Project 1 Title: Mechanistic Investigations of Catalytic Mineralization for Efficient CO_2 Capture and Sequestration

(Supervised in Hebrew/English)

This project focuses on advancing the fundamental understanding of carbonate mineralization processes to improve their efficiency, and selectivity. Mineralization, a natural crystallization process, plays a critical role in various fields and industrial applications. For example, in marine environments, organisms convert dissolved ions into biogenic minerals with remarkable precision, influenced by factors like water composition, pH, and nucleation sites. By studying these processes in-depth, we aim to develop innovative techniques for carbon capture and sustainable ocean mining, ultimately reducing environmental impacts and reliance on traditional quarrying. Our current research emphasizes the controlled formation of calcium carbonate ($CaCO_3$) using advanced techniques such as operando Attenuated Total Reflection Surface Enhanced Infrared Reflection Absorption Spectroscopy (ATR-SEIRAS), Raman microsspectroscopy, Dynamic Light Scattering (DLS), and electron microscopy, we investigate the mechanisms and kinetics of mineral growth under varied conditions, including the effects of supersaturation, surface energy, and external fields. As part of this project, the student will conduct analytical water chemistry analyses, such as alkalinity and hardness measurements, and learn to perform state-of-the-art ATR-SEIRAS spectroscopy to study dynamic systems. They will gain hands-on experience in experimental laboratory work and techniques, theoretical water chemistry, and data analysis. This role provides a unique opportunity to engage in cutting-edge research on sustainable processes, as well as develop skills applicable to both further academic research and the chemical industry.

Project 2 Title: Operando Spectroscopic Investigations of CO_2 Electroreduction over Copper Catalysts

(Supervised in English)

The climate crisis demands urgent action, driving the need for innovative solutions to mitigate its effects before it is too late. Among the promising technologies under investigation, the (electro)conversion of atmospheric CO_2 into fuels and valuable chemical building blocks offers a dual benefit: actively lowering their emission in the atmosphere, and their economic valorization. In our lab, we explore the mechanisms behind this transformation using state-of-the-art spectroscopic techniques, integrated with advanced data analysis methods. Students joining the project will play an active role in preparing and conducting electrochemical experiments, operating FTIR spectrometers, analyzing complex datasets with Python and advanced data mining techniques (if desired), and interpreting the results to identify key factors affecting catalyst performance. This immersive experience provides the opportunity to develop expertise in spectroscopy, electrochemistry, and computational analysis, while contributing to groundbreaking research in sustainable energy and chemical production.