Exciting features of quantum-confined materials arise from the fact that it is possible to fabricate structures with their radius smaller than the electron-hole-pair exciton Bohr radius. Decreasing the particle radius below the Bohr radius results a separation of electronic levels (i.e., electron affinity and optical bandgap) and the ultra-small particles of this nature are commonly referred to as quantum dots (Q-dots). In recent years semiconductor Q-dots have attracted much attention from the scientific community because of their strong size-dependent physical and chemical properties. Potential applications of semiconductor Q-dots have been reported recently in superior biological labels, white-light laser sources, tunnel diodes, near-IR emitters, organic-inorganic hybrid and nanocrystalline solar cells and molecular electronics owing to their size-dependent absorption and emission properties [1].

The dye-sensitized nanocrystalline TiO$_2$ solar cell which was proposed as a cheap alternative to crystalline silicon solar cells, gives peak light harvesting efficiencies approaching 100% by monolayer adsorption of the sensitizer organic dye, ‘N3’ (cis-dithiocyanato-N,N-bis(2,2’-bipyridyl dicarboxylate) Ru(II)) via its carboxylic moiety. The size of the CdS nanocrystals are well established. The tunability of optical absorption by particle size selection allowed us to show efficient photosensitization of nanocrystalline TiO$_2$ with self-assembled layers of CdS Q-dots [3]. Spectroscopic and photoelectrochemical properties of these electrodes have extensively studied [3]. CdS Q-dots were self-assembled in situ on TiO$_2$ electrodes by arrested precipitation. 3-mercaptopropionic acid was chosen as the stabilizer in order to facilitate assembly on the TiO$_2$ substrate via the carboxylic moiety. The size of the CdS Q-dots was adjusted by controlling the stabilizer concentration in the colloidal synthesis step.

However, any prospective inorganic Q-dot material that could possibly challenge the existing organic sensitizer dyes must have an optical absorption edge close enough to near IR region so that the spectral response of the sensitized device matches the incident solar radiation. Therefore, currently we are trying to self-assemble other inorganic semiconductor Q-dots such as Bi$_2$S$_3$, which has a fundamental absorption edge close to 800 nm on nanocrystalline TiO$_2$ electrodes, and use them in photosensitization. We have successfully extended the self-assemble methodology to graft Bi$_2$S$_3$ Q-dots on nanocrystalline TiO$_2$ electrodes. These electrodes have investigated for photoelectrochemical and optical properties. Further work in progress on the use of other semiconductor Q-dots for the photosensitization of nanocrystalline TiO$_2$ electrodes and use them in solar energy conversion devices. Our recent attempts on photosensitization of nanocrystalline TiO$_2$ electrodes with self-assembled semiconductor Q-dots and their photoelectrochemical and optical properties will be presented.