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Dye Degradation and Bactericidal Potential of Bi-Doped Mos_2 Nanosheets

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Commentary

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ABSTRACT

Two dimensional (2D) materials, for instance, molybdenum disulfide (MoS_2) exhibit antibacterial potential in contrast to several microorganisms and decent degradation responses against different dyes. As MoS_2 is highly conductive possessed high charge mobility and large surface area, so it can provide a better response in antibacterial activity, biomedical application and to degrade dyes without toxic effect on the environment.

COMMENTARY

2D Ultrathin atomic layer MoS_2 nanostructure has attained much research interest attributable to its novel and significant chemical, physical, optical and electrical properties. MoS_2 is a transitional metal dichalcogenide (TMD) which widely used in the research field. It is 2D layered structure in which transitional metal Mo atoms are sandwiched between two sulfur (S) layers of atoms. Bulk MoS_2 possessed an indirect bandgap of (1.29 eV) while, monolayer of MoS_2 exhibits a direct bandgap of (1.8 eV). Therefore, monolayer MoS_2 offers strong electro- and photo-luminescence, as well as great response in *in vivo* antibacterial activity and dye degradation process, owing to its direct bandgap [1,2].

To date, numerous struggles have been done to order monolayer MoS_2, containing micromechanical and chemical exfoliation, hydrothermal process, physical and chemical vapor deposition. Among all above-mentioned techniques, hydrothermal process is most promising technique in terms of simple-operation, low cost and used to prepare monolayer of various 2D materials [3].

Recently, (TMDs) MoS_2 show great potential in antimicrobial activity against different microorganisms. The most threatening pathogen called ESKAPE that has become a big challenge for human and living organisms. The ESKAPE pathogens exhibit strong growth of antibiotic resistance and were affirmed by Infectious Diseases Society of America (IDSA). The more dreadful bacteria are Methicillin Resistant *Staphylococcus aureus* (MRSA) that becomes a major risk of death in the whole-world. Every year, *Escherichia coli* (*E. coli*) gram negative bacteria spread Diarrheal illness, particularly transmitted within impure water. Due to this alarming situation, the death rate of children under five years reached up to 1.3 million in a globe [4].

Organic dyes are widely used in many industries such as food, cosmetic and textile owing to their low-cost and accessibility of dyes. In organic dyes, most of the dyes are poisonous and carcinogenic for aquatic life and human life as well. With the release of these toxic effluents, serious pollution has been observed in surface water and groundwater. So, from the contaminated aqueous solution, the removal of dyes is mandatory for a healthy environment. For this purpose, advanced oxidation process [AOP] has been extensively used for organic dye removal from contaminated water [5].

For the degradation of organic dyes, semiconductor catalysis is most suitable and effective AOP remediation due to its efficiency and friendly environment. Moreover, catalytic activity can be utilized under ambient conditions for complete organic dyes degradation. Generally, various semiconductors are used for degradation of organic dyes such as MoS_2, ZnO, TiO_2 and CdS. Among all these materials, MoS_2 is a best and potential candidate for catalytic response owing to its novel properties [6].

Research update

Antibiotics work as miracle drugs which is an urgent need of medical appliances in the past. Unfortunately, with the excess use and inappropriate treatment of antibiotics, there seems to be a shocking situation in clinical medicine today. With excessive usage of antibiotics, many diseases specifically incision drainage of the wound and high dosage of antibiotics patients suffer great pain and high cost of medicine making treatment. However, for reasonable and better treatment an adaptive method used with bacteria in the formation of biofilm leading to antibacterial activity. Biofilm coatings cover the surface of bacterial cell and provide a protective shield against several extracellular adverse effects of the environment [7].

In the last two decades, nanomaterial have been widely used for the better solution of environmental problems arising from polluted water or shortage of water. Nanomaterial such as MoS_2 has found in environmental applications like removal of water contamination, photo catalytic oxidation, biomedical, membrane-based separation environmental catalysis and adsorbents [8].

Similarly, environmental pollution has become major risk for all human and aquatic life lies under ponds, lakes and oceans are in a search of fresh water. Recently, various efforts have been made to remove all toxic from wastewater and industrial-effluents. In this context, various approaches including photocatalytic or catalytic degradation, filtration and electrochemical treatment have been described. Numerous investigations have applied to develop products to elucidate water pollution challenges such as ZnO, TiO_2. MoS_2 nanosheets have many advance photoelectric characteristics, catalytic performance, high absorbance, greater chemical stability, more carrier stability and direct bandgap. Owing to these excellent properties of MoS_2 drive catalytic researchers to join it with semiconductor, for instance, Bi-doped MoS_2. As reported, these nanocomposites have been used to degrade organic dyes offering a potential candidate for industrial decontamination in the future [9,10].

Future perspective guidelines

As antibiotic resistant and contaminated water has become serious issue in the current situation. In this commentary, we report excellent catalytic activity and potential antimicrobial activity of Bi-doped MoS_2 regarding the organic dye of MB synthesized by a simple hydrothermal method. The outstanding catalytic activity of Bi-doped MoS_2 could be prolonged for the degradation of other organic dyes. Two-dimensional materials like MoS_2 with the incorporation of post-metal transition such as Bi would be the best candidate against the growth of antibiotic resistant. We believe that Bi-doped MoS_2 has unique antibacterial outcomes and impressive catalytic activity making it a superior candidate in the near future.

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