in an orange color. Abbreviations: DI (Deionized), v/v (volume ratio), MW (Microwave), MWCO (Molecular Weight Cut-Off), CDs (Carbon dots).