

Jessica Whalen, Oscar Marin Flores, Su Ha

The Gene and Linda Voiland School of Chemical Engineering and Bioengineering  
Washington State University

## INTRODUCTION

Energy consumption continues to skyrocket worldwide. Biodiesel is a renewable fuel source that has become more popular due to its high energy output, making it a good candidate as potential feedstock in solid oxide fuel cells. Petroleum based fuels become scarcer daily, and biodiesel provides renewable energy. This fuel is created from the reaction of alcohol with vegetable oils and can therefore be made from a diverse number of sources from waste frying oil to algae.

Researchers have found molybdenum dioxide displays excellent behavior as catalytic material for the oxidative reforming of both isooctane [1] and dodecane [2]. Isooctane yielded 78% H<sub>2</sub> 100% carbon conversion while dodecane had 99.21% H<sub>2</sub> yield. High conversion and yield percentages with isooctane and dodecane make molybdenum a good candidate as an effective catalyst for biodiesel.

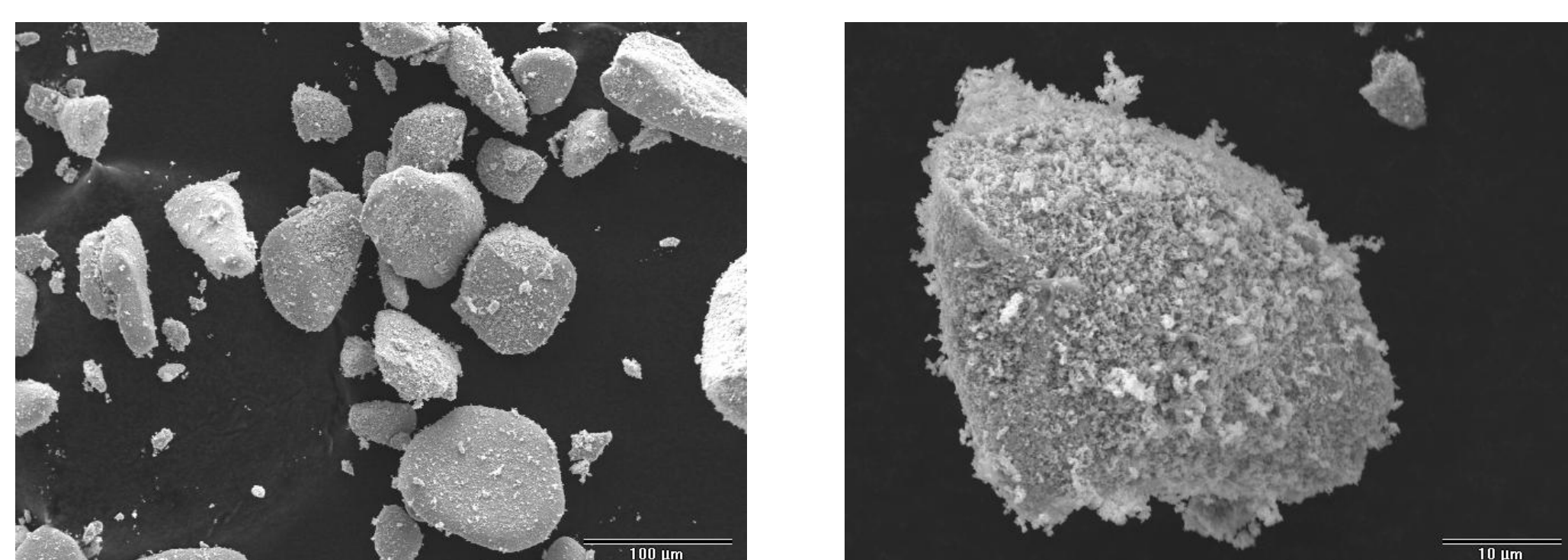
Few papers have been published on the topic of catalytic partial oxidation with molybdenum dioxide. Further research must be done to fully understand its potential for use in solid oxide fuel cells. This cutting edge area of research continues to be important as energy consumption increases worldwide. Combining two promising components, biodiesel and molybdenum dioxide, may prove useful for solid oxide fuel cells.

