THE UNIVERSITY OF ALABAMA IN HUNTSVILLE | COLLEGE OF SCIENCE

Research and Creative Experience for Undergraduates (RCEU) Program 2024

Use of Pulsed Laser Ablation in Metal Cluster Synthesis

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Background

Pulsed laser ablation in liquids is an eco-friendly chemistry method used to create nanoparticles by ablating a metal target with a laser beam. The nanoparticles are then available to react with other compounds or as a precursor to a catalyst.

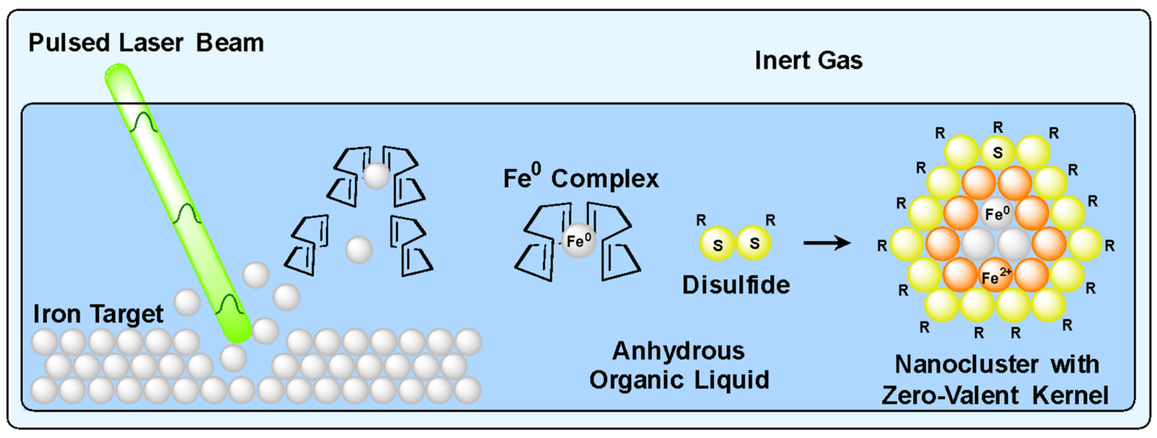

Figure 1: Illustrated laser ablation process

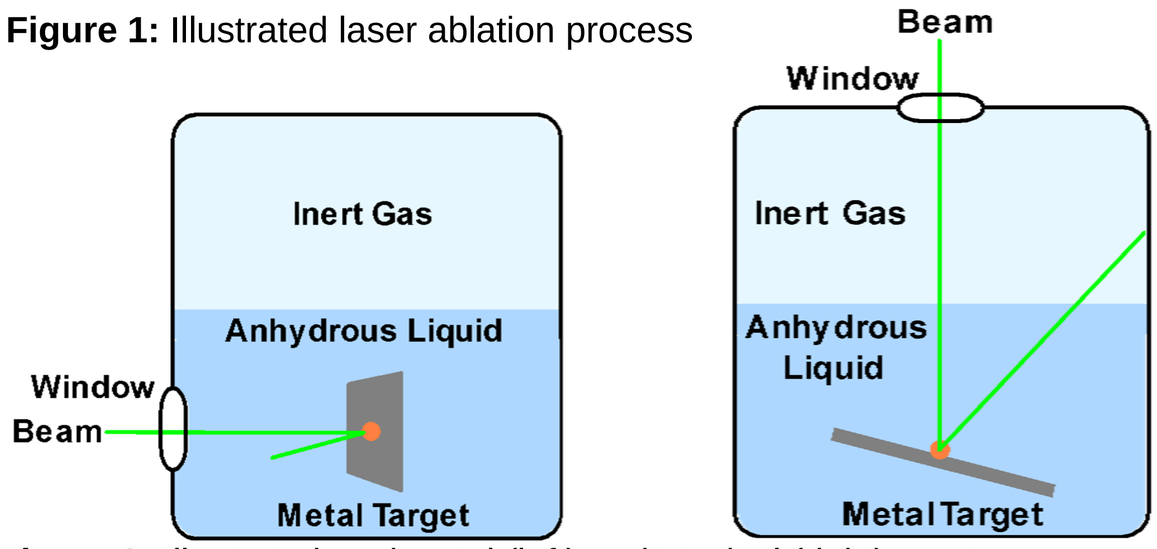

Figure 2: Illustrated Horizontal (left) and Vertical (right) reactors

Experimental Design

The goal of this project was to create bis(cyclooctadiene)nickel(0), $Ni(COD)_2$, an industrially significant catalyst. To do this, a nickel target, an organic solvent, and the COD ligand were placed into a custom-made reactor under a dinitrogen atmosphere inside a glovebox. Once removed, the reactor was subsequently flushed with argon gas to help prevent exposure to oxygen and to regulate pressure. Using a Nd:YAG laser, the reaction mixture was irradiated by either a focused or unfocused beam, depending on the experiment.

