Hexagonal MoO_3 as a multi-functional material for energy storage, optoelectronics and photocatalytic applications

P. Almodóvar [1,*], M. López [2], C. Díaz – Guerra [1], J. Ramírez Castellanos [2], J.M. González Calbet [2], K. Lorenz [3], M. Peres [3], S. Suárez [4], B. Sánchez [4]

[1] Departamento de Física de Materiales, Facultad de Ciencias Físicas, Universidad Complutense de Madrid, Madrid, Spain.
[2] Departamento de Química Inorgánica, Facultad de Ciencias Químicas, Universidad Complutense de Madrid, Madrid, Spain.
[3] Instituto Superior Técnico, Universidade Técnica de Lisboa, Campus Tecnológico e Nuclear, Lisboa, Portugal.
[4] FOTOAIR – CIEMAT, División de Energías Renovables. Madrid, Spain.

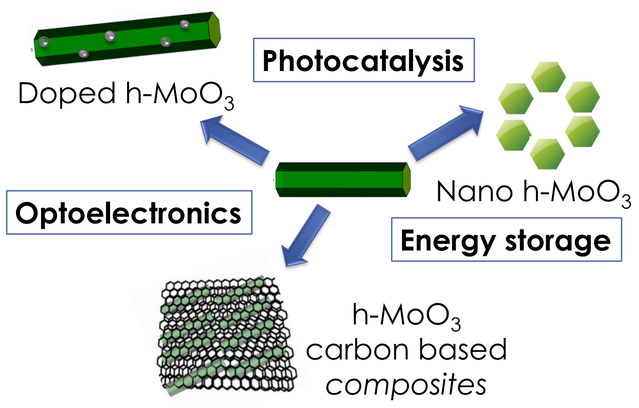
INTRODUCTION

BACKGROUND

Molybdenum oxides are considered **exceptionally functional and adaptable optical and electronic oxides** [1-2]. Known for almost one century and still a source of findings, hexagonal MoO_3 (h-MoO_3) is a metastable material which structure and physicochemical properties are still not well known [3].

AIM

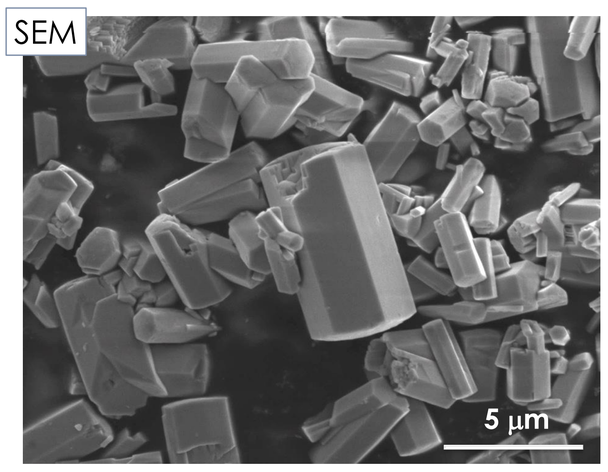
In this work we investigate **potential applications of h-MoO_3** and related composites in different fields, such as **energy storage, photocatalysis and optoelectronics.**



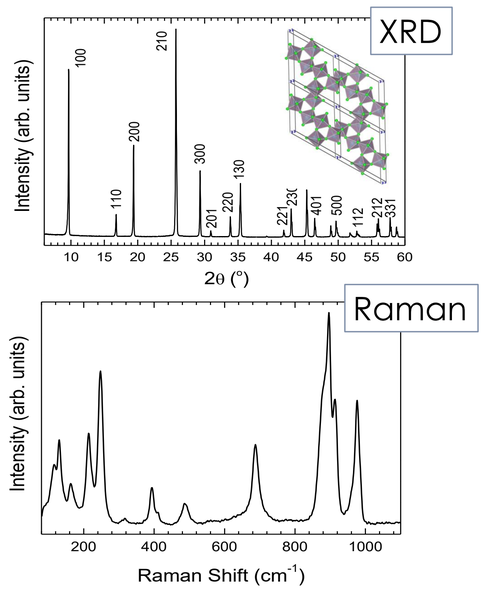
h-MoO_3 SYNTHESIS

$(NH_4)_6Mo_7O_{24} + 6HNO_3 \rightarrow 7MoO_3 [NH_4]_x[OH]_y + 6NH_4NO_3 + 7H_2O$

SEM



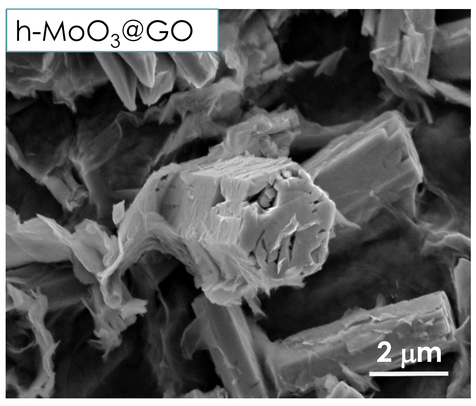
Single crystal, h-MoO_3 rods were obtained. Average size is ~1 μm x 5 μm, but can be adjusted modifying the synthesis conditions.