## METHODS

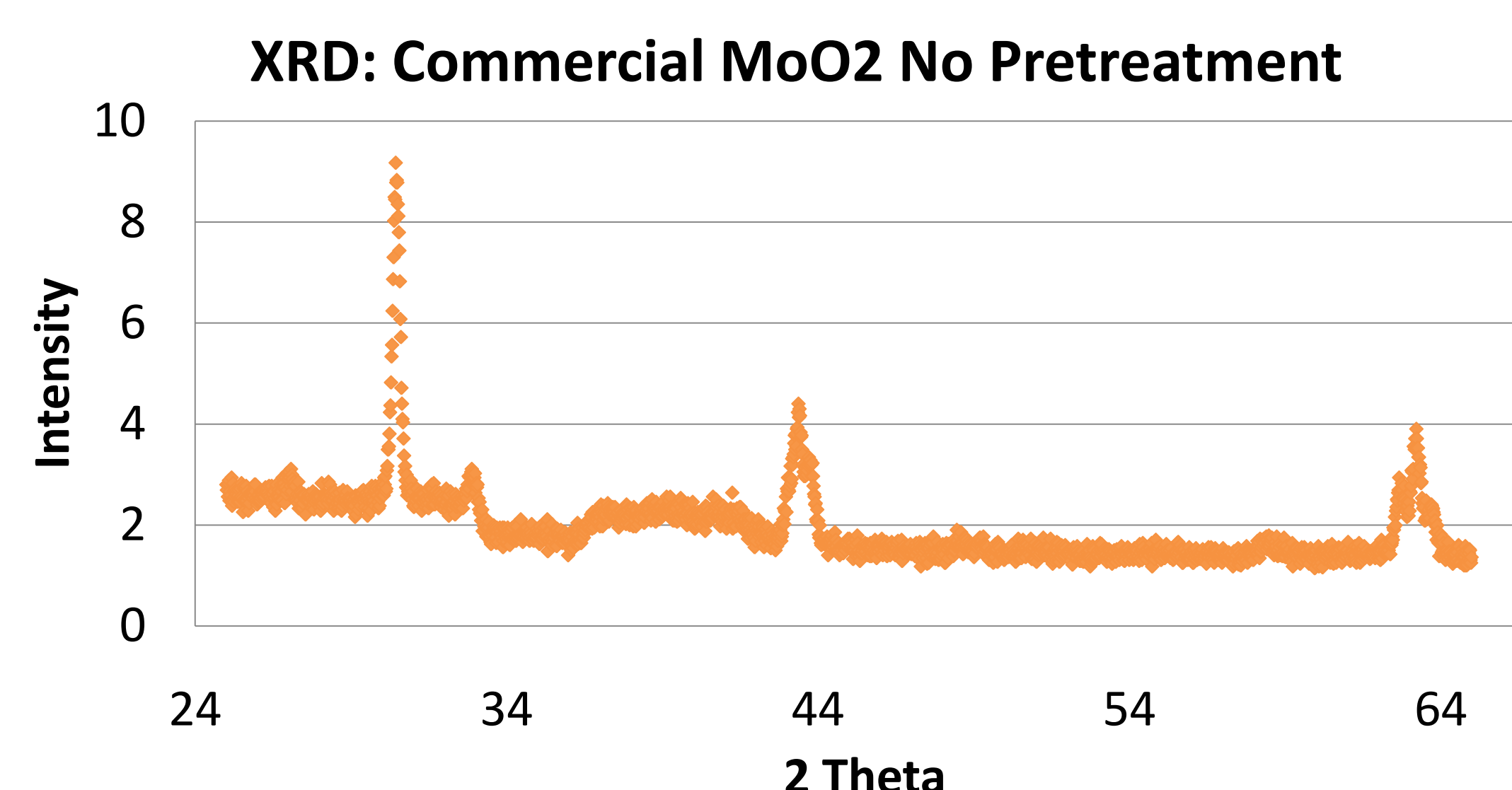
Commercial molybdenum dioxide was used for all tests. Catalytic partial oxidation was carried out in a fixed bed tubular (quartz) reactor. Typically, 0.5 grams of sample were used for each run. Tests were performed with the O<sub>2</sub>/C ratio = 0.5, WHSV = 1 h<sup>-1</sup>, at 850° C and atmospheric pressure unless otherwise noted. All syngas information was taken from a gas chromatograph. XRD information was gathered as part of the characterization process. A Horiba LA-950V2 machine provided particle size distribution information. SEM and EDX images were taken to better understand how the catalyst changed after testing. The BET surface area was measured using a Micromeritics ChemiSorb 2720.

