

Current study reveals simple and unique additive free synthetic method to prepare both nanocrystals and nanorods structures at sub-zero temperature using easily accessible chemicals. The role of sub-zero reaction temperature from -40 to -10 °C on the structure of TiO_2 and phase transformation between anatase to rutile have been investigated. The current work also throws light on the role of temperature in dimension control of titania nanostructures. The current investigation explores the agile architecture of nanostructures and smart combination of semiconducting close shell metal oxide materials where, novel mesoporous solid nanospheres of ZnO-TiO_2 with type-II heterojunction reduces the recombination, and synergistically enhances the electron mobility and charge collection capability. Also, substantial efforts have been focussed on the phase tunable synthesis of TiO_2 for improving the charge recombination in TiO_2 . The band gap engineering of TiO_2 is highly important for its effective utilization. Hydrogenated TiO_2 nanospheres at a low doping concentration of HfO_2 nanodots exhibited pronounced optical absorption and light scattering effects. The hydrogenation of TiO_2 shifted the band gap to IR while HfO_2 doping reverted the optical bandgap to the visible region.

All prepared TiO_2 have been explored as photoanode material in DSSC. Collaborative role of the mixed phase and different morphology remarkably shows enhancement in both photocurrent density and photoconversion efficiency. With high specific surface area, pronounced optical absorption and light scattering effects of close shell metal oxides nanosphere exhibited a significant increase in the performance of DSSC. Interestingly, the smaller active area of photoanode emerged as a key elevating factor. Also, graphene associated with various substrate was also found to be promising candidate to replace Pt counter electrode.

To remove hazardous contaminants like Cr(VI) and organic industrial waste dyes, simple, high removal efficiency, low-cost, ease of operation and cost effective photo assisted filter membrane method was introduced. The hole-scavenger have been also used in photoreduction of harmful contaminants in air atmosphere. All synthesized materials have demonstrated superior activity to the Cr(VI) photoreduction. The catalyst has also demonstrated good recoverability as well as recyclability.

