VERTICALLY ALIGNED NANOPLATES OF ATOMICALLY PRECISE Co6S8 CLUSTER FOR PRACTICAL ARSENIC SENSING

IITM Technology Available for Licensing

Problem Statement

- **Arsenic contamination in drinking water affects over 120 million people worldwide** and is expanding due to excessive groundwater use and chemical usage.
- **Existing arsenic sensors lack practicality due to reduced stability, selectivity**, analysis limits, and high costs.
- The need for a practical arsenic sensor in water **without pre-concentration** and sophisticated instrumentation is crucial.
- In view of the **sensitivity of cobalt-based systems for arsenic sensing**, a atomically precise Co6 cluster system is explored to develop a practical sensor.
- The inventors have developed **a method of ambient electrospray deposition (ESD) is used to create 2D nanostructures of the Co6 cluster system** with unique morphologies.
- The goal is to develop a practical electrochemical arsenic sensor capable of **detecting arsenite down to 5 parts per billion (ppb) in tap water**, suitable for field applications.

Technology Category/ Market

Category - Analytical Chemistry, Sensors
Applications - Electrochemical arsenic sensor, Heavy metal testing, Bioremediation, Water Testing
Industry - Electrochemistry, Environmental Monitoring, Water Testing & Treatment

Market – The global arsenic removal market size was valued at USD 622.25 million in 2021 and is expected to grow at a CAGR of 2.33% during the 2021 - 27, reaching USD 714.62 million by 2027.

TRL (Technology Readiness Level)

TRL - 4, Technology validated in lab.

Research Lab

Prof. Pradeep .T, Dept. of Chemistry

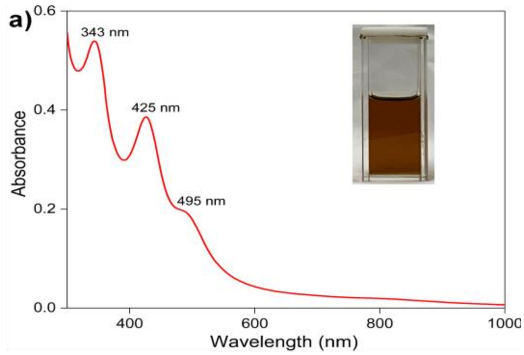

FIG. 1. a) UV-vis absorption spectrum of Co6 in DCM.

Intellectual Property

- IITM IDF Ref. **2469**
- **IN 202241076581**

Technology

- The present invention relates to the **formation of vertically aligned nanoplates of a cobalt containing cluster [Co6S8DPPE6Cl6]** cluster (Co6 in short), protected by 1,2-bis(diphenylphosphino)ethane, using ambient electrospray deposition (ESD).
- A method of preparing an electrode, comprises:

1. **Preparing nanoplates by electrospray deposition of the Co6S8 nanocluster from its solution in dichloromethane.**
2. **Electrospray deposition of the charged droplets on water; refer Fig. 2.**
3. **Harvesting the nanoplates and casted on glassy carbon electrode with a conducting polymer results in vertically aligned crystalline nanoplates; refer Fig. 1 (b).**
4. **Detecting arsenite by its electrochemical oxidation characterized in that, the vertically aligned crystalline nanoplates act as catalytically active surfaces for As3+ binding and detects arsenite by its electrochemical oxidation. Fig. 3.**

CONTACT US
Dr. Dara Ajay, Head
Technology Transfer Office,
IPM Cell- IC&SR, IIT Madras

IITM TTO Website: https://ipm.icsr.in/ipm/

Email: smipm-icsr@icsrpis.iitm.ac.in
sm-marketing@imail.iitm.ac.in
Phone: +91-44-2257 9756/ 9719

Key Features / Value Proposition

1. Materials Cost and Reusability:
- Binder and consumables contribute to materials cost per electrode (< $0.5).
- Electrodes are reusable, leading to potential cost reduction.
- Total cost per analysis can be kept under $1.

2. Arsenic Sensing Invention:
- Developed practical method for sensing arsenic (As3+).
- Utilized atomically precise Co6 cluster for sensing.
- Achieved detection down to 5 ppb in tap water.

3. Novel Cobalt Cluster:
- Synthesized [Co6S8DPPE6Cl6] cluster under ambient conditions.
- Characterized using SCXRD and spectroscopic studies.

4. Sensing Platform Preparation:
- Electrospray deposition (ESD) used to create water surface-based sensing platform.
- Resulted in vertically aligned crystalline nanoplates.

5. Enhanced Sensing Performance:
- Cluster ions interacted with water surface, organizing nanoplatelets.
- Improved surface area and selectivity.
- Excellent response to As3+ achieved.

