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SJSU Undergraduate Research Grants

Developing Artificial SEI Layers Using Microbes for Aqueous Lithium Ion Batteries

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Abstract

Lithium Ion batteries (LIB) exhibit enhanced performance with the implementation of a porous nanostructure. However, the current methods for implementing these structures into Lithium-Ion Batteries utilize unsustainable, environmentally harmful, and expensive manufacturing techniques. Alternatively, this project aims to create an efficient porous nanostructure into a carbonaceous Solid Electrolyte Interphase (SEI) utilizing naturally occurring, inexpensive, bio-degradable, and non-pathogenic Escherichia Coli (E. coli) bacteria. Upon the successful bio-templating of the bacteria into the SEI, the components will be utilized in the formation of next-generation LIB with enhanced battery life and safety measures.

Research Questions

1. What is the optimal microbial species to use to produce a LIB with components that generate the most effective results.
2. How does E. coli shape and size effect battery performance?
3. Can an increase in E. coli concentration increase battery performance?
4. Which electrolyte formula will allow for best battery performance without compromising safety?
5. Can this process be modified to be used in large-scale production?

E. coli as Porogens

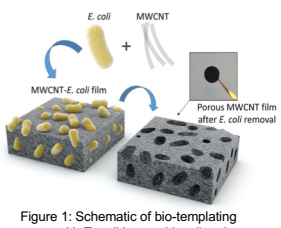


Figure 1: Schematic of bio-templating pores with E. coli into multi-wall carbon nanotube electrodes

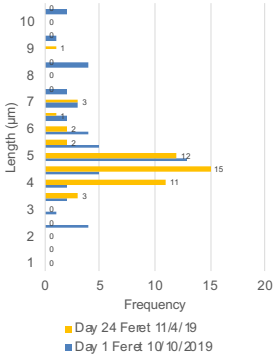
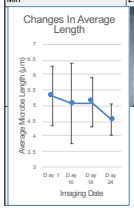


Figure 2: (right): Microbe Feret Length Analysis distribution

E. coli Length Analysis

	Day 1	Day 10	Day 18	Day 24
(um)	10/10/19	10/21/19	10/31/19	11/4/19
Average	5.319	5.076	5.11	4.549
Standard Deviation	1.945	2.627	1.602	1.018
Max	10.449	14.061	12.335	8.555
Min	2.033	1.917	2.875	3.03



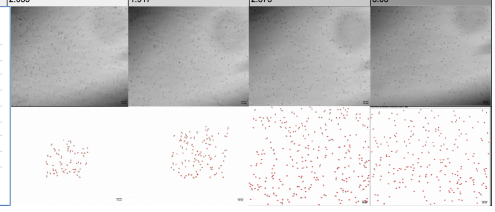


Figure 3: ΔenvC OD 1.2 Microbe Imaging and Analysis

Conclusion

- Of four evaluated species, ΔenvC OD 1.2 produces the most effective results.
- Data results indicate that overall ΔenvC OD 1.2 E. coli shape becomes more homogenous over time.
- Higher uniformity seen in evaluated species has a positive effect on battery performance.
- Additional correlations between microbe length and porous nanostructure is under evaluation with the testing of battery performance.

Citations

[1] Oh, D., Ozgit-Akgun, C., Akca, E. *et al.* Biotemplating pores with size and shape diversity for Li-oxygen Battery Cathodes. *Sci Rep* **7,** 45919 (2017) doi:10.1038/srep45919

[2] Subramanya, S., Chua, C., Leong, V,. *et al.* Carbon-based Artificial SEI Layers for Aqueous Lithium-ion Battery Anodes, *RSC Advances*, (2020), 10.1039/C9RA08268A

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