## CHARACTERIZATION OF THE CATALYST

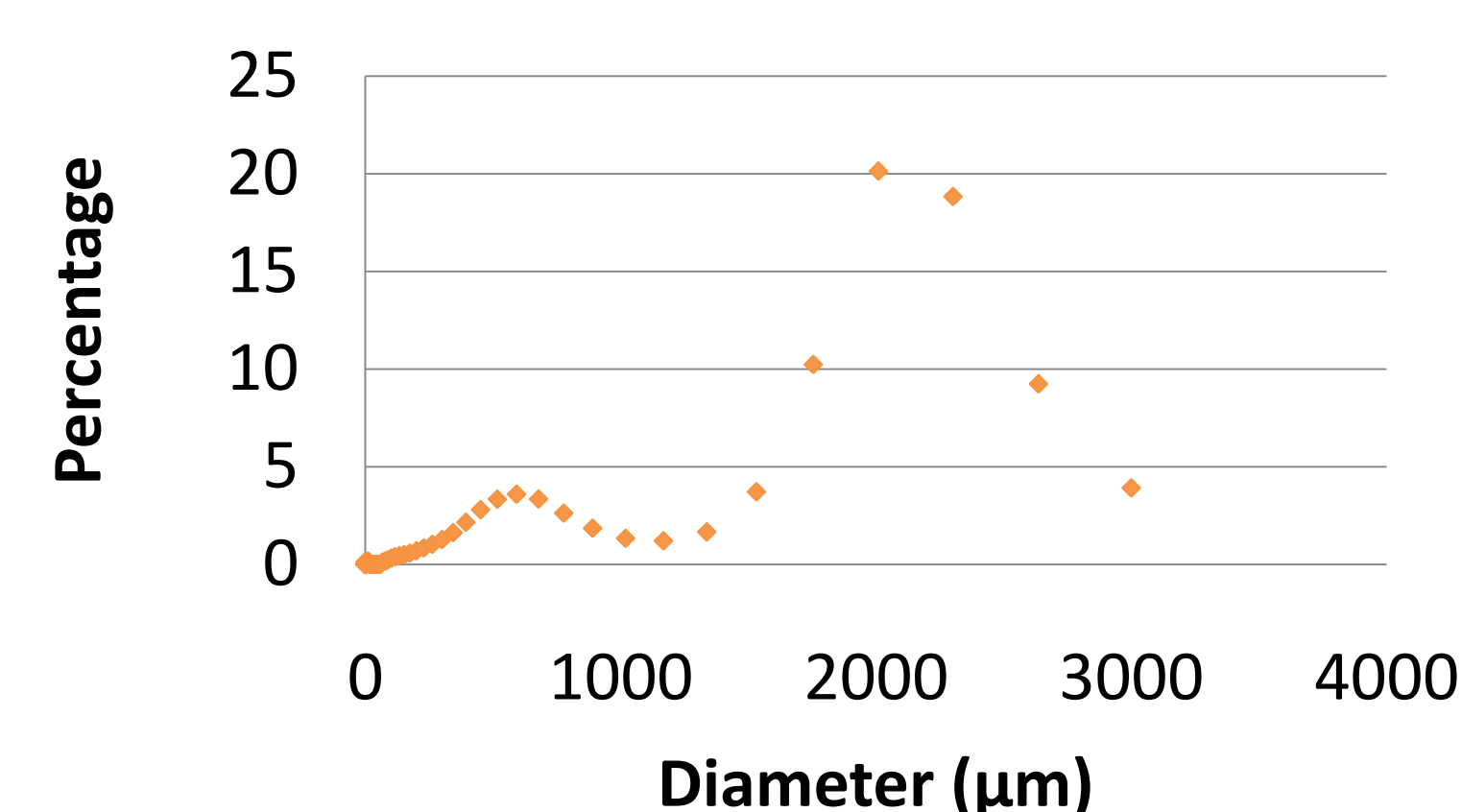
BET surface area = 3.9 