Surface analysis on the photocatalytic behaviors of Fe-loaded TiO_2 towards volatile organic compounds degradation under the visible light irradiation: TOF-SIMS and operando DRIFT studies.

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It has been reported that the small loading of Fe-oxides on the surface of commercial TiO_2 particles can enhance the photocatalytic activities towards volatile organic compounds (VOCs) degradation under visible light irradiation. We have studied the surfaces of the Fe-loaded commercial TiO_2 particles using various surface analysis techniques, such as X-ray photoelectron spectroscopy (XPS), time-of-flight secondary ion mass spectrometry (TOF-SIMS), and operando FT-IR spectroscopy (operando DRIFT). This presentation will deal with our recent results in the two categorized parts as follows.

1) The first part will be about the origin of the annealing temperature dependent behaviors of photocatalytic activity of the Fe-loaded TiO_2 particles (Fe-loaded R996), and 2) the second part will be about the humidity dependency of the photocatalytic degradation of acetaldehyde and toluene on the surface of the Fe-loaded TiO_2 particles (Fe-loaded P25) under the visible light irradiations. In the below, you can find a bit more detailed description for each part.

1) The Fe-loaded commercial TiO_2 particles (0.4 wt% of Fe loading, R996 commercial rutile TiO_2 particles) were annealed at various temperatures (300, 375, 450, 525, and 750 ^oC) and the variation of their photocatalytic activities towards acetaldehyde degradation under visible light irradiations upon the annealing temperatures was observed. The photocatalytic activity of the Fe-loaded R996 increased as the annealing temperature increased up to 375 ^oC, but it decreased when the annealing temperature further increased from 375 ^oC. The XPS and TOF-SIMS analysis results revealed that Fe atoms in the higher oxidation states (Fe(II) or Fe(III)) can facilitate the electron/hole separation resulting in the enhancement of the photocatalytic activity. However, the strong metal-support interaction (SMSI) at higher temperatures (< 375 ^oC) can reduce the oxidation states of Fe atoms leading to the reduction of the enhancement effects of Fe-loading on the photocatalytic activity of the TiO_2 particles.

2) The photocatalytic activities of the Fe-loaded P25 (commercial TiO_2 particles) towards acetaldehyde and toluene degradation were examined under three different relative humidity conditions (0, 30, and 60RH%), and the surface of the Fe-loaded P25 during the reaction were also analyzed by means of operando DRIFT. The apparent removal of two VOCs which included the adsorption, partial oxidation, and total oxidation of VOCs, decreased when the humidity level increased (0 – 60RH%) which was largely attributed to the competitive adsorption of water vapors of VOCs on the Fe-TiO_2 surface. However, careful examinations of CO_2 selectivity values and operando DRIFT datum revealed that total oxidation of two VOCs into CO_2 gas was facilitated by water vapors in the humidity range of 0 – 30RH%. On the other hands, the inhibition of total oxidation of toluene was observed upon a further increase of humidity from 30 to 60RH%. Whereas facilitation of the total oxidation of acetaldehyde by water vapors was evidenced in the full range of humidity (0 – 60RH%) studied by our experimental works, indicating that the influence of the humidity on behaviors of photocatalyst for VOCs degradation can be dependent on the natures of VOCs.

References

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