EILERS GRADUATE STUDENT FELLOWSHIP
FINAL REPORT

EILERS FELLOW:	Randal Marks
FACULTY ADVISOR:	Kyle Doudrick
REPORT PERIOD:	2017
PROJECT TITLE:	Investigation of nanostructured MoS_2 as an earth abundant catalyst for nitrite hydrogenation
CONNECTION TO ND ENERGY'S RESEARCH AREAS (CHECK ALL THAT APPLY):	**(X) Energy Conversion and Efficiency** **( ) Sustainable and Secure Nuclear** **( ) Smart Storage and Distribution** **( ) Transformation Solar** **( ) Sustainable Bio/Fossil Fuels** **( ) Transformative Wind**

MAJOR GOALS AND ACCOMPLISHMENTS:
List your major research goals and provide a brief description of your accomplishments (1-2 sentences). Indicate the percentage completed for each goal. Please use a separate sheet to share additional details, technical results, charts, and graphics.

MAJOR RESEARCH GOALS	ACTUAL PERFORMANCE AND ACCOMPLISHMENTS	% OF GOAL COMPLETED
Evaluate MoS_2 efficacy as nitrite hydrogenation catalyst	MoS_2 removes nitrite through redox reaction, not hydrogenation	100
Investigate the stability of MoS_2 nanosheets to aqueous oxidants	Nanostructured MoS_2 vulnerable to aqueous oxidants including nitrite and bromate	100
Protect MoS_2 nanosheets from oxidants	Development of carbon coating scheme that prevents MoS_2 dissolution	80
Evaluate electrochemical potential of carbon coated MoS_2	Carbon coated MoS_2 shows comparable activity to uncoated material for Hydrogen Evolution Reaction	80

RESEARCH OUTPUT: Please provide detailed information below regarding any output resulting from your research project.

CATEGORY	INFORMATION
EXTERNAL PROPOSALS	(Sponsor, Project Title, PIs, Submission Date, Proposal Amount) NSF Career: Design and investigation of non-noble metal sulfide catalysts for treating oxidized contaminants in water, Kyle Doudrick, PI
EXTERNAL AWARDS	(Sponsor, Project Title, PIs, Award Date, Award Amount)
JOURNAL ARTICLES	(Journal Name, Title, Authors, Submission Date, Publication Date, Volume #, Page #s) Environmental Science: Nano, Instability of MoS_2 nanosheets to aqueous oxidizers and strategies for protection, Submission (est): 5/31/18
BOOKS AND CHAPTERS	(Book Title, Chapter Title, Authors, Submission Date, Publication Date, Volume #, Page #s)
PUBLIC PRESENTATIONS, SEMINARS, LECTURES	(Event, Presentation Title, Presentation Date, Location) ACS National Meeting and Convention, Investigation of nanostructured MoS2 as an earth abundant catalyst for nitrite hydrogenation, March 21, 2018, New Orleans ND Energy Research Symposium, Protection of MoS2 nanosheets from dissolution by aqueous oxidants using graphitized carbon, 4/18/2018, Notre Dame, IN
AWARDS, PRIZES, RECOGNITIONS	(Purpose, Title, Date Received) ACS ENVR Division, Travel Award for ACS National Meeting, 3/18/2018, $240
INTERNAL COLLABORATIONS FOSTERED	(Collaborator Name, Organization, Purpose of Affiliation) Patrick Fay, Electrical Engineering, Material Synthesis
EXTERNAL COLLABORATIONS FOSTERED	(Collaborator Name, Organization, Purpose of Affiliation)

WEBSITE(S) FEATURING RESEARCH PROJECT	(URL)
OTHER PRODUCTS AND SERVICES (e.g., media reports, databases, software, models, curricula, instruments, education programs, outreach for ND Energy and other groups)	(Please describe each item in detail)

MAJOR GOALS AND ACCOMPLISHMENTS
(Additional Details, Technical Results, Charts and Graphics)

The initial focus of investigation was to investigate the efficacy of MoS_2 nanosheets for hydrogenation of nitrite as a low-energy water treatment technique. MoS_2 nanosheets were synthesized by hydrothermal methods (Figure 1). Investigation of MoS_2 nanosheets revealed unexpected instability to aqueous oxidants including nitrite and bromate (Figure 2). This instability significantly limits the application of MoS_2 nanosheets for environmental applications, including photocatalysis, absorbance, sensing, and filtration. By coating MoS_2 nanosheets with a graphitized carbon coating the nanosheets were protected from dissolution by aqueous oxidants(Figure 3). Carbon coating thickness is controllable by simple synthesis methods. Thin layers of carbon are sufficient for protection of MoS_2 and do not interfere with electrochemical properties of MoS_2, as illustrated by use of MoS_2 nanosheets as a cathode for the hydrogen evolution reaction.

