

# Innovative Guideline to Functionalize TiO<sub>2</sub> for the Practical Uses

## Background

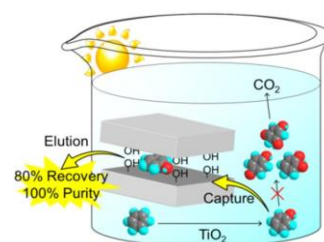
Due to its useful properties like semiconducting one, combined with low-price, non-toxicity and long-term stability, TiO<sub>2</sub> is an important material having different applications such as photovoltaics, photocatalytic H<sub>2</sub> production and environmental purification. A wide variety of TiO<sub>2</sub>-based materials has been developed, while, non-TiO<sub>2</sub> materials have also been synthesized for better performances and new applications.

## Aim

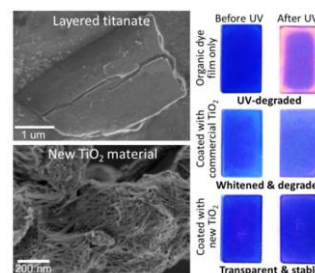
We have designed a new TiO<sub>2</sub> materials with better performances and new applications via unique routes. Also, we have developed unique operating environments to obtain high performances even using cheap and abundant TiO<sub>2</sub>.

## Advanced Research Topics

**Photocatalytic fine chemical synthesis:** when used as a photocatalyst for fine chemical synthesis, TiO<sub>2</sub> tends to overoxidize organic substrates to undesired by-products such as CO<sub>2</sub>. Recently, we have reported a conceptually new methodology to attain a high photocatalytic activity for desired partial oxidations even using TiO<sub>2</sub>. When the partial oxidation of benzene to phenol, which is one of the most important reactions in chemical industry, was conducted using TiO<sub>2</sub> in the presence of a phenol-philic adsorbent derived from a layered silicate, phenol was recovered in unprecedentedly high selectivity and yield. This resulted from that the adsorbent captured the generated phenol promptly, selectively, and effectively to prevent the overoxidation, after which the captured phenol could be easily eluted. Using a catechol-philic adsorbent, we could recover catechol, not but phenol, after the benzene oxidation on TiO<sub>2</sub>.



**UV absorber:** TiO<sub>2</sub> has been desired to be used as UV absorbers embedded in commodity polymer coatings. However, TiO<sub>2</sub> exhibits a photocatalytic activity and reflective index considerably higher than those of polymer matrices which cause photo-degradation and whitening of polymer matrices, respectively, in which it is embedded, limiting the application seriously. We have recently reported that the hydrothermal treatment of a layered titanate allows us to design a new TiO<sub>2</sub> material (nanofiber with multi-microchannels) with a well-restrained photocatalytic activity and extremely low refractive index and then use it as a highly efficient transparent UV protective coating on a UV-sensitive substrate.



## Publications

- Y. Ide, M. Torii, T. Sano, *J. Am. Chem. Soc.* **2013**, *135*, 11784
- H. Hattori, Y. Ide, T. Sano, *J. Mater. Chem. A* **2014**, *2*, 16381

## Applied area and future prospects

- Solar cells
- Catalysts
- Photocatalysis for fine chemical synthesis and environmental purification
- Cosmetics
- Adsorbents

## Issues for technology transfer

- Large scale synthesis (mol scale) of products is necessary for photocatalytic fine chemical synthesis using TiO<sub>2</sub> and layered silicates.
- Large scale production of a new TiO<sub>2</sub> material is required for the practical applications.



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