Visible light absorption of titanium dioxide achieved through cerium synchronous doping in anatase

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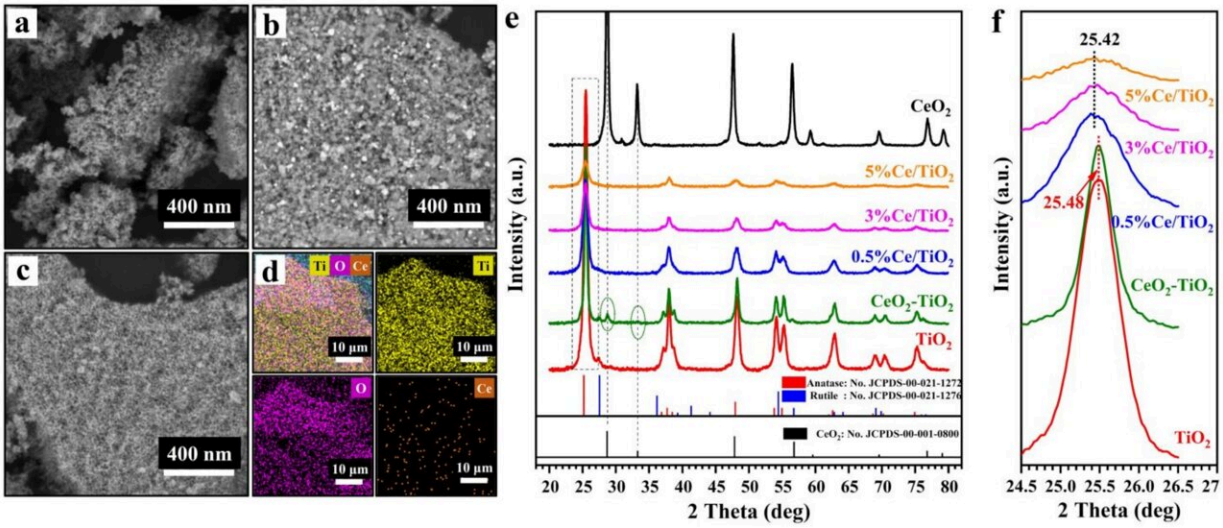

SEM images of (a) pure TiO_2, (b) CeO_2-TiO_2, and (c) Ce/TiO_2; (d) element mapping images of Ti, O, and Ce in the Ce/TiO_2 sample; (e) XRD patterns of the CeO_2, pure TiO_2, CeO_2-TiO_2 mixture, and Ce/TiO_2 samples with different Ce doping contents; (f) 23.5–25.0° refined XRD spectrums of (e). Credit: *Molecules* (2023). DOI: 10.3390/molecules28062433

The introduction of rare earth elements into TiO_2 can effectively improve the electron-hole separation of TiO_2 and prolong the visible light response of TiO_2.

Cerium (Ce) shows variable valence states Ce^{3+}/Ce^{4+} with different electronic structures ($4f^1 5d^0$ and $4f^0 5d^0$, respectively) among rare earth elements, which easily form oxygen vacancies. Ce element with unique electronic structure can be used to modify semiconductor photocatalysts to improve their photocatalytic performance.

In a study published in *Molecules*, the research group led by Prof. Lu Canzhong from Fujian Institute of Research on the Structure of Matter of the Chinese Academy of Sciences, reported the visible light absorption of Ce/TiO_2.

The researchers achieved simultaneous doping of Ce in the TiO_2 lattice using a simple sol-gel method which achieved Ce synchronous doping in the lattice of TiO_2. They observed morphology and structure of the pure TiO_2, Ce-doped TiO_2 (Ce/TiO_2), and CeO_2-mixed TiO_2 (CeO_2-TiO_2) samples by X-ray diffraction (XRD), scanning electron microscopy (SEM), and transmission electron microscopy (TEM). They found that Ce doping in the lattice of anatase TiO_2 resulted in a smaller grain size of the sample.

Additionally, the researchers revealed the high photocurrent density (10.9 $\mu A \times cm^{-2}$) of Ce/TiO_2 by linear sweep voltammetry (LSV) test, which is 2.5 times that of common TiO_2 material (4.3 $\mu A \times cm^{-2}$). They evaluated the light absorption range of Ce/TiO_2 using incident photo-to-current efficiency (IPCE) test. Ce/TiO_2 shows visible light absorption up to 500 nm, while pure TiO_2 shows no obvious response in the visible region.

Moreover, the researchers unveiled that the electron-trapping centers formed by Ce doping into the TiO_2 lattice improved the separation efficiency of photogenerated electrons and holes. The narrow bandgap of Ce-doped TiO_2 showed excellent visible light absorption and photocurrent response. Due to the Ce doping, the Ce/TiO_2 samples

achieved high photocurrent density and incident photon current efficiency (IPCE).

This study provides a practical strategy and an important reference for the preparation and understanding of highly efficient visible light-activated rare earth-doped photocatalysts.

More information: Mei-Hong Tong et al, Cerium Synchronous Doping in Anatase for Enhanced Photocatalytic Hydrogen Production from Ethanol-Water Mixtures, *Molecules* (2023). DOI: 10.3390/molecules28062433

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