Titanium Dioxide: Energy Conversion, Photocatalysis and Isotope Labeling

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Abstract

Titanium dioxide attracted considerable attention after the pioneering work of Fujishima and Honda in 1972, which stems from several promising applications in solar cells, batteries, and photocatalysis for environment protection. The dye sensitized solar cell is a low-cost, highly efficient device to rival Si-based photovoltaics. It was discovered in 1991 by O'Regan and Graetzel and their work triggered great academic and technological feedback during the next 2.5 decades. The generic device is a liquid-junction photoelectrochemical cell with a dye sensitized nanocrystalline TiO_2 photoanode. An alternative of this system is the solid-state dye sensitized solar cell in which the photogenerated holes are transported by a solid conductive material. Recently, this concept developed into the methylammonium-lead-iodide perovskite solar cell achieving more than 20 % conversion efficiency. Accommodation of Li in TiO_2 (anatase), monoclinic TiO_2(B) and particularly $Li_4Ti_5O_{12}$ (spinel) is readily applicable to the development of anodes for Li-ion batteries, and possibly also No-ion batteries. The search for Na-ion batteries is motivated by the expectation that the world supply of lithium could not be sufficient within the long-term horizon to back up the growth of battery market for electromobiles and grid stabilization. Titania-based photocatalysis is used for mineralization of environmental pollutants in air and water. We have recently upgraded these studies by titania catalysts labeled by oxygen isotopes 16, 17, 18, each in anatase and rutile forms. The products were characterized by Raman spectroscopy and by Raman spectroelectrochemistry of Li-insertion. The second-order Raman scattering in rutile, and the overlapping Raman features in anatase were addressed in detail. The heterogeneous catalytic processes at the interface of titania and gaseous reactants were investigated by high-resolution FTIR spectroscopy in dark and upon UV-excitation.