m<sup>2</sup>/g



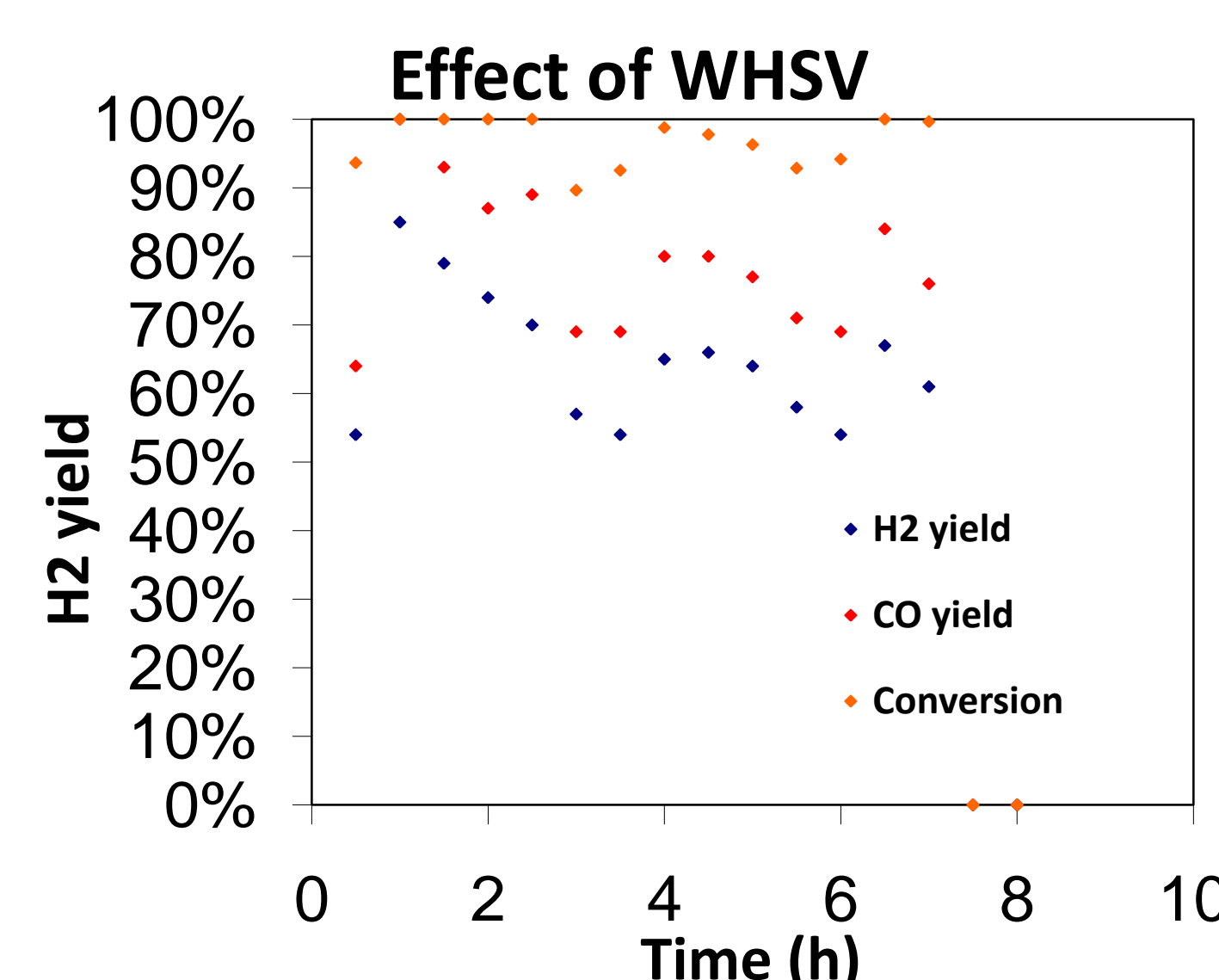
SEM images of commercial MoO<sub>2</sub>



