Method for Creating Nanopores in MoS_2 Nanosheets by Chemical Drilling for Disinfection of Water Under Visible Light

IITM Technology Available for Licensing

Problem Statement

- **Water scarcity** is a global concern, and finding efficient methods for **water purification and disinfection is crucial.**
- Traditional disinfection methods often involve use of **chemicals or UV light**, which can have **many drawbacks** and in some cases it can make the water **harmful for consuming**.
- Old methods could **not be adapted for large-scale industrial applications**. The scalability is important for **addressing real-world water treatment challenges**, as large volumes of water need to be treated efficiently.
- Existing methods for introducing nanopores in MoS_2 nanosheets often **involve complex and sophisticated** instrumentation, making them **expensive** and **difficult to scale up**.
- Thus, an invention is needed to address challenges in water treatment, that offers a **simpler & more cost-effective method** for introducing **nanopores in MoS_2 nanosheets**, contribute to advancements in nanomaterials, and potentially provide more **environmentally friendly water disinfection way**.

The present patent discloses a method that addresses above mentioned issues.

Technology Category / Market

Categories: Micro & Nano Technology, Environmental Engineering

Industry: Water Treatment & Desalination Industry, Environmental Technology, Chemical Engineering, Nanotechnology, Catalysis, Renewable Energy, Biotechnology & Medical Industry, Pharmaceutical, Cosmetics & Personal Care Industries.

Applications: Water Desalination & Disinfection, Sensors, Energy Storage, Photocatalysis, Anti-bacterial Applications, Environmental Remediation, Advanced Materials, Nano-filtration.

Market: The global market for Ultraviolet (UV) Disinfection estimated at **US $ 4.7 B in 2022**, is projected to reach a revised size of **US $ 12.9 B by 2030**, growing at **13.4% CAGR in 2022-2030**.

Intellectual Property

IITM IDF No: 1589; IP Grant No: 356015

TRL (Technology Readiness Level)

TRL - 4, Experimentally validated in lab.

Research Lab

Prof. Pradeep T
Department of Chemistry

Key Features / Value Proposition

1. Enhanced Water Interaction:

- Nanopores in MoS_2 nanosheets increase surface area and reactivity.
- This boosts efficiency in water treatment by improving interactions with water molecules.

2. Improved Contaminant Removal:

- Defect-rich nanoporous structure enhances surface reactivity. This aids in removing contaminants from water, making it cleaner. **The result showed 100% disinfection after 5 cycles (Refer Fig 3).**

3. Controlled Nanopore Formation:

- Electrosprayed Ag ions create controlled nanopores in nanosheets. Adjusting deposition time customizes pore sizes for various applications.

4. Versatile Applications:

- Customizable nanopore size suits diverse industrial needs like in catalysis, sensing, and energy storage, beyond water treatment.

5. Sustainable Water Disinfection:

- Using visible light aligns with sustainable practices.
- Disinfection method meets environmental regulations and benefits nature and health.

6. Relevance to Industry Challenges:

- Addressing water scarcity and pollution aligns with industry challenges. The technology's potential solutions make it more significant.

7. Industrial Feasibility:

- Process's efficiency holds industrial promise.
- Scalability makes it suitable for large-scale water treatment.

8. Cost-Effectiveness and Simplicity:

- Affordability and simplicity benefit industrial adoption. The process is cost-effective, easy, and works in regular temperatures.

Refer Fig 1, 2, and 3

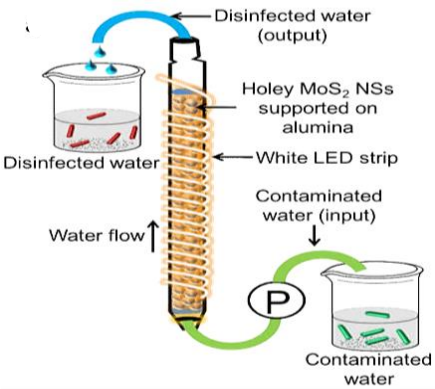

Fig 1 Prototype with holey MoS_2 for water disinfection using low power LED strips

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Technology

The present Patent discloses a **method** of making nanoscale holes in a two dimensional MoS_2 nanosheets, the method **comprising**:

electrospray deposition (under ambient conditions) of reactive Ag^+ ions onto a 2D MoS_2 nanosheets, wherein the Ag^+ ions react with the sulfur atoms on the basal plane of MoS_2 nanosheets forming Ag_2S, resulting in a defect-rich MoS_2 nanosheets;