6. Low LOD and Compliance:
- Achieved Limit of Detection (LOD) of 0.66 ppb.
- LOD below WHO guideline for arsenic in drinking water (10 ppb).

7. Practical Benefits:
- Affordability, selectivity, and sensitivity of the method.
- This can be integrated to electrochemistry so that **data are available on the cloud**.
- There is no need of reagents and consumables.
- Cost-effectiveness makes it a suitable option for arsenic sensing.
- Potential for significant global health impact by enabling affordable arsenic sensing below 10 ppb in water.

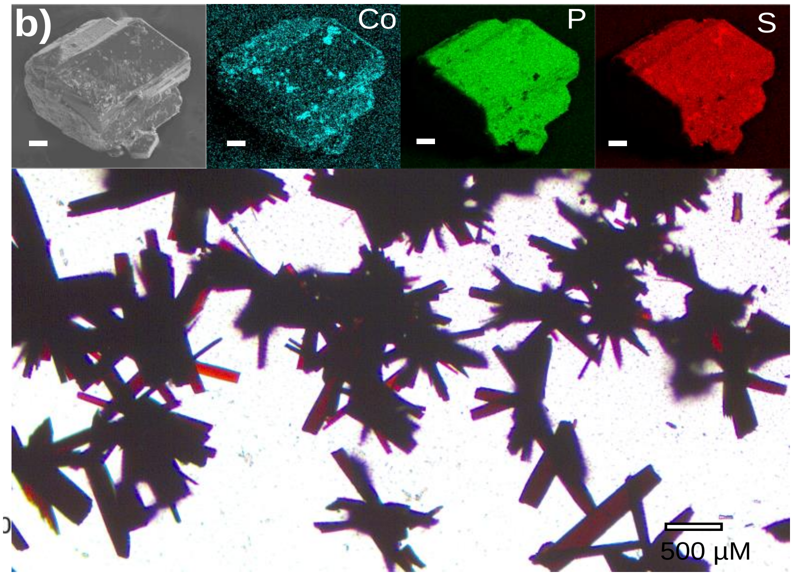

FIG. 1. b) Optical microscopic image of the crystals (inset shows the FESEM micrograph of a crystal and the respective elemental mapping; scale bar corresponds to 500 nm).

CONTACT US
Dr. Dara Ajay, Head
Technology Transfer Office,
IPM Cell- IC&SR, IIT Madras

IITM TTO Website:
https://ipm.icsr.in/ipm/

Email: smipm-icsr@icsrpis.iitm.ac.in
sm-marketing@imail.iitm.ac.in
Phone: +91-44-2257 9756/ 9719

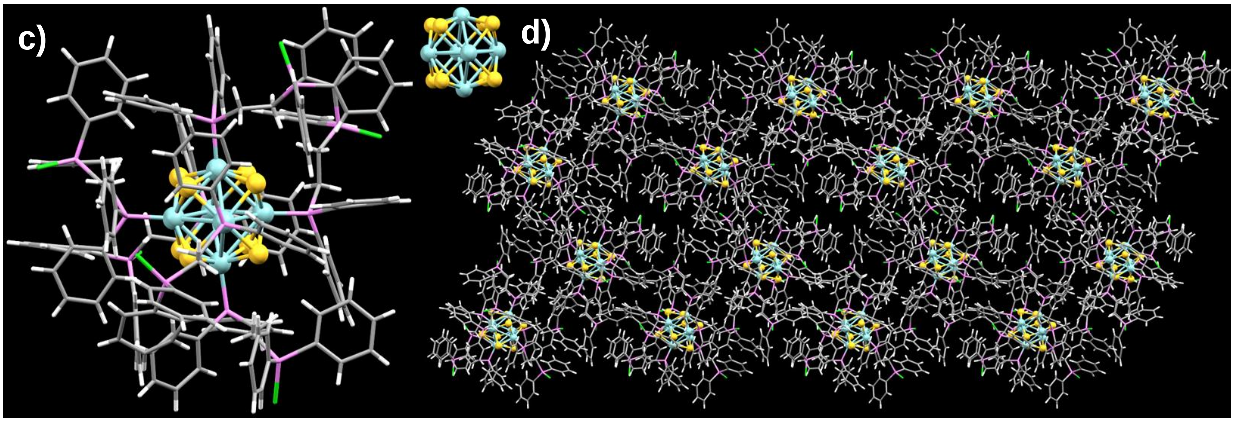

FIG. 1. c) Molecular structure of the cluster including ligands (inset shows the Co6S8 core, with an octacapped octahedron geometry). d) Large area supramolecular packing of [Co6S8DPPE6Cl6] in the b plane. Atomic color codes for c and d: cyan = cobalt, yellow = sulphur, pink = phosphorous, green = chlorine, grey = carbon, and white = hydrogen.