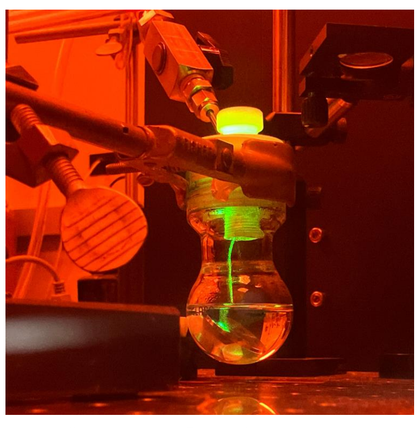

Figure 4 (left): Vertical reactor during ablation showcasing the beam path

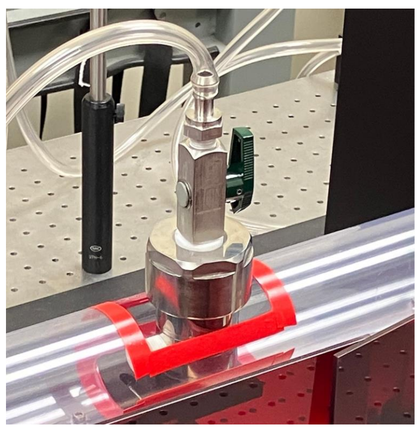

Figure 5 (right): Horizontal reactor attached to the argon line for pressure regulation

Synthesis

The following reaction was performed using the two custom reactors, Vertical and Horizontal:

Nickel Target, Toluene, COD —(λ = 532 nm, Time: 1 hour)→ $Ni(COD)_2$

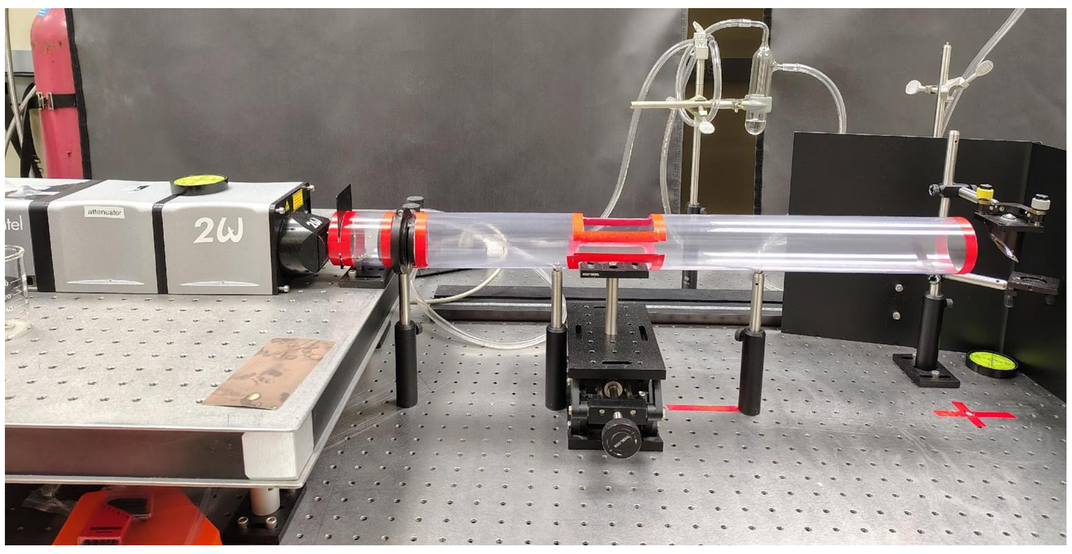

Figure 6: Laser table setup, with the Nd:YAG laser on the raised table and the beam path contained within the plastic tube

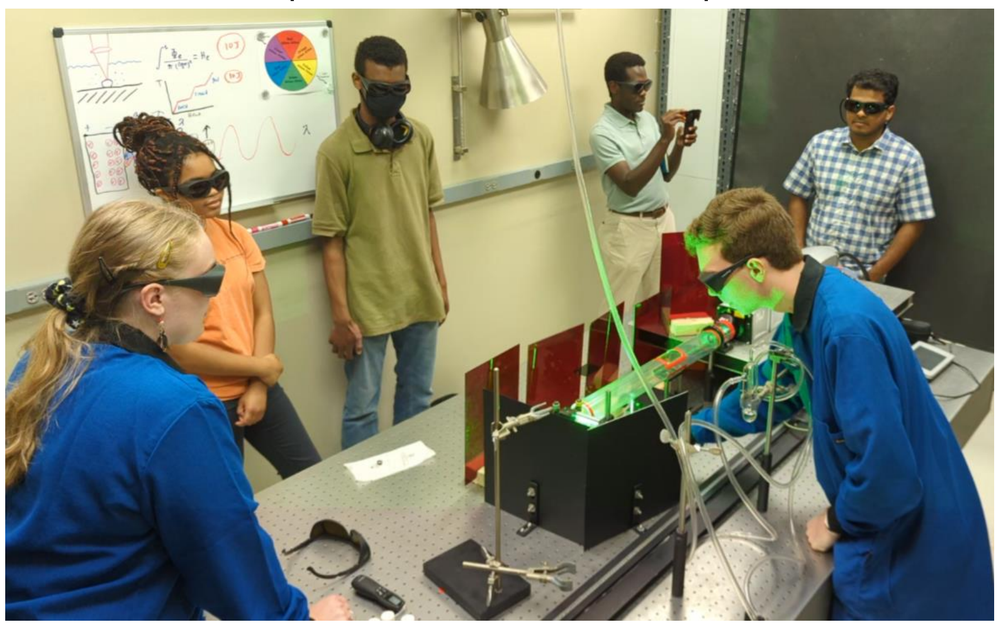

Figure 7: Laser ablation demonstration

Results and Future Research

Over the summer, both reactor designs were successfully optimized, which will now allow this project to move forward. The obstacles of oxygen leaks and back reflection of the laser beam into the optics have been identified and overcome. With the reactor designs optimized, it is now possible to proceed with synthesizing the target compound.

Future avenues for research include changing the laser wavelength into the ultraviolet spectrum, reacting under cold conditions, and using a new, three-necked reactor.

Acknowledgements

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