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Use of Pulsed Laser Ablation in Metal Cluster Synthesis

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RCEU 2023 Project Proposal

Project Title

Use of Pulsed Laser Ablation in Metal Cluster Synthesis

Faculty Information

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I. Project Description

Clusters of ferromagnetic metals with zero-valent kernels are expected to possess unique electronic and magnetic properties and could be used in catalysis or quantum information science. In this project, intense laser pulses will be focused onto metallic targets in anhydrous liquids to ablate metal atoms and to form such clusters. In contrast to the synthetic procedures commonly used for laser ablation, all experiments will be conducted under inert reaction conditions as known from modern organometallic chemistry. Therefore, the water- and air-free samples will be handled in a dinitrogen-filled glovebox and Schlenk techniques will be applied.

II. Student Duties, Contributions, and Outcomes

a. Specific Student Duties

- Follow safety instructions at all times
- Load and seal reaction flasks in glovebox
- Irradiate reactions flasks with laser outside the glovebox
- Work up reaction mixtures in glovebox
- Perform spectroelectrochemical characterization methods in glovebox
- Document all experimental details in a laboratory notebook
- Summarize findings in a report
- Present project with a poster

b. Tangible Contributions by the Student to the Project *(10% of Review)*

- Test and evaluate new synthetic protocols for cluster compounds
  (Test different metal targets for laser ablation; test different organic ligands; test different organic solvents; test different laser pulse wavelengths and/or intensities)
- Optimize reaction conditions
  (Maximize yield by identifying optimal scale, concentration, and ablation duration)
- Develop purification strategies
  (Evaluate various extraction, precipitation, and crystallization methods in glovebox)
- Acquire and evaluate spectroscopic and voltametric data
  (Characterize compounds using coupled UV/Vis and cyclic voltammetry experiments)

c. Specific Outcomes Provided by the Project to the Student *(30% of Review)*

- Learn good scientific conduct
- Get experience in scientific writing and presenting
- Work under inert gas
- Handle hazardous substances safely
- Operate lasers
- Use spectroscopic and voltametric methods to characterize compounds

III. Student Selection Criteria

There are no requirements or prerequisites for this project.

However, knowledge in the field of organic, inorganic, and/or electrochemistry chemistry, as well as spectroscopy and/or laser optics is preferred.

Most competitive are students who can demonstrate a high interest in the project, a hard-working attitude, and reliability.

IV. Project Mentorship *(30% of Review)*

The mentor, Dr. Olaf Nachtigall, will provide relevant literature, discuss the project and make a tentative work schedule with the student prior to the internship.

In addition to laboratory workspace and research equipment, the mentor will provide PPE and a desk in an office space outside the laboratory for the student.

The mentor will be present on the UAH campus for the full internship period. There will be no laboratory work if the mentor is not in the Materials Science Building. The student is not allowed to work alone in any laboratory. Either the mentor or a graduate student will be working with the student in the laboratory at all times.

Since the project involves challenging synthetic procedures, the mentor will supervise the student in a hands-on fashion. The mentor will conduct a comprehensive safety training with the student on the first day of the internship. The training will cover general and site-specific safety practices. Furthermore, the mentor will give a theoretical and practical introduction for each synthetic and analytic method prior to use. The mentor will explain all relevant equipment and demonstrate the standard operating procedures. The mentor and the student will discuss all potential risks associated with the chemicals and equipment involved in the project. The mentor will oversee the correct handling and disposal of all chemicals.

The research results will be discussed and evaluated in daily conversations and weekly group meetings. The mentor will help adjust the project if necessary.

The student will be guided by the mentor when writing the report and preparing the poster presentation. The mentor encourages the student to write up their results in an ACS article template. The poster presentation will be practiced in a group meeting.