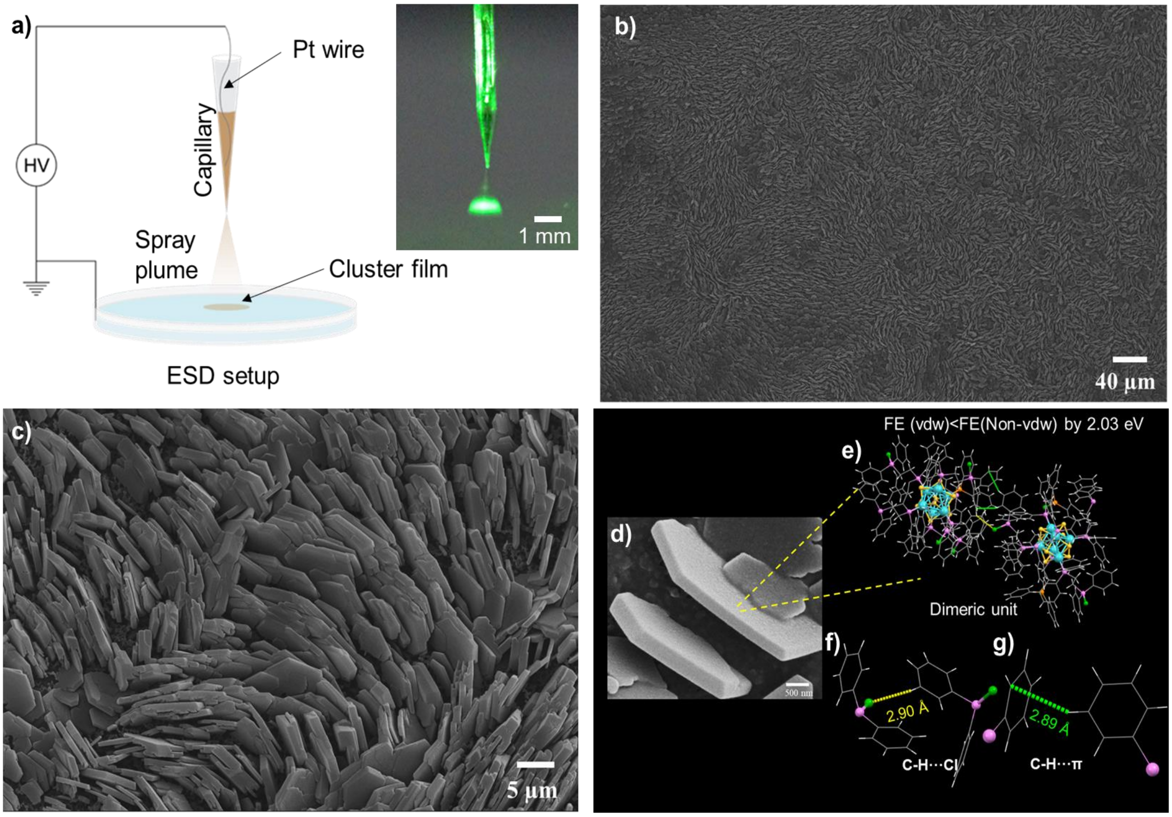

FIG. 2. a) Schematic representation of our home-built electrospray setup. Inset shows a photographic image of the nanospray plume generated from the tip of the capillary. The plume is visualized using a green laser which scatters from it. b) Large area, and c) magnified FESEM micrographs of the vertically aligned nanoplates. d) An expanded image of microcrystalline hexagonal nanoplates. e) Intercluster interaction leading to such a superstructure. f, g) Ligand-centered short contact interactions between two clusters.

