



Colorado Science and Engineering Fair

2025 Individual Project Abstract Form

Please print 2 copies of the completed form. Sign both copies, keep 1 for your notebook and submit 1 copy to your Regional Fair Director with your other paperwork.

Title of Project: From Bench to Atmosphere: New Materials for the Direct Air Capture (DAC) of CO₂ Using Electro-Swing Chemistry

Finalist's Name: Zoe Wang

School and City: Fairview High School, Boulder

Sponsor's Name: Xiang Wang

Category: Environmental Engineering

Division: Senior (grades 9 - 12)

Abstract (250 words or less):

The increased amount of carbon dioxide (CO₂) in the atmosphere is the main factor contributing to recent climate change. This accumulation of CO₂ is mainly due to the burning of fossil fuels that disrupts the natural carbon cycle. In addition to global warming, the abundance of atmospheric CO₂ also causes ocean acidification, agriculture disruption, and negative impacts on human health. Recent studies determined that simply reducing emissions is insufficient to restore the Earth's atmospheric system—negative emissions are now in dire need. Current carbon (i.e., CO₂) capture technologies use thermo/pressure swing which suffers from low energy efficiency, high cost, and geographic constraints. Electro-swing chemistry-based carbon capture using quinone sorbents emerged as a promising potential solution to these problems. However, strong, CO₂-binding sorbents, not susceptible to oxygen interference, remain elusive. In this study, I designed and synthesized three novel quinones for direct air capture (DAC) of CO₂. Cyclic voltammetry studies of these quinones and follow-up data analysis found that 2,3-dicyanobenzoquinone (DBQ) has a second reductive potential of -0.935 V, positive of that of oxygen, and binds to CO₂ strongly with the binding free energy ΔG_{bind} of -5.39 kcal/mol. These results suggest that DBQ is the desired sorbent that can capture >70% of CO₂ in the current atmosphere using electro-swing chemistry. This technology can be further developed for worldwide applications and solve global warming and its implications.

I hereby certify that the above statements are correct and the information provided in the Abstract is the result of one year's research. I also attest that the above properly reflects my own work.

Finalist's Signature:

Date:

In addition, all students must complete the ISEF Student Checklist (1A), Research Plan, Approval Form (1B), and Checklist for Adult Sponsor (1), and any other ISEF forms required for this type of project. See the International Rules and Guidelines for form requirements. Return COPIES of all of these forms to your Regional Fair Director with you Finalist Verification/Permission Form. **A signed copy of this form must be included in your notebook.**