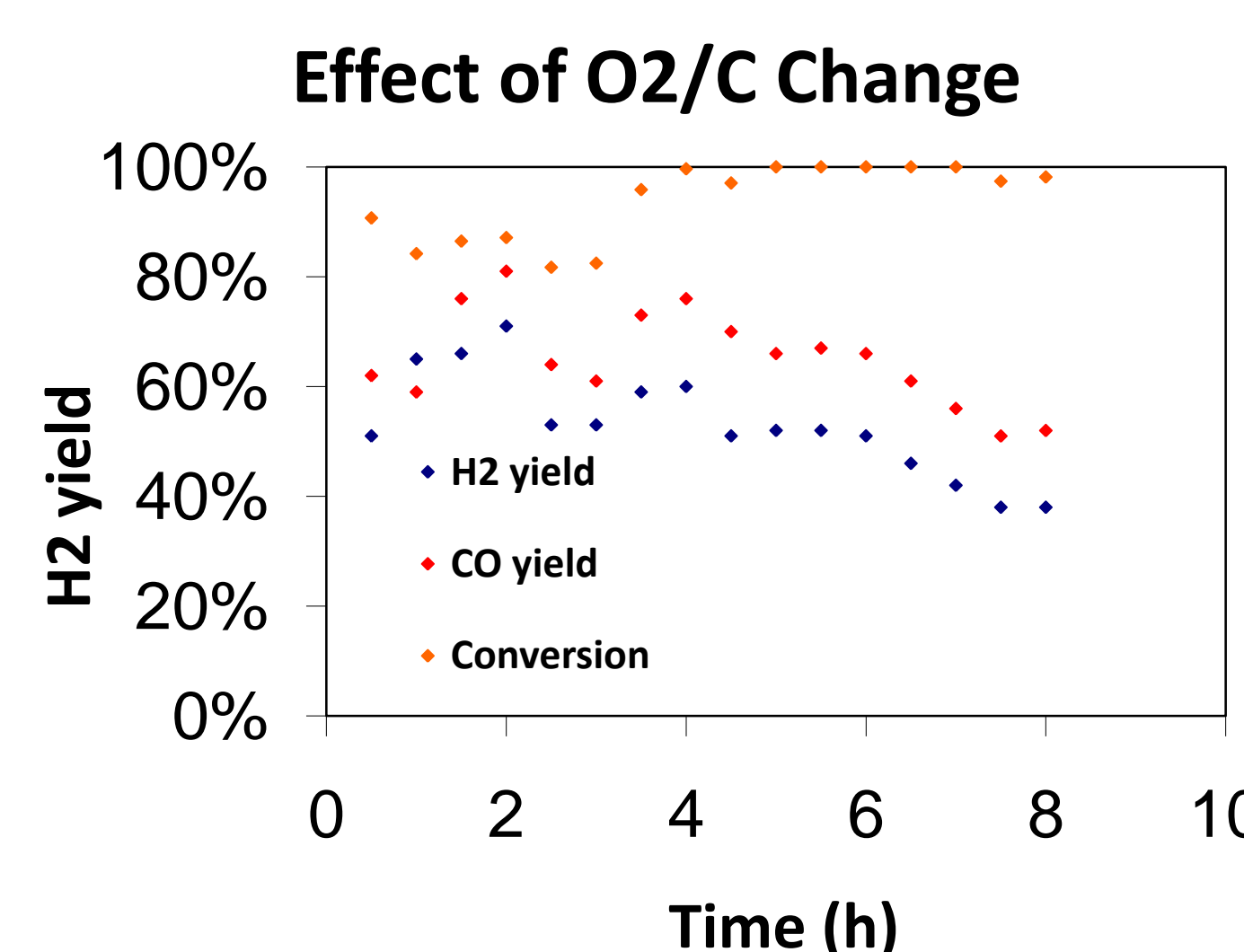
Particle Size Distribution



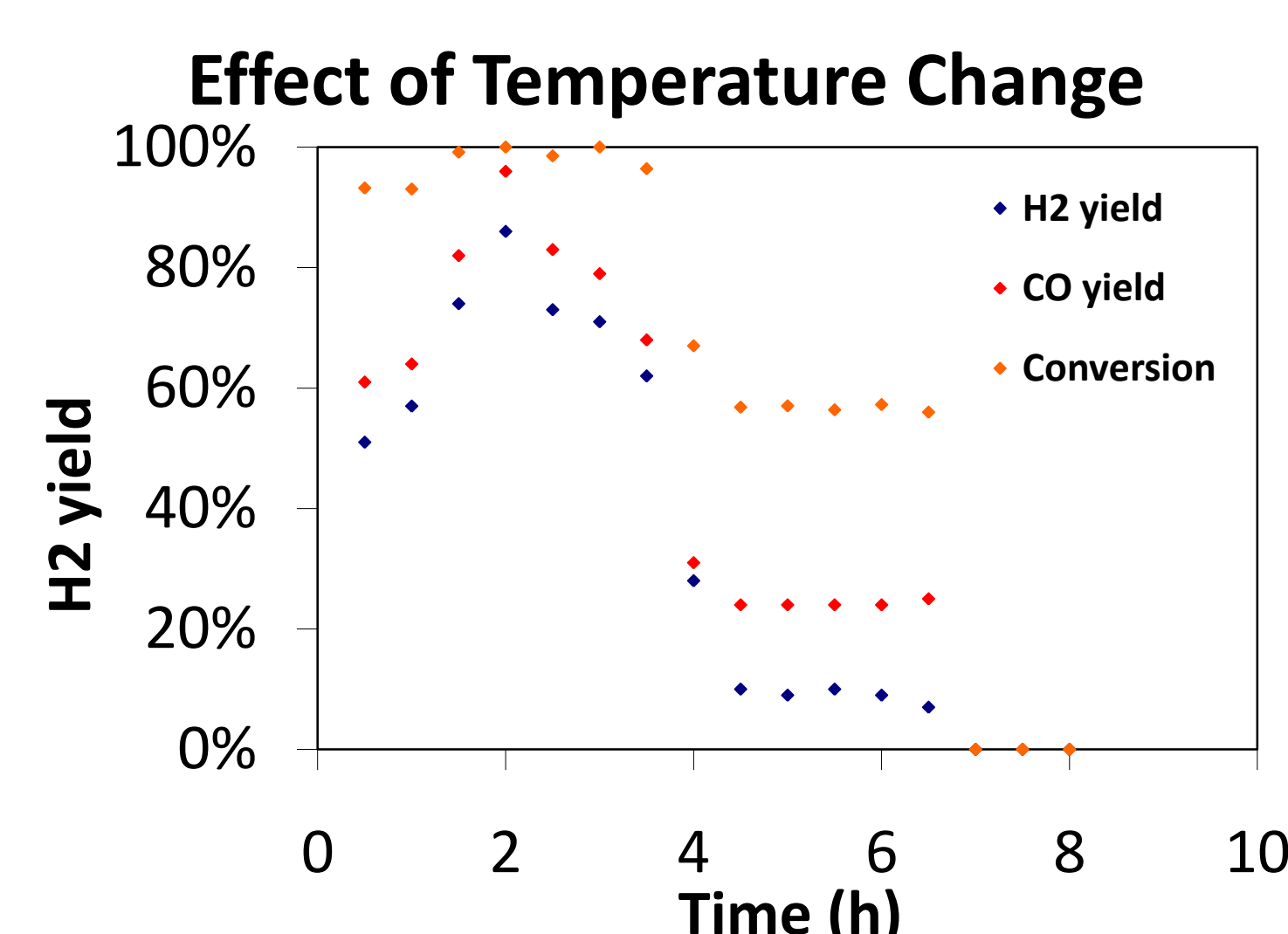
## RESULTS AND DISCUSSION



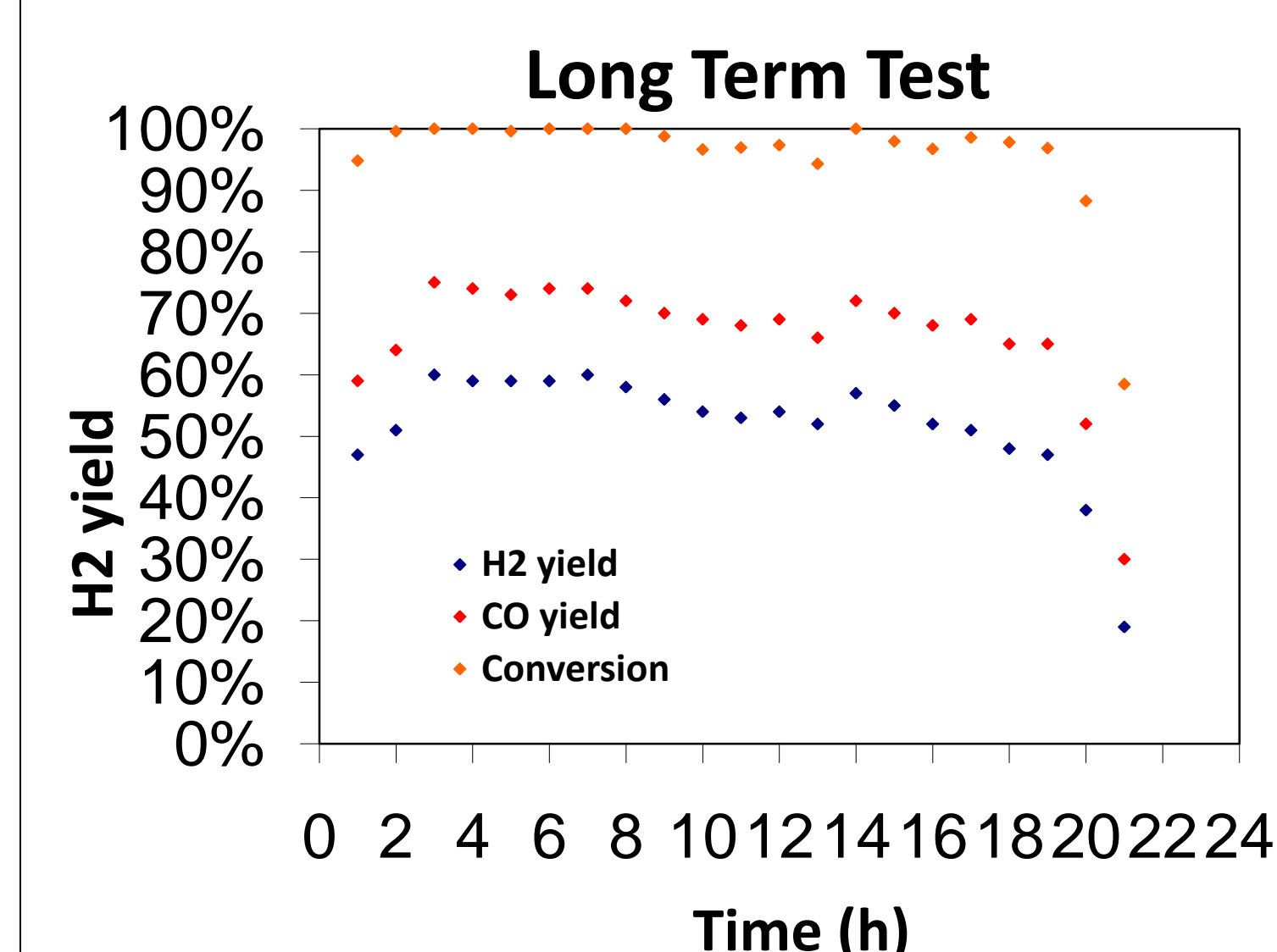
The WHSV was increased every 2 hours in increments of 1.0 beginning with WHSV = 1 h<sup>-1</sup>. The best conversion occurs at WHSV = 1 h<sup>-1</sup>.



