**Self-Powered Enzyme Microparticle Pumps**

Alyssa Bixler¹, Lyanne Valdez¹, Grenalyn Ilacas² and Dr. Ayusman Sen¹ (mentor)

¹Department of Chemistry, *The Pennsylvania State University*; ²Department of Chemistry and Biochemistry, *California State University*

**Abstract**

Enzyme microparticle pumps have been developed as a novel platform to examine the reactive sensing and pumping in response to specific analytes. Pumps were prepared by uniformly coating silica microspheres with common and accessible enzymes. When these pumps are in the presence of the corresponding substrate, the energy produced during catalytic turnover is transferred to the surrounding fluid. This causes a movement of the fluid observed using tracer particles in various concentrations of the substrate. Following, this motion was used to construct a rectified fluid pump within a closed system.

**Goals & Purpose**

To monitor motion caused by a new architecture of immobilized enzyme in the presence of the corresponding substrate, converted to product and to note how concentration of substrate influences the rate of movement.

To determine the cause of the directionality of each closed system by analyzing each component.

To combine pumps of different behaviors in order to enhance flow rates of the system.

**Background Information**

Inspired by autonomous movement found in nature, immobilized enzymes transfer energy to surroundings. Planar surfaces studied previously – new spherical surfaces increases surface area, and consequently increases activity and rates of the system. Particle beads appeal is ease of fabrication and deployment.

- **Streptavidin Coated Silica Microspheres**: 5 μm diameter, after tagging with enzyme, 1 μL deposited into hybridization chamber
- **Biotin NHS-LCLC / Biotin Maleimide**: act as linkers for streptavidin layer of spheres and designated enzyme through amino/thiol groups
- **Glucose Oxidase (GOx)**:
  \[ C_6H_{12}O_6 + O_2 \rightarrow C_6H_{12}O_6 + H_2O \]
- **Urease**:
  \[ (NH_2)_2CO + H_2O \rightarrow CO_2 + 2NH_3 \]
- **Phosphate-Buffered Saline**: filtered buffer used to prepare all solutions (100 mM & 10 mM concentrations) kept at a pH of 7.2 for optimal activity
- **Tracer Particles**: polystyrene sulfate functionalized 2 μm diameter spheres, used to follow the flow of the substrate for easy observation after recording motion under a microscope

**Citations**


**Conclusion and Opportunities for Further Work**

- As expected, GOx pumps had inward motion, high conc. = fast rates
- Urease pump coverage amount yielded different directionality of flow due to rate of product production and density effects
- Combined urease system was dominated by high coverage pump rates
- GOx and urease system led to directed, enhanced flows – push and pull
- Direct cargo with enhanced flow and easily deployable pumps
- Create enzyme cascade with complimentary enzymes, GOx and catalase with a hydrogen peroxide intermediate for fluid flow reversal

**Acknowledgements**

Thank you PPG providing me with this opportunity to complete such rewarding research. Thank you Lyanne, Gren, and Dr. Sen for your guidance, assistance and instruction throughout this process. It has been invaluable along the way. Thank you to my many lab members for making me feel like family.

*The PPG Undergraduate Research Fellowship Program is supported by the PPG Research Foundation through the Materials Research Institute*