Industry Day Theme # {Emerging Nano and Advanced Materials (ENA)}

Economical and Efficient Room Temperature Liquid Phase Exfoliation route to few layer MoS_2

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Abstract

2-Dimensional transition metal dichalcogenides (TMD) materials are of interest to the scientific community due to their immense potential for applications in societal relevance like water splitting to produce H_2 and in Li or Na ion batteries. 2D sheets have been exfoliated on a laboratory scale using techniques like scotch tape method, but large scale liquid phase exfoliation techniques using non-toxic and inexpensive solvents and surfactants is still a challenge. Here, using MoS_2 as a model compound we report the development of solvent-surfactant systems that can potentially result in large scale exfoliation of 2D-TMD that can be utilized for various industrially relevant applications.

Introduction

Among the large family of Transition Metal Dichalcogenides (TMDs), the group VI based compositions MX_2 (M = Mo, W; X = S, Se) are particularly interesting because they are semiconductors with indirect band gaps which lie in the visible region (in the range of 1.1−2 eV). They possess layered structures having strong lateral covalent bonding in between the atoms and weak interlayer non-covalent interactions that make them unique. 2D-TMDs have been demonstrated to be useful in the field of lithium-ion batteries, photocatalysis, hydrogen storage, water splitting as well solid lubricants. The aim of this work is to come up with simple methodologies for low temperature chemical routes to obtain two dimensional TMDs and other related materials.

Materials and Methods

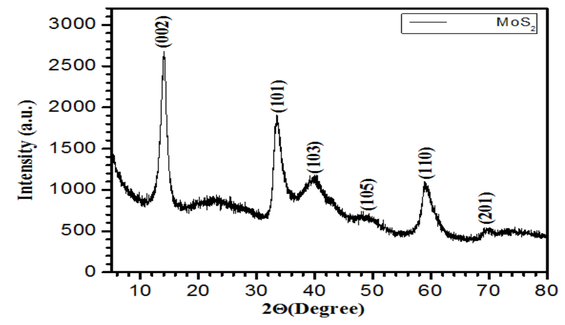
Bulk Synthesis

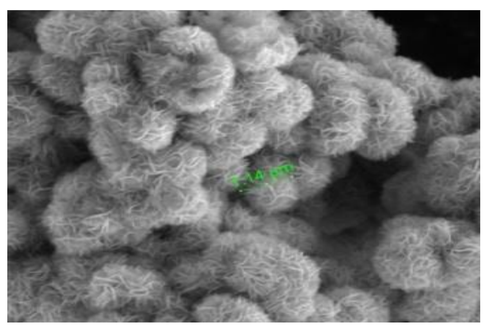
Ammonium heptamolybdate dispersed water → Added Thiourea → Continuous Stirring for 2-3 hrs → Reaction mixture transferred to a hydrothermal autoclave, kept at 180°C for 36 hrs.

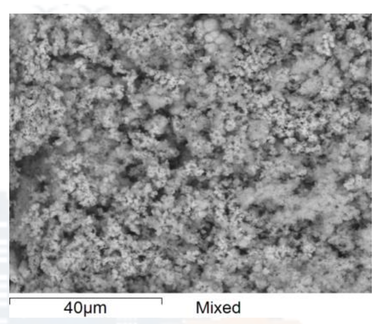
Exfoliation Method

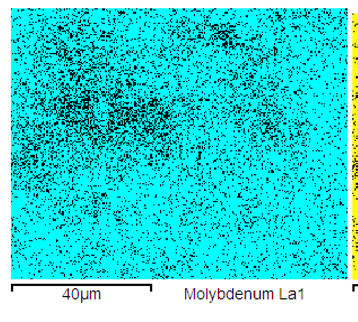
MoS_2 + Polymer in Organic Solvent →  → Ultrasonicated for 5 hrs ⟷ Centrifuged for 30 min at 4000 rpm → 

