Novel REOF@TiO_2 nanomaterials with potential applications in photocatalytic processes

Over the past few decades, environment contamination, such as water and air pollution, has become a huge problem all over the world. Photocatalytic processes are regarded as a potential solution to this problem because they belong to the most sustainable and environmentally friendly technologies. In this method, in contrast to conventional methods, we do not introduce additional chemicals during purification. Moreover, this process allows the use of renewable energy source which is the solar radiation, even in areas where solar radiation has a lower intensity.

Titanium dioxide (TiO_2) is one of the most widely used semiconductors for photocatalytic applications. The greater interest in TiO_2 rests in the fact that it is cheap, non-toxic, chemically and photochemically stable and has a strong oxidation capacity. Photocatalytic reactions at the surface of TiO_2 have been attracting much attention due their practical applications to environmental cleaning such as self-cleaning of glasses, tiles and windows. TiO_2 represents an effective photocatalyst for water and air purification and for self-cleaning surfaces. Furthermore, it can be used as antibacterial agent by reason of strong oxidation activity and superhydrophilicity. However, despite the promising properties, anatase TiO_2 is sensitive only to UV light due to a wide band gap (3.2 eV). Therefore, its application is limited because the UV region represents only 3–5% of the entire solar spectrum. Many studies have been performed to develop various modifications of TiO_2 to obtain photocatalysts sensitive to visible light ($\lambda > 400$ nm).

In this regard it is proposed to developing a novel, stable photocatalysts based on titanium dioxide and metal-organic frameworks (MOFs) containing in their structure rare earth metals (RE) characterized by a high luminescence intensity and thus high activity under the UV, Vis and NIR irradiation (Figure 1). In REOF materials the luminescence of the rare earth metals is efficient and intensive, and above all, it is possible to convert absorbed energy to light with higher energies (up-conversion process). The organic ligands act like photon collectors and transfer absorbed energy to RE^{3+} ion induction level. Then, RE^{3+} emits ultraviolet radiation resulting in excited an electron (e^-) from the valence band (VB) to the conduction band (CB) of TiO_2 photocatalysts. These photogenerated charge carriers (electron-hole pairs) can migrate to the surface of the photocatalyst, where they are then available to undergo redox reactions with substrates. This is followed by the formation of reactive oxygen species at the surface of the semiconductor and/or a direct oxidation of the polluting species.

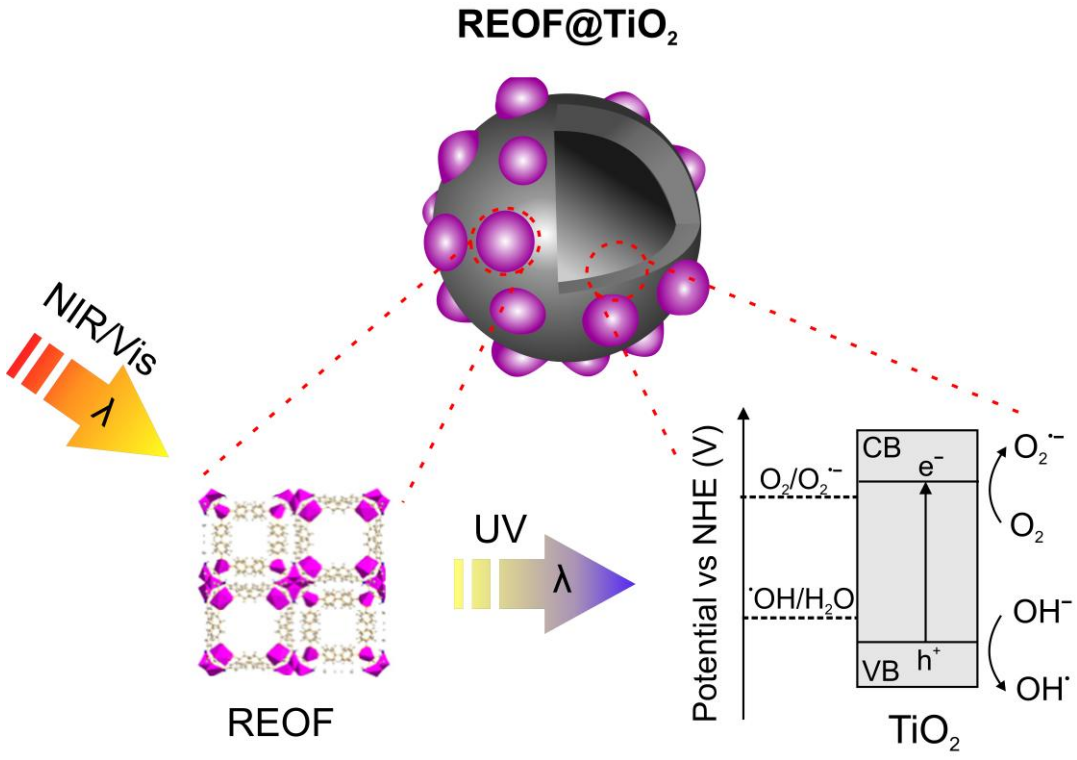

Figure 1. Simplified mechanism of TiO_2 excitation by up-conversion luminescence agent