Development of multifunctional micro/nanoparticles based on transition metal dichalcogenides for environmental remediation

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Remediation of wastewater has become a great challenge to face worldwide, it is included as one of the goals for the 2030 ONU Agenda to achieve universal and equitable access to safe and affordable drinking water for all. Although there are several mechanisms to degrade pollutants from water, photocatalysis is a simpler, more sustainable and cost-effective water treatment technology that uses light and no additional reactants to mineralize toxic pollutants. The use of nanomaterials or nanostructured semiconductor photocatalysts has shown significant efficiency in the degradation of organic and inorganic pollutants. Recently, new layered 2D nanomaterials based on transition metal dichalcogenides (TMDs) are featuring special attributes for photocatalysis such as low-bandgap for efficient visible light conversion energy, significant photon absorption, and band-gap tunability via modulation of the VB and CB with the number of stacked layers. Also of interest is the capability to tune the layer stack growth in different orientations and exploit layer edges as highly catalytic sites for photocatalytic activity enhancement. Therefore, MoS_2 and $MoSe_2$ TMDs displaying such attributes can be exploited for the generation of reactive oxygen species (ROS) that are essential for the degradation of pollutants in water.
The present work aims at the development of multicomponent micro/nanoparticles by integrating TMD semiconductors as the main photocatalysts to degrade pollutants. These photocatalysts are combined with different silicon microstructures such as mesoporous particles and doped silicon wires as platforms to obtain high loading of the active TMD nanostructures. Likewise, different synthesis methods and phases of MoS_2 are studied, compared, and characterized. In addition, to improve ROS production and reduce the photo recombination of generated species, co-catalysts, like noble metals, other TMDs materials, and/or magnetic nanostructures are used. The photocatalyst performance is evaluated on typical dyes pollutants such as Rhodamine B and also on antibiotics such as tetracycline.