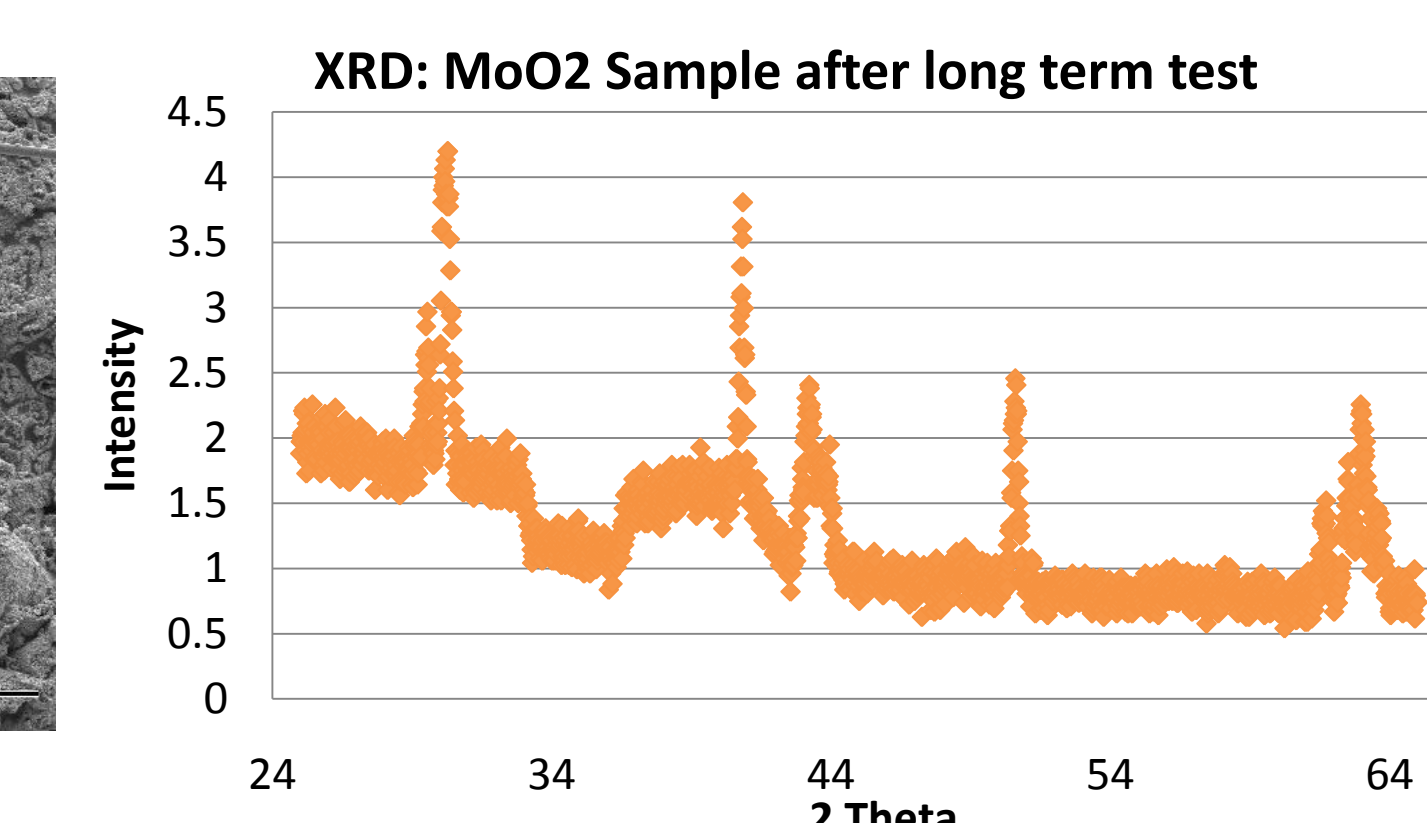
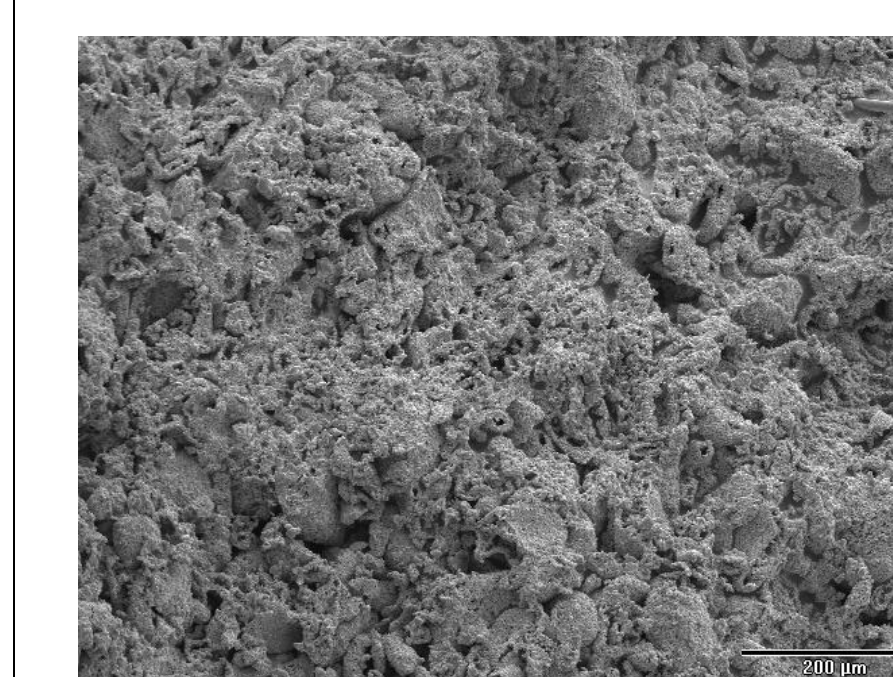
The O<sub>2</sub>/C ratio was increased every 2 hours in increments of .1 beginning with O<sub>2</sub>/C=0.5. The best conversion occurs at O<sub>2</sub>/C=0.5.