Wherein

- **The Mo rich edges of the said nanoscale holes in MoS_2 nanosheet generates H_2O_2 under visible light for disinfection of water efficiently.**
- **Ag^+ ions are selected from various salts of Ag including but not limited to silver acetate, silver nitrate, and silver perchlorate.**
- **Chemical drilling with metal ions make MoS_2 nanosheet photocatalytically active, which increases reactive oxygen species generation.**
- **The nanoporous MoS_2 nanosheets supported on silica, alumina is used as a device for filtration and as a membrane for desalination of water.**
- **The metal ions for chemical etching are supplied as droplets in the gas phase onto the 2D nanosheets supported on a substrate.**

Fig 2 Shows drilling of MoS_2 nanosheet by ambient ions. Schematic representation of chemical drilling of MoS_2 nanosheets using electrospray deposited Ag^+ ions

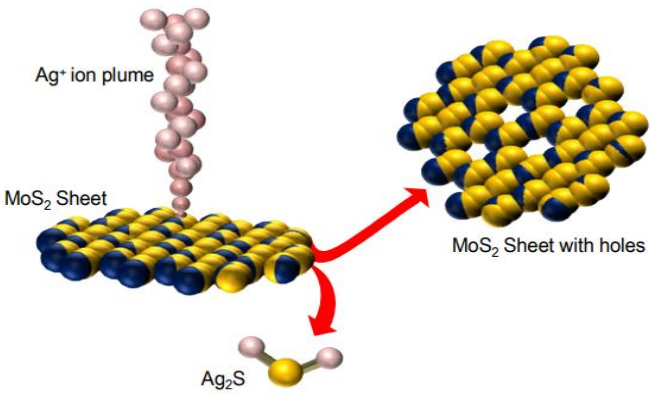


Fig 3 Shows a plot of bacterial count after 2-5 cycles of operation. The result showed 100% disinfection after 5 cycles

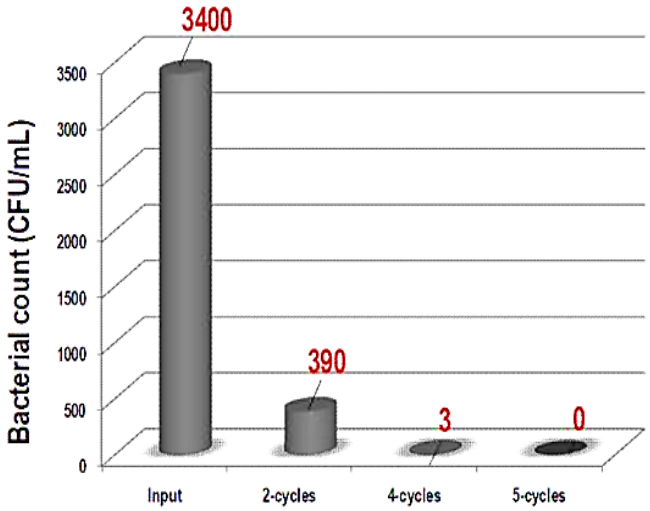
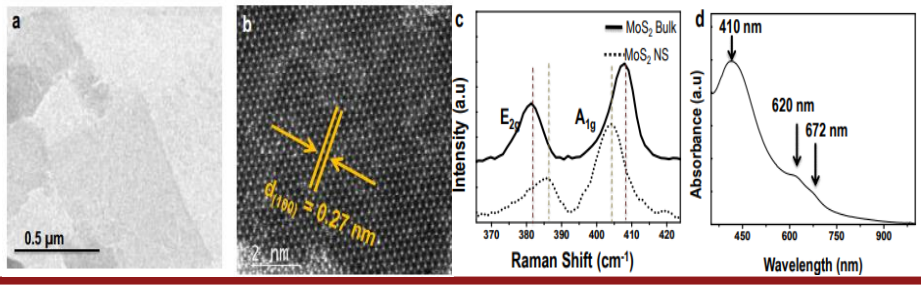


Fig: 4 Shows the MoS_2 nanosheets characterization.



a. TEM image of as-synthesized MoS_2 nanosheet.
b. HAADF TEM image of (a) MoS_2 nanosheet showing that there are no defects in it.
c. Raman spectrum collected from the MoS_2 nanosheet and bulk MoS_2. The peak difference (~18 cm^{-1}) of E2g and A1g for MoS_2 nanosheet suggests that the sheets are one layer thick.
d. UV-Vis spectrum collected from MoS_2 nanosheets suspension.

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