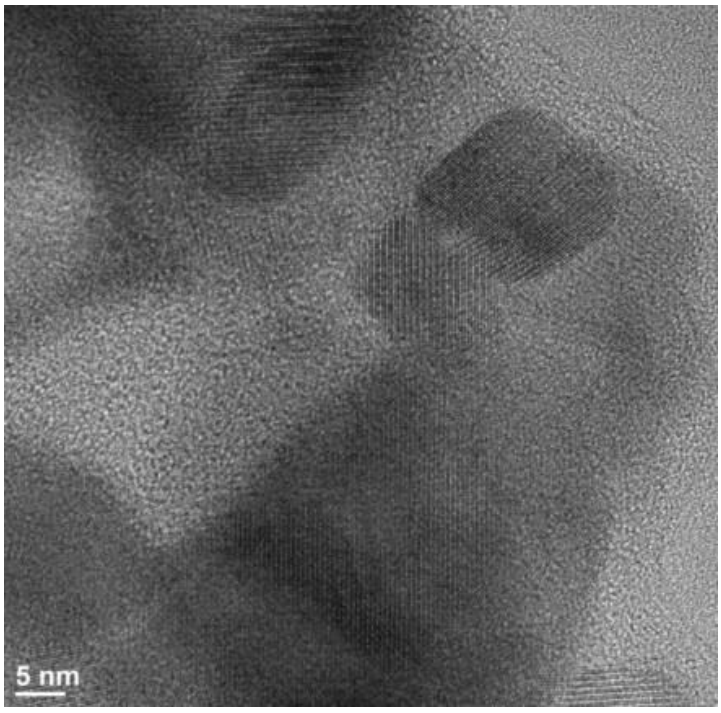

Figure 1. TEM image of hydrothermally synthesized MoS_2 nanosheets

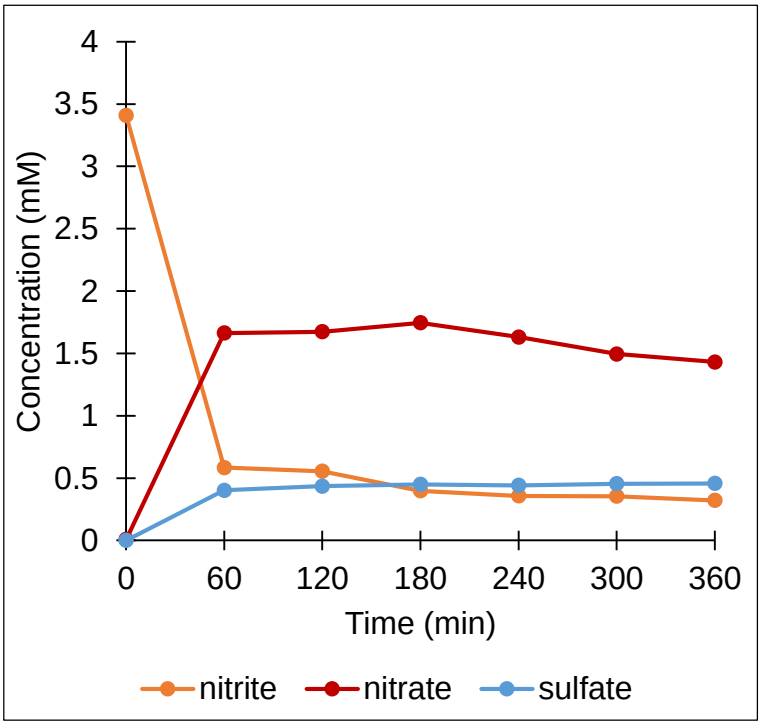

Figure 2. Loss of nitrite and corresponding formation of nitrate and sulfate when MoS_2 nanosheets are exposed to aqueous nitrite (50 mgN/L)

