Methanol Dynamics & Co. LLP

Direct Methanol Fuel Cell (DMFC) Project

CBE 3300B, University of Pennsylvania
Spring 2025

Progress Log

- **January 30:** We evaluated liquid versus vapor methanol feed modes.
  - Reviewed trade-offs of methanol crossover versus reaction kinetics.
  - Selected a Pt–Ru catalyst to minimize CO poisoning, based on recent literature.
  - Outlined MVP prototype: active feed with peristaltic pump, Arduino and Processing for controls, 10-cell stack from the Fuel Cell Store.
- **January 31:** We drafted the Preliminary Report framework in Dr. Huff's lab.
  - Assigned report sections (electrochemistry, prototyping, safety).
  - Peer-reviewed our work.
  - Defined milestones for finalizing the report by February 4.
- **February 4:** We completed the first full draft of the Preliminary Report.
  - Identified optimal methanol concentration (3 wt%) for initial tests.
  - Performed back-of-envelope power and fuel consumption calculations.
  - Established experimental design matrix: feed mode, stack orientation, temperature.
- **February 13:** We presented the draft to our class and uploaded materials to GitHub.
  - Collected feedback on scope and clarity.
  - Finalized purchasing list for MVP, tubing, sensors, and pump.
  - Scheduled MVP testing with Dr. Huff for the following week.
- **February 14:** We incorporated review comments and submitted the revised report.
- **February 21:** We disassembled a PEM electrolyzer to examine internal components.
  - Studied membrane-electrode assembly structure and catalyst ink distribution.
  - Researched methanol vaporization techniques to reduce crossover.
- **February 24–25:** We ordered the 10-cell Flex-Stak DMFC and supporting hardware.
  - Finalized Gantt chart in Google Sheets, outlining fourteen-week timeline.

  - Procured peristaltic pump, Nafion tubing, flow meters, and temperature sensors.
- **March 2–3:** We designed and breadboarded the Arduino-based control circuitry.
  - Developed PWM code for pump speed regulation.
  - Created a calibration protocol: measured pump flow vs. voltage.
  - Logged preliminary Q–V data in Jupyter notebooks for analysis.
- **March 4–5:** We performed full pump calibration and tubing swelling tests.
  - Characterized flow rates from 9 V to 18 V, plotted calibration curves.
  - Assessed methanol compatibility by measuring tubing expansion over time.
- **March 8–16:** Spring break; no laboratory activities.
- **March 17–21:** We assembled the prototype stack, plumbing, and control electronics.
  - Mounted cell, tubing, Arduino readings, and controls.
  - Debugged early software crashes; stabilized serial communication.
  - Executed first live fuel-cell activation with DI water.
- **March 24–25:** We transitioned to 3 wt% methanol feed.
  - Sealed plumbing leaks and verified no backflow.
  - Ran again the pump calibration at operational voltage (11.4 V, 75cc/min).
  - Diagnosed and fixed zero-voltage under load: realigned MEA stack.
- **March 26–28:** We conducted DI water and methanol performance tests.
  - Observed voltage ramp: 1 V/min to 3.3 V, then 0.1 V/min to 3.7 V unloaded.
  - Monitored effluent for methanol crossover using refractive index measurements.
  - Finalized dual-mode interface circuit for I–V profiling and Arduino logging.
- **March 31–April 2:** We recorded load tests and refined data analysis.
  - Performed 20-minute loaded runs, captured I–V curves in Google Sheets.
  - Consulted Dr. Osuji on interpreting polarization losses and mass-transport effects.
  - Began soldering permanent control board for durability and repeatability.
- **April 7–9:** We optimized thermal management and code integration.
  - Added auxiliary cooling fan; measured temperature impact on voltage stability.
  - Adapted temperature-sensor script to plot voltage, flow rate, and temperature in real time.
  - Validated logging pipeline, exporting data sets to CSV for post-processing.

- **April 14:** We finalized the progress log, ensuring reproducibility and transparency for future reports.