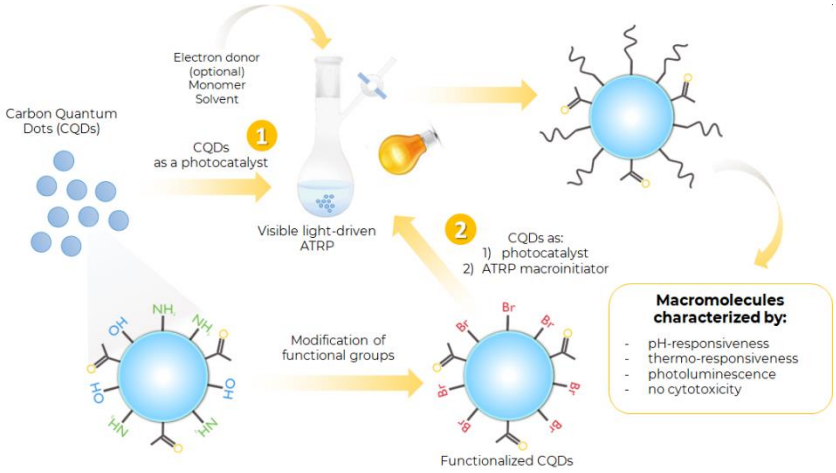
Carbon Quantum Dots (CQDs) represent one of the most promising categories of carbon nanomaterials, having garnered attention since their discovery in 2004 due to their distinctive characteristics and structure. These nanoparticles possess sizes smaller than 10 nm and are composed of carbon cores. They can be synthesized from both non-renewable resources such as coal, petroleum coke, and biomass wastes, owing to their substantial carbon content [1]. Renowned for their unique emission color, which can be tailored to match the excitation wavelength (photoluminescence), and their capability for photoinduced electron transfer, they hold particular significance for numerous selective photocatalytic reactions [2]. Carbon quantum dots stand apart from conventional semiconductor quantum dots due to their benign chemical composition, adjustable fluorescence emission, ease of functionalization, and exceptional chemical and physical stability [3]. Notably, they are biocompatible and demonstrate remarkable potential as versatile nanomaterials suitable for a broad range of applications, encompassing chemical sensing, biosensing, bioimaging, drug delivery, photodynamic therapy, photocatalysis, and electrocatalysis [2]. Altering the surface functional groups of luminescent nanomaterials substantially enhances their interaction capabilities with other molecules and materials, thus expanding their application potential. This stems from the fact that these functional groups exert a significant influence on nanomaterial properties, including charge, size, and shape, all of which profoundly impact their interaction abilities [4].



Scheme 1. The concepts of using CQDs in photoinduced ATRP.

Consequently, the primary objective of this project is to synthesize functional polymers using atom transfer radical polymerization (ATRP) with CQDs as photocatalyst and dual-purpose photocatalysts and initiators after functionalization (Scheme 1). Functional monomers will undergo polymerization, resulting in graft polymer chains with diverse compositions, encompassing linear (co)polymers and macromolecules with branched architectures. These systems will then be rigorously examined to assess specific attributes such as cytotoxicity and drug-release profiles (including pH-responsiveness and thermoresponsiveness), with the aim of evaluating the potential applicability of the modified CQDs in intelligent drug delivery systems that facilitate ongoing drug tracking within the body, as well as for cell bioimaging.

The project is structured around four main tasks, starting with an assessment of CQDs catalytic efficacy in photoinduced ATRP. Subsequently, the project involves expanding the utility of polymerization methodologies across a diverse spectrum of monomers, including acrylates, methacrylates, and acrylamides. This optimization step will be accompanied by an in-depth exploration of the mechanism underpinning CQDs behavior, particularly within the context of metal-free ATRP. The subsequent phase involves functionalizing reactive groups on the surface of CQDs, unraveling the changes in their structural elements due to modification, and conducting a thorough analysis of the fluorescence characteristics displayed by carbon quantum dots. This is followed by the modification of CQDs with polymers using a photoinduced ATRP approach based on the kinetics investigation conducted earlier. Therefore, the plan encompasses the synthesis of polymers featuring a branched architecture – the polymer chains integrated with CQD cores. This project aims to develop a cost-effective strategy for the production of novel functional materials for drug delivery. Additionally, it aims to form promising materials with the potential for utilization in cell imaging for cancer therapy.

This project is anticipated to yield an enhanced comprehension of the mechanisms underlying CQDs photocatalytic potential through ATRP methodologies driven by light such as photo-ATRP and metal-free ATRP. These techniques will be harnessed to produce an array of functional polymeric materials, not only for linear polymers but also for refining existing properties or instilling entirely novel attributes into carbon quantum dot surfaces.

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