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Professional Profile

Dr. Modak's areas of expertise include experimental and computational studies of lithium-ion batteries, analysis of redox-flow batteries (RFBs), exploration of electrochemical CO2 separation methods, development of novel organic redox-active molecules, identification of and mitigation strategies for molecular degradation pathways in batteries. He is proficient in several spectroscopic techniques like ultraviolet spectroscopy (UV-Vis), mass spectroscopy, nuclear magnetic resonance (NMR) and scanning electron microscopy (SEM), along with abuse testing of lithium-ion batteries and use of flow/fuel cell hardware. Apart from the field of batteries, Dr. Modak has experience developing heat transfer and CFD simulations for solid and multi-phase problems.

Prior to Joining exponent, Dr. Modak held internship/co-op positions with Lordstown Motors, where he worked on computational modeling of electric vehicle battery aging and Mercedes Benz R&D India