Supporting information

Sn$_x$Ti$_{1-x}$O$_2$ Solid-solution-nanoparticle Embedded Mesoporous Silica (SBA-15) Hybrid as an Engineered Photocatalyst with Enhanced Activity

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Fig. S1  XPS spectra of Sn$_{0.05}$Ti$_{0.95}$O$_2$ - sphere-like SBA-15 and TiO$_2$- sphere-like SBA-15 (a) complete survey; (b) Ti 2P; (c) and (d) O1s.

Fig. S2  Photoluminescence spectra of Sn$_{0.05}$Ti$_{0.95}$O$_2$ - sphere-like SBA-15 and TiO$_2$- sphere-like SBA-15.
Fig. S1 shows the XPS spectra of Sn$_{0.05}$Ti$_{0.95}$O$_2$ - sphere-like SBA-15 and TiO$_2$-sphere-like SBA-15 particles. There is a positive shift (Fig S1b) in Ti2p peak of Sn$_{0.05}$Ti$_{0.95}$O$_2$-sphere-like SBA-15 in comparison to TiO$_2$-sphere-like SBA-15, which confirms the Ti-O-Sn bond formation. Furthermore, the replacement of Sn$^{4+}$ in Ti$^{4+}$ lattice could lead to the weakening of Ti-O bonds. As a result, oxygen vacancies are created. The percentage of oxygen vacancy increased for Sn$_{0.05}$Ti$_{0.95}$O$_2$- sphere-like SBA-15 (to 10.85 %), as compared to TiO$_2$- sphere-like SBA-15 (only 8.35%). It can be clearly seen from Fig. (c) and (d), where the peak area of oxygen vacancies at 531 eV for Sn$_{0.05}$Ti$_{0.95}$O$_2$- sphere-like SBA-15 is higher than that of TiO$_2$- sphere-like SBA-15. This is also supported by the photoluminescence spectra, shown in Fig. S2, where Sn$_{0.05}$Ti$_{0.95}$O$_2$-sphere-like SBA-15 hybrid exhibits a lower PL emission intensity than that of TiO$_2$- sphere-like SBA-15. Moreover, the peak at around 410 nm is ascribed to the intrinsic state transitions of anatase phase TiO$_2$. Peaks around 460 nm and 520 nm can correspond to trapped charges and oxygen vacancy. Therefore, the lower PL spectra are mainly attributed to the surface states resulting from the oxygen vacancies and defects on the TiO$_2$ surface. The oxygen vacancy site in the photocatalyst can trap charge carriers, leading to decrease in recombination of electron-hole pairs. Besides that, presence of hydroxyl species on the catalyst surface also helps in increasing the photocatalytic activity. As a result, the decrease in recombination of charge carriers reduces the intensity of photoluminescence spectra of Sn$_{0.05}$Ti$_{0.95}$O$_2$-sphere-like SBA-15 hybrid. Thus, an improved photocatalytic activity is achieved for Sn$_{0.05}$Ti$_{0.95}$O$_2$-sphere-like SBA-15 hybrid.