MONASH University

MONASH ENGINEERING

Faculty of Engineering

ASPIRE Summer Research Program 2026-2027

Project Title: Investigating Anion Effects on Heme Enzyme Electrochemistry and Catalysis

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Objective

To determine how anion identity and the surrounding solvation environment influence electron transfer and catalytic activity at horseradish peroxidase (HRP) electrodes. Electrochemical measurements will be combined with in situ UV–vis spectroelectrochemistry, while FeTCPP will be used as a simplified heme model to distinguish changes at the iron–porphyrin centre from those involving the protein environment.

Project Details

Heme enzymes contain an iron–porphyrin centre whose reactivity is regulated by the surrounding protein and solution environment. In electrochemical studies, the electrolyte is often treated simply as a charge carrier. Our preliminary work with HRP electrodes shows otherwise: changing the anion produces markedly different electrochemical responses and potential-dependent changes in the heme UV–vis spectrum. This project will use HRP as the primary system to examine how anion identity and solvation affect electron transfer and catalysis. HRP–carbon electrodes will be prepared and tested in a small electrolyte matrix, with pH and ionic strength controlled. Cyclic voltammetry and impedance spectroscopy will be used to compare redox potentials, interfacial charge transfer, catalytic current, substrate response, reproducibility and stability. In situ UV–vis spectroelectrochemistry will then track changes at the heme centre under applied potential, and selected aqueous co-solvent conditions will be used to perturb the solvation environment. FeTCPP, a synthetic iron porphyrin, will serve as a simplified heme model. Comparing HRP with FeTCPP will help separate effects intrinsic to the iron–porphyrin centre from those produced by the surrounding protein. The project will establish a relationship between electrolyte environment, heme redox state and catalytic response. If clear catalytic conversion is observed, the study will be extended to controlled-potential electrolysis and product analysis.

Project Timeline

TASK	1	2	3	4	5	6	7	8	9	10
Induction, literature review and project design										
HRP electrode preparation and electrochemistry training										
HRP benchmark and reproducibility										
Anion effects under controlled conditions										
Solvation and catalytic response study										
In situ UV–vis spectroelectrochemistry										
FeTCPP model and extended catalytic validation										
Data analysis, report and presentation										

Prerequisites

No prior experience in electrochemistry or enzyme research is required. The project will suit a student in chemical engineering, chemistry, materials science or a related discipline who is interested in bioelectrochemistry and hands-on laboratory work. Full experimental training will be provided.

Student Placement Agreement

A student placement agreement must be signed by the supervisor and student before commencement.
ASPIRE Student Placement Agreement

Additional Information

Established HRP electrode and spectroelectrochemical protocols are available. The student will complete an independent electrolyte–reactivity study and receive training in electrode preparation, electrochemistry, in situ UV–vis spectroscopy and quantitative data analysis. Applicants may be invited to a brief interview.