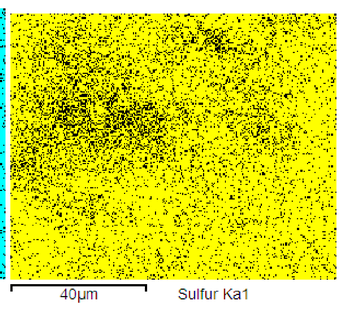
Result

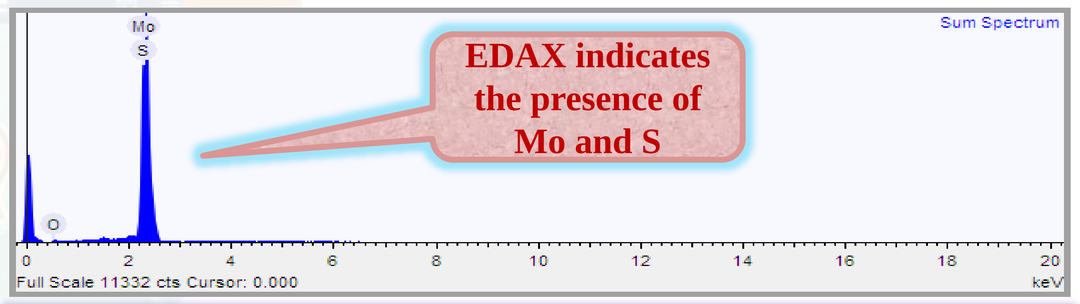




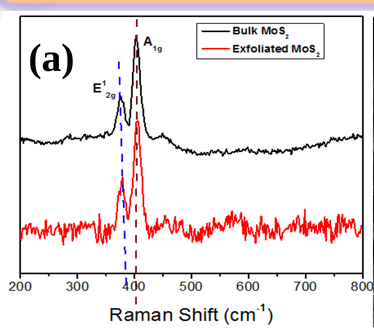


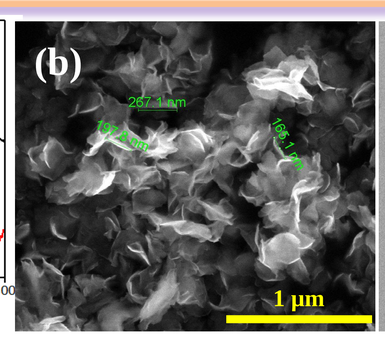


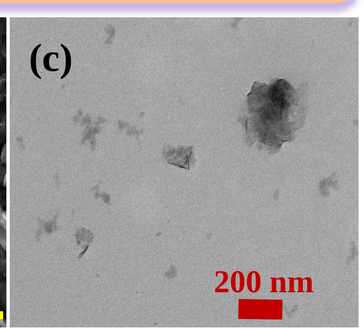


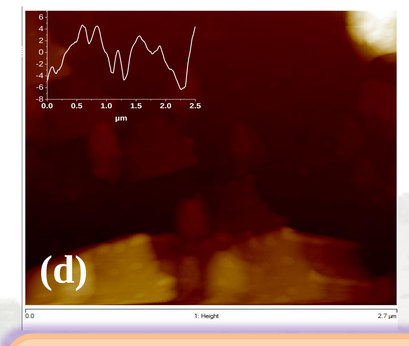


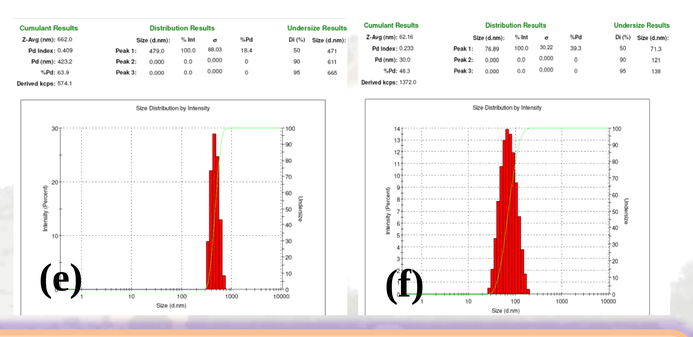
Powder XRD pattern, FESEM and EDAX analysis of Bulk MoS_2











(a) Raman spectra of bulk as well as Exfoliated MoS_2 (b) FESEM (c) TEM (d) AFM Images of Exfoliated MoS_2 and Dynamic light scattering analysis of (e)Bulk MoS_2 [Av. size: 662 nm] and (f) Exfoliated MoS_2 [Av. size: 62 nm]

Conclusions

- A cheap and simple technique was developed to exfoliate MoS_2 bulk material into 2D flakes.
- Bulk MoS_2 material was characterized by Powder XRD, FESEM, EDAX and DLS.
- Exfoliated MoS_2 material was characterized by FESEM, DLS and Raman Spectroscopy.
- Currently attempting to optimize the solvent conditions to increase exfoliation yield and stabilize dispersion.

Industrial Significance

2D TMD have been demonstrated to be excellent photo(electro) catalysts for water splitting to produce H_2 and O_2 and Li ion batteries.

We have been successful in identifying a solvent- surfactant system that is cheap and non-toxic and is able to produce exfoliated MoS_2 on a large scale.

Technology Readiness Level:

Lab scale trials are showing positive results. Scale up in pipeline.

References

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