Reaction temperature was lowered every 2 hours in increments of 50° C, beginning at 850° C. The most effective temperature was 850° C.



After finding ideal WHSV, O<sub>2</sub>/C ratio, and temperatures for the reaction, a long term test was performed at 850° C and atmospheric pressure with WHSV = 1 h<sup>-1</sup>, and O<sub>2</sub>/C=0.5. The catalyst was stable for 19 hours.



SEM images and XRD of commercial MoO<sub>2</sub> after long term test

## CONCLUSIONS

Maximum hydrogen yield and conversion were achieved at 850° C and atmospheric pressure with WHSV = 1 h<sup>-1</sup>, and O<sub>2</sub>/C=0.5. Long term tests with similar conditions allowed the catalyst to continue producing stable results with 50 percent hydrogen yield after 19 hours. EDX images showed little coking, so the decline of the catalyst cannot be attributed to coking problems. XRD of the spent sample shows evidence of sintering, which lead to the lowering of the already low surface area, eventually causing the decline of the catalyst.

## FUTURE WORK

More efficient technology for energy production is important. The prospect of solid oxide fuel cells using biodiesel and molybdenum dioxide shows great promise and must be studied further. Though alone molybdenum dioxide is stable for 19 hours, more can be done to increase the length of stability and productivity of the catalyst. The addition of components such as nickel may improve performance. Further study is in progress to see how nickel will alter catalyst performance.

## ACKNOWLEDGEMENTS

This work was supported by the National Science Foundation's REU program under grant number EEC-0754370.

## REFERENCES

- [1]. O. Marin Flores and S. Ha, *Appl. Cata. A Gen.* **352** (2009), p. 124- 132.
- [2]. O. Marin Flores, T. Turba, J. Breit, M. Grant Norton, and S. Ha, *Appl. Cata. A Gen.* **381** (2010), p. 18-25.