CONTACT US
Dr. Dara Ajay, Head
Technology Transfer Office,
IPM Cell- IC&SR, IIT Madras

IITM TTO Website:
https://ipm.icsr.in/ipm/

Email: smipm-icsr@icsrpis.iitm.ac.in
sm-marketing@imail.iitm.ac.in
Phone: +91-44-2257 9756/ 9719

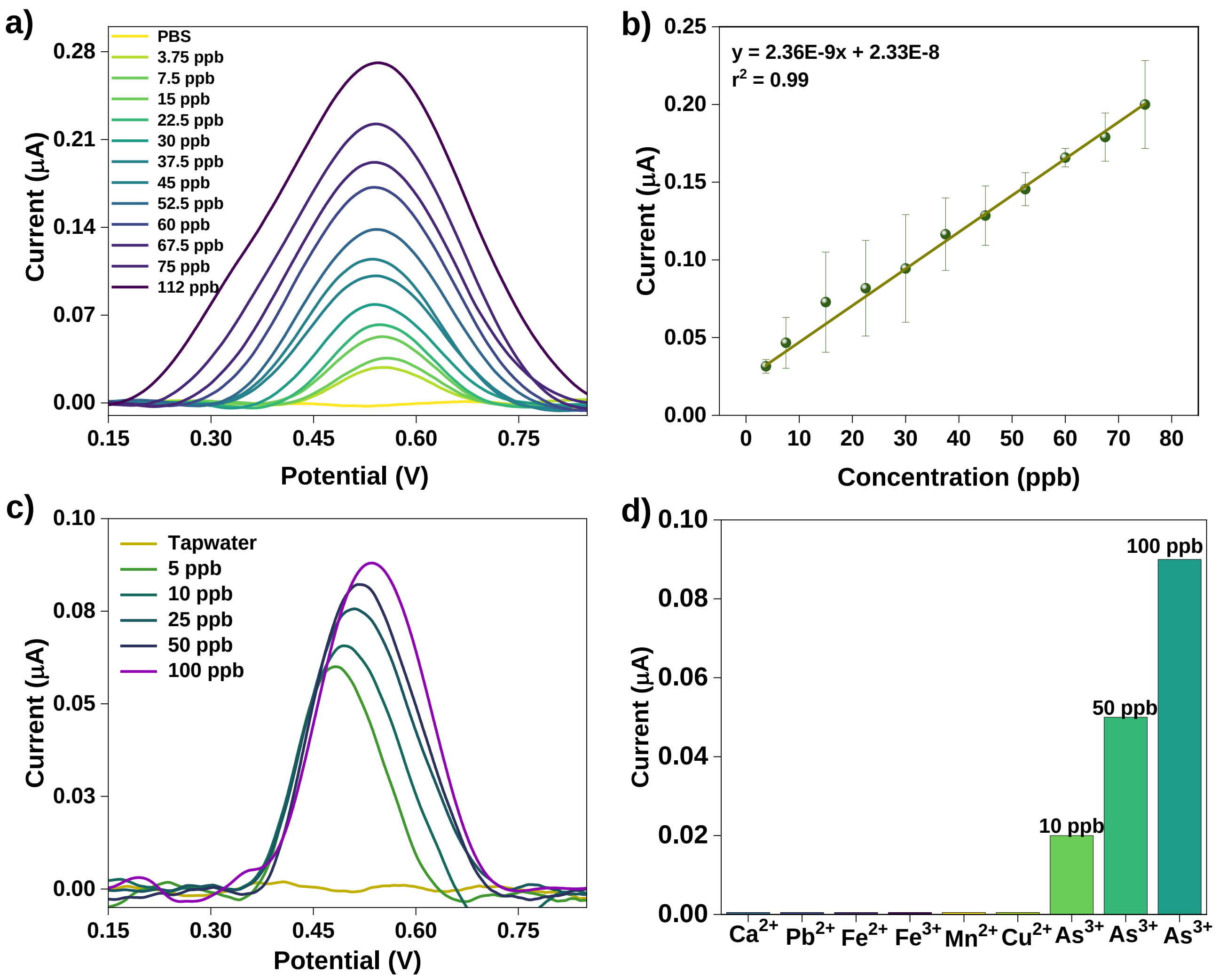

FIG. 3. a) Baseline corrected voltammetry profiles of ESD-modified Co6 GC electrode in response to various concentrations (3.75 − 112 ppb) of As3+ in a buffer solution. b) Linearity analysis of cyclic voltammetry for different concentrations of As3+. Error bars represent inter electrode variability. c) Baseline corrected voltammetry profiles for various concentrations (5 − 100 ppb) of As3+ in tap water. d) Interfering ion studies with different metal ions (100 ppb each of Ca2+, Pb2+, Fe2+, Fe3+, Mn2+, and Cu2+ added sequentially) and the response of arsenic in presence of all of the metal ions.

CONTACT US
Dr. Dara Ajay, Head
Technology Transfer Office,
IPM Cell- IC&SR, IIT Madras

IITM TTO Website:
https://ipm.icsr.in/ipm/

Email: smipm-icsr@icsrpis.iitm.ac.in
sm-marketing@imail.iitm.ac.in
Phone: +91-44-2257 9756/ 9719