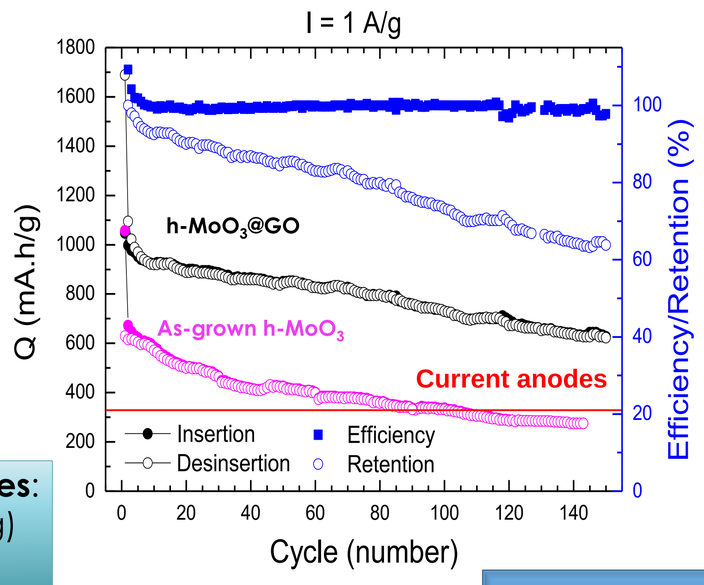


GRAPHENE OXIDE COMPOSITES

$(NH_4)_6Mo_7O_{24} + HNO_3 + \mathbf{GO} \rightarrow MoO_3 [NH_4]_x[OH]_y\mathbf{@GO} + NH_4NO_3$

h-MoO_3@GO



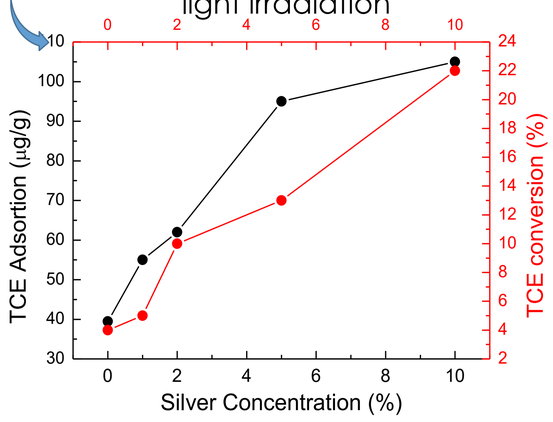


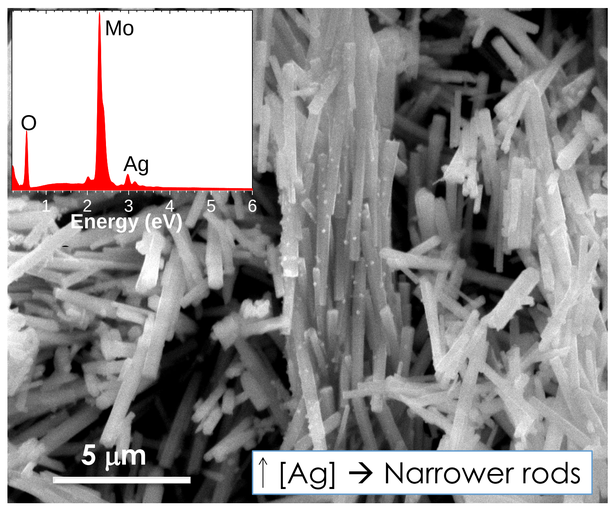
High Performance Li-ion Anodes:
- ✓ Q > 600 mA·h/g (I= 1A/g)
- ✓ Cycle number > 150

Ag-DOPED

$(NH_4)_6Mo_7O_{24} + HNO_3 + \mathbf{Ag(NO)_3} \rightarrow MoO_3 [NH_4]_x[OH]_y\mathbf{:Ag} + NH_4NO_3$

Degradation of trichloroethylene (TCE) in gas phase under visible light irradiation

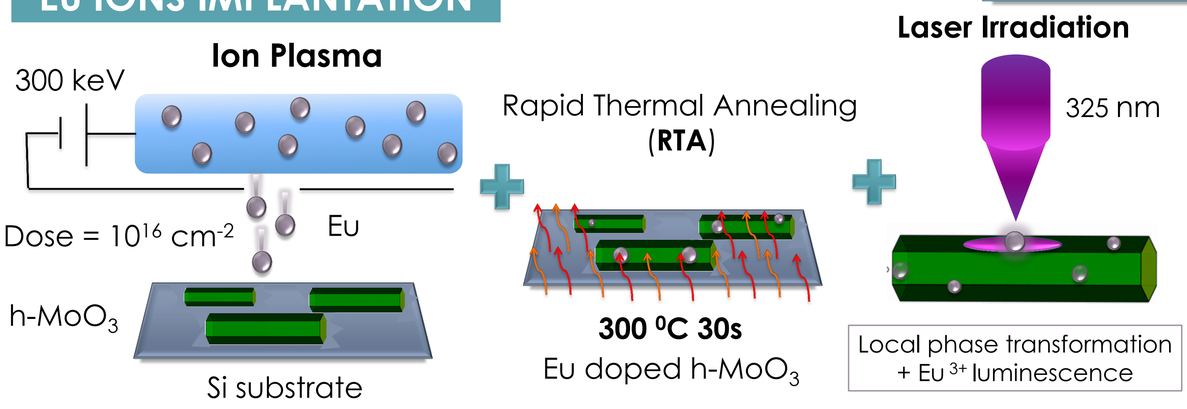


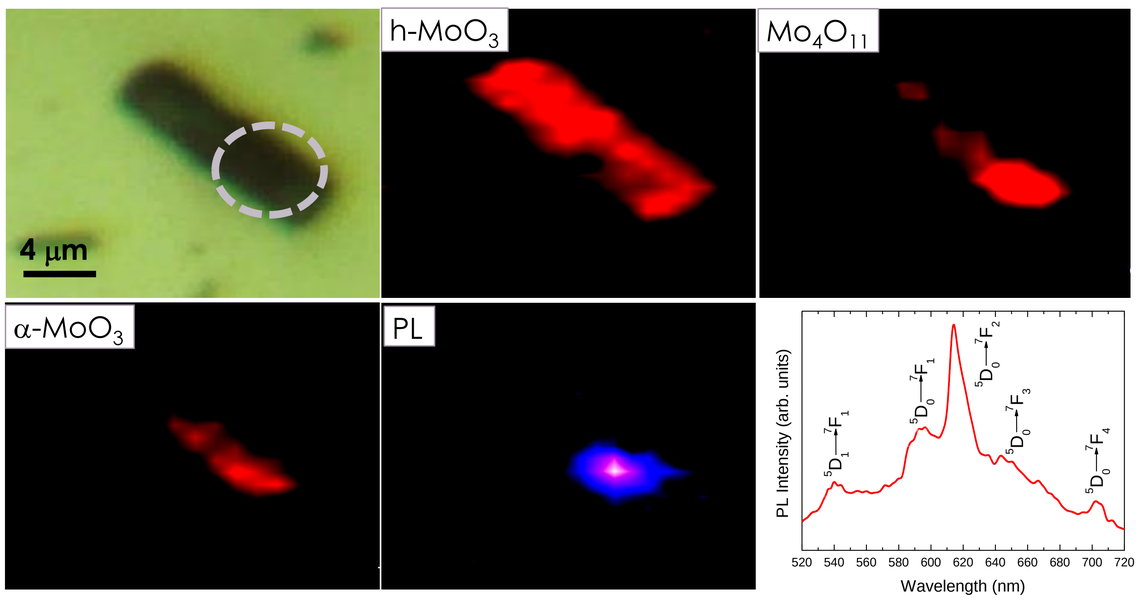


Improvement of the **photocatalytic activity** as a function of Ag doping

APPLICATIONS

Eu IONS IMPLANTATION

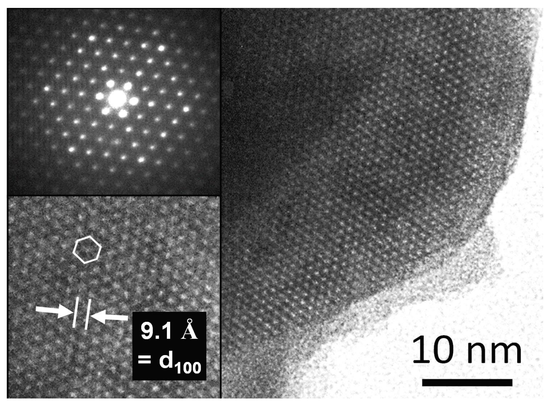


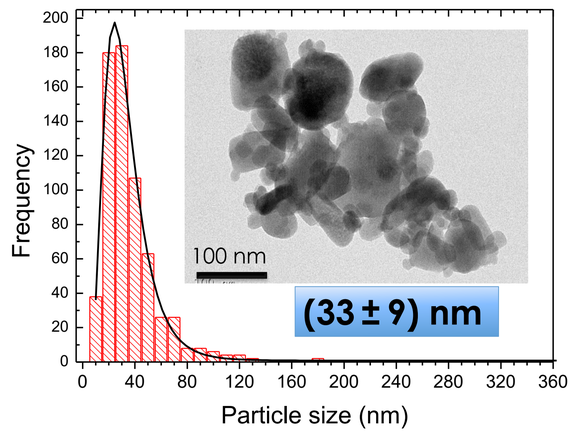


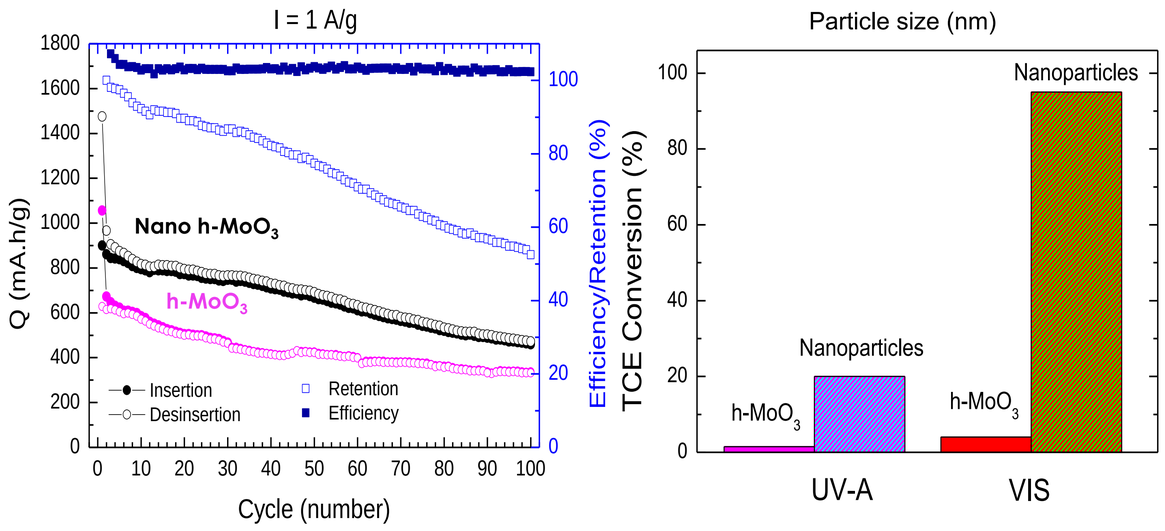
Optical activation of Eu ions implanted in h-MoO_3 can be effectively achieved by **laser irradiation**. Raman and PL mappings reveal that **Eu^{3+} luminescence** emission is triggered **by a h-MoO_3 to α-MoO_3 and Mo_4O_{11} phase transformation** (P. Almodóvar et al. Appl. Phys. Lett. **113** (2018) 031902; CrystEngComm **20** (2018) 4954)

BALL MILLING

100 h ball-milled h-MoO_3 rods → h-MoO_3 nanoparticles







Increased **anode stability** as well as significantly improved **photocatalytic activity,** as compared to as-grown h-MoO_3.

CONCLUSIONS

Potential applications in diverse fields of undoped and doped h-MoO_3 microrods and nanoparticles and their composites with GO have been proven.

- ✓ Energy Storage → h-MoO_3@GO and h-MoO_3 nanoparticles.
- ✓ Photocatalytic activity → Ag-doped h-MoO_3 and h-MoO_3 nanoparticles.
- ✓ Optoelectronics → Eu-implanted h-MoO_3 + laser irradiation.

REFERENCES

[1] I. Alves de Castro, R. Shankar Datta, J. Zhen Ou, A. Castellanos-Gómez, S. Sriram, T. Daeneke and K. Kalantar-zadeh, Adv. Mater, **29** (2017) 1701619.

[2] P. Almodóvar, C. Díaz-Guerra, J. Ramírez-Castellanos, J. M. González-Calbet, M. Peres, and K. Lorenz, Appl. Phys. Lett. **113** (2018) 031902.

[3] H.-J. Lunk, H. Hartl, M.A. Hartl, M.J.G. Fait, I.G. Shenderovich, M. Feist et al., Inorg. Chem. **49** (2010) 9400.

*e-mail: palmodov@ucm.es