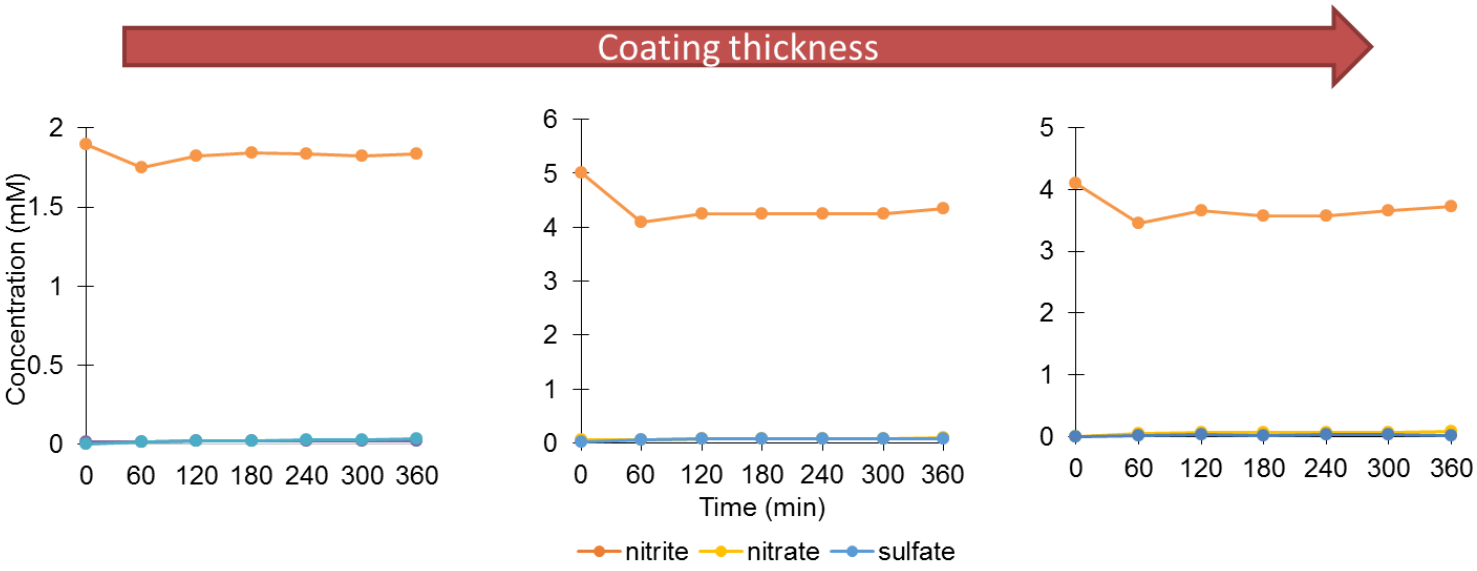

Figure 3. Concentrations of nitrite, nitrate, and sulfate during attempted nitrite hydrogenation by carbon coated MoS_2. Nitrite concentrations drop in the initial period due to sorption. No subsequent hydrogenation occurred as nitrite concentations stabilize. Lack of formation of sulfate and nitrate indicate that carbon coating prevents MoS_2 dissolution.

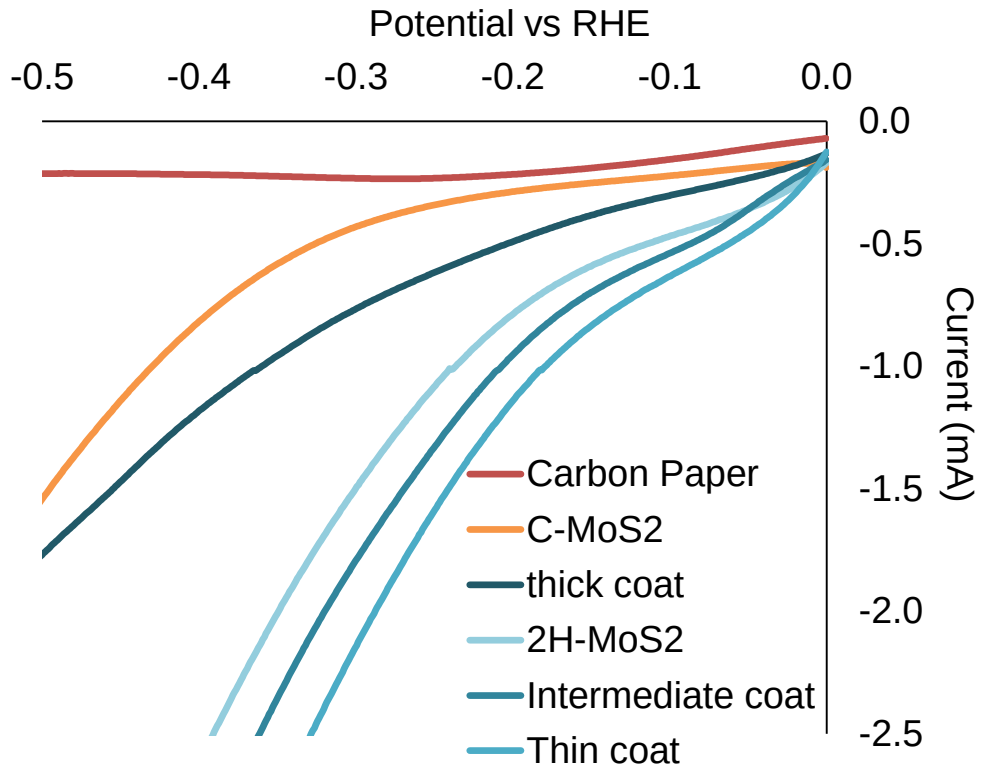

Figure 4. LSV curves for hydrogen evolution reaction using MoS_2 cathode and platinum counterelectrode. Onset potential of hydrogen evolution is not affected by thin or intermediate carbon coating of MoS_2 nanosheets.