Photocatalysis has been a pivotal topic of various research studies, due to the potential to solve the environmental and energy problems, e.g., via pollution degradation and solar-light conversion, with minimum side effects. Commonly, UV light is used in the photocatalytic system since wide-bandgap semiconductors of high photocatalytic activity are mainly used. However, since solar light consists of only very small portion of UV light (ca. 4%), UV lamps are usually used, which requires additional costs. On the other hand, visible light (vis) and infrared rays (IR) occupy significant portions of solar radiation, i.e., ca. 46% and ca. 50%, respectively. Therefore, to supress the cost of the photocatalytic systems, vis- or/and IR-active photocatalysts should be used to enable the efficient utilization of solar energy. However, the photocatalytic activity of vis- and IR-responsive materials is often much lower than that of UV-active photocatalysts, and thus they could not efficiently utilize the sunlight. Therefore, considerable number of studies have been carried out on the development of photocatalysts active under solar conditions. Here, obviously, the largest number of papers deal with vis-active materials.

Carbon quantum dots (CQDs) have been receiving a lot of attention after their first accidental finding in 2004 because of their unique features, e.g., low toxicity, low cost, and high photostability. Moreover, it has been found that CQDs have ability to enhance the photocatalytic activity under vis and even IR. In photocatalysis, CQDs could act as an electrons reservoir, a photosensitizer, and an up-converted photoluminescence (UCPL, i.e., the ability to emit higher-energy light by absorbing lower-energy light) agent. However, the CQDs role as a UCPL agent is still under debate among researchers. Moreover, there has been no 'reliable' proof about the role of CQDs either as photosensitizer or UCPL agent, e.g., by action-spectrum analysis or wavelength dependence of photocatalytic activity. On the other hand, for UCPL, photons of high energy are emitted by CQDs, and thus exciting the photocatalyst. It should be mentioned that dyes are often used as a substrate for photocatalytic-activity tests, which might cause the unreliability of the result since dyes are also a well-known photosensitizer. Therefore, PI believes that the deeper study about the CQDs roles will significantly contribute to the world of photocatalysis.

Unfortunately, sole CQDs are not a good photocatalyst due to fast charge-carriers recombination.1 Therefore, another material, i.e., inverse-opal bismuth vanadate (IO-BiVO4), with slow photon effect property will be used as a photocatalytically-active support for CQDs (IO-BiVO4 is the recent topic of the PI.). In the evaluation of photocatalytic activity, colorless substrates (instead of dyes) will be used to get reliable results. It is well-known that photocatalytic-activity test using colorless substrate is more difficult than that of dyes. Therefore, in order to observe even low photocatalytic activity, high emission of photoluminescence by CQDs is preferable to induce an observable photocatalytic reaction. Hence, the passivation of CQDs is also planned to increase the photoluminescence-quantum yield.5 By combining the unique characteristics of passivated CQDs with that of IO-BiVO4, high photocatalytic activity is expected due to efficient utilization of vis or even IR part of solar spectrum. Under vis or IR irradiation, passivated CQDs are expected to activate BiVO4 due to UCPL and photosensitisation by CQDs (additionally to BiVO4 photocatalytic activity at UV-vis range), thus enabling the broader response to solar radiation. Furthermore, efficient charge-carriers separation is also expected due to the passivated CQDs, working also as electrons reservoir, enhancing the photocatalytic activity at UV/vis range.