The 2018 Partnership in Research and Education in Materials
Research Experience for Undergraduates

Optimized Growth Conditions of MoS_2 Nanoflowers for HER Evolution

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Introduction

Climate change induced by anthropomorphic activity has driven the search for sustainable sources of energy. Many of these technologies are limited by the slow reaction kinetics of the oxygen reduction reaction (ORR) and hydrogen evolution reaction (HER) which demand expensive metal catalysts for practical use. Herein, inexpensive MoS_2 nanoflowers are grown and have the potential to catalyze many of the reactions required for future sustainable energy applications.

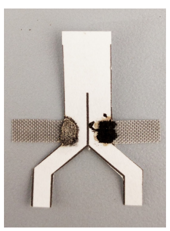
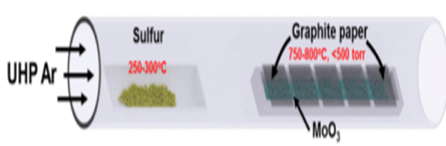


Figure 1: An example of future sustainable energy: a paper based direct formate fuel cell dependent on the oxidation of potassium formate[1].

Figure 2: Schematic of the furnace used to grow the nanoflowers[2]



Methods

The MoS_2 nanoflowers were grown via powder vapor disposition (PVD) from precursor molybdenum oxide and sulfur chips on flexible graphite paper. Various conditions were investigated for optimal growth including argon flow, temperature, time, and pressure.

Results

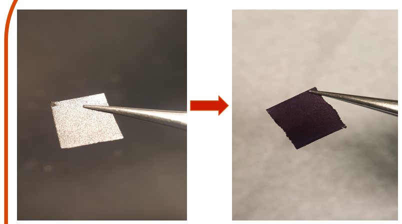


Figure 3: (left to right) The graphite paper substrate before and after the growth. The purple color indicates the growth of the flowers.

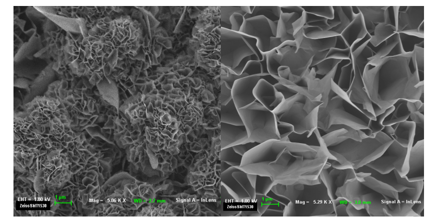


Figure 4: FESEM surface image of the nanoflowers

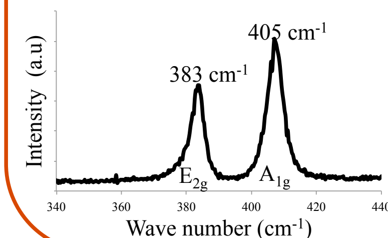


Figure 5: Raman spectra of the substrate surface after growth. The E_{2g} and A_{1g} vibrational modes of MoS_2 at 380 and 406 cm^{-1}, respectively show high quality MoS_2 growth.

Discussion and Conclusion

Figures 3-5 suggest the presence of MoS_2 nanoflowers. Optimal growth seems to occur at conditions of 200torr, 200sccm, 800°C, and 30min for pressure, flow rate, temperature and bake length, respectively. Given the system drift inherit in PVD techniques, these conditions vary over time even when using the same equipment.

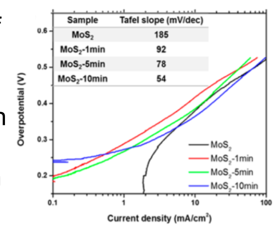


Figure 6: An example of Tafel slopes obtained by electrochemical characterization[2].

Owing to the increased edge sites of the MoS_2 nanoflowers, these substrates are expected to catalyze various reactions. Electrochemical techniques such as cyclic voltammetry and linear sweep voltammetry should be deployed to conduct the catalytic characterizations of these nanostructures.

References

[1] Galvan, V.; Domalaon, K.; Tang, C.; Sotez, S.; Mendez, A.; Jalali-Heravi, M.; Purohit, K.; Pham, L.; Haan, J. Gomez, F. A., An improved alkaline direct formate paper microfluidic fuel cell. *Electrophoresis* **2015**, 37 (3), 504-510.
[2] Bhimanapati, G. R.; Hankins, T.; Lei, Y.; Vila, R. A.; Fuller, I.; Terrones, M.; Robinson, J. A., Growth and Tunable Surface Wettability of Vertical MoS2 Layers for Improved Hydrogen Evolution Reaction. *ACS Applied Materials and Interfaces* **2016**, 8, 22190-22195.

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