Design, synthesis, and physicochemical characterization of 2D nanosheet-based hybrid photocatalysts for degradation of pharmaceuticals

Clean and drinkable water, free of toxic, carcinogenic substances and pathogenic microorganisms, is necessary for human health. In recent years, pharmaceuticals has become a class of emerging environmental contaminants that are extensively and increasingly being detected in aquatic systems. The surface and ground waters are contaminated with trace amounts of substances not susceptible to biological degradation such as furazolidone, acetaminophen, diazepam, lincomycin, hydrochlorothiazide, naproxen, triclosan, ibuprofen and other. Therefore, in order to meet the water supply demands, more efforts should be done to develop new methods for the purification of water, from recalcitrant organic pollutants.

Photocatalysis is a promising approach to solve future environmental problems. Extensive research is devoted mainly to TiO_2 photocatalytic oxidation. Despite the large application potential in photocatalytic oxidation of recalcitrant organic pollutants, titanium (IV) oxide nanoparticles still exhibit several limitations hindering their wide scale industrial utilization. Generally, the enhancement of TiO_2 photocatalytic activity involves the suppressing of the electron-hole pairs recombination, improvement of their generation and the photons absorption. TiO_2 is a wide bandgap photocatalyst, thus practically limits its light harvesting capability to UV light, while the visible light and longer-wavelength photons are not effectively used in photocatalysis.

Among various efforts to extend TiO_2 photocatalytic activity especially attention is focused on the design of TiO_2 morphology and microstructure during preparation procedure in order to achieve enhanced photodegradation of persistent organic pollutants. Recently, two-dimensional (2D) TiO_2 nanomaterials with atomic-level thickness have attracted considerable attention. The application of 2D titania nanosheet can provide an effective way to improve the photocatalyst performance. Moreover, heterojunction of TiO_2 nanosheets with highly exposed (001) facets with conducting polymer nanostructures will allow to achieve high-performance photocatalysts under UV and visible light irradiation. To solve the problem with separation of nanosized TiO_2 we propose functionalization of 2-D TiO_2 with 0D, 2D magnetic particles. As presented in Figure 1, the 2-D TiO_2 nanosheet can be applied as effective building blocks for novel functional hybrid materials. Depending on the reaction conditions, the reassembling of exfoliated TiO_2 nanosheet yields either to well-ordered intercalation structure or disordered porous structure with developed specific surface area.

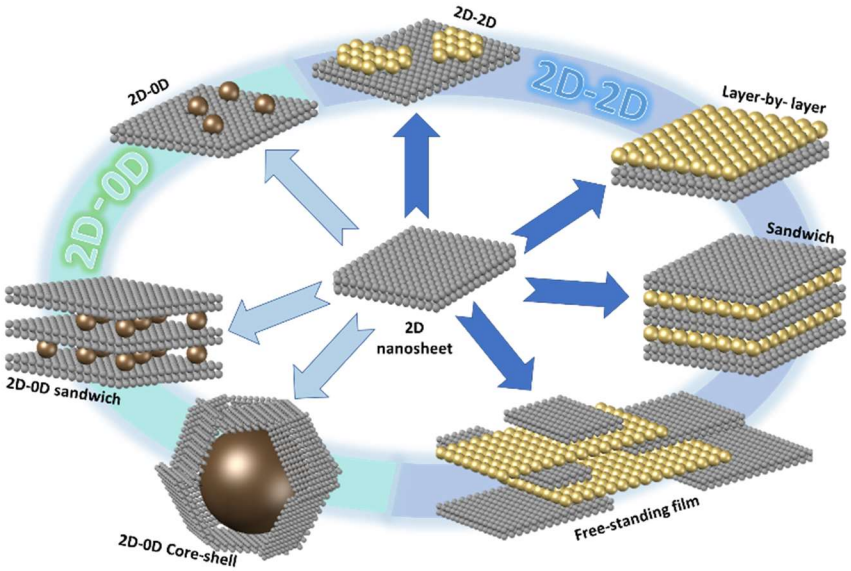

Figure 1. Schematic illustration of proposed strategies of preparation hybrid 2D sandwich and 2D/0D structure photocatalysts

Obtained 2D hybrid photocatalysts can be easily separable from the system and reused in the photocatalytic reaction of the degradation of pharmaceuticals in the aqueous phase. Model for quantitatively describing the relationship between the structure and the properties of photocatalysts will be developed and allow to optimize the degradation process, and therefore more efficient photocatalytic degradation of pharmaceuticals from water.