

Ada-Carbon: A self-driving laboratory to enable the lowest-cost pathway to scalable CO₂-to-fuels conversion

Curtis P. Berlinguette,^{1,4} Amanda K. Brown,¹ Andrew M. L. Jewlal,¹ Daniel Lin¹

¹Department of Chemistry, University of British Columbia, 2036 Main Mall, Vancouver, British Columbia V6T 1Z1, Canada, ²Department of Chemical and Biological Engineering, University of British Columbia, 2360 East Mall, Vancouver, British Columbia V6T 1Z3, Canada, ³Stewart Blusson Quantum Matter Institute, University of British Columbia, 2355 East Mall, Vancouver, British Columbia V6T 1Z4, Canada ⁴Canadian Institute for Advanced Research (CIFAR), 661 University Avenue, Toronto, Ontario, M5G

Correspondence to: Curtis P. Berlinguette curtis.berlinguette@ubc.ca

Carbon capture and utilization pathways require that CO₂ captured from the atmosphere (or a point source) be released from the sorbent, and that the sorbent be recycled to capture additional CO₂. Alkaline solutions such as KOH are effective at capturing CO₂ through reactions that form (bi)carbonates, but the recovery of CO₂ gas and hydroxide before CO₂ electrolysis requires energy-intensive steps. We solved this problem by designing an electrochemical reactor that converts bicarbonate “reactive carbon capture solutions” into carbon-containing products [1-2]. In this presentation, I will show how this reactor couples CO₂ conversion with upstream carbon capture. Not only does this reactor bypass the expensive step of liberating CO₂ from the sorbent, but it can also perform better than the reactors fed with gaseous CO₂.

The emergent challenge is how to balance CO₂ capture with CO₂ conversion. This is a multi-variant problem that we built an autonomous laboratory to solve. This self-driving lab is named Ada-Carbon [3] (Fig. 1).

I will demonstrate how we reconfigured Ada [4], a self-driving laboratory designed for solar cells, into Ada-Carbon: a platform for discovering and optimizing electrochemical reactors that upgrade waste CO₂ into valuable fuels. We did this by using “flexible automation”. Flexible automation is the concept of creating reconfigurable automated experiments, enabling the integration of various experimental procedures into fully automated workflows [5]. Importantly, flexible automation platforms can evolve with the changing needs of the experimentalist. This talk will show flexible automation in action.

Acknowledgments

Natural Resources Canada; National Research Council of Canada; Natural Sciences and Engineering Research Council of Canada; Canada First Research Excellence Fund; Canadian Institute for Advanced Research

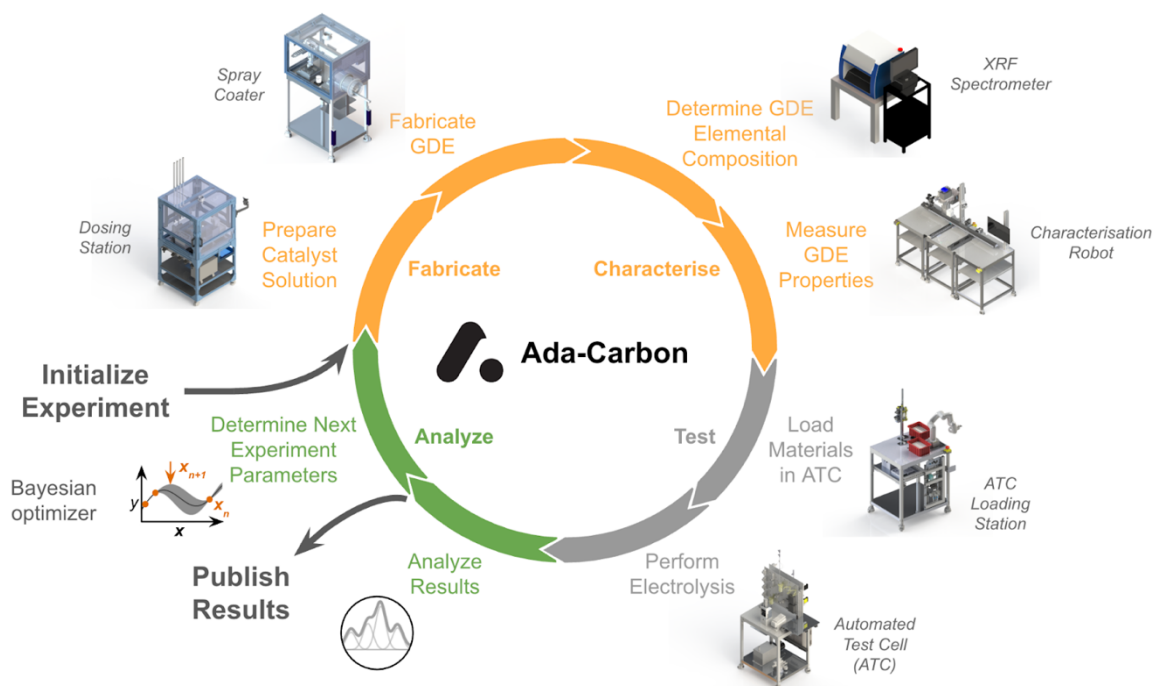


Fig. 1: Ada-Carbon workflow for fabricating, characterising, and testing gas-diffusion electrodes (GDEs).

References

- [1] Li, T., et. al. Electrolytic Conversion of Bicarbonate into CO in a Flow Cell. *Joule*, 3 (6), 1487–1497, 2019.
- [2] Namdari, M., et. al. Reactive Carbon Capture Using Electrochemical Reactors. *Chem. Soc. Rev.*, 54 (2), 590–600. 2025.
- [3] Soni, A., et. al. Accelerated Optimization of Gas Diffusion Electrodes for CO₂ Electrolyzers. *Matter*, 102519, 2025.
- [4] MacLeod, B. P., et. al. Self-Driving Laboratory for Accelerated Discovery of Thin-Film Materials. *Sci. Adv.*, 6 (20), eaaz8867, 2020.
- [5] MacLeod, B. P., et. al. Flexible Automation Accelerates Materials Discovery. *Nat. Mater.*, 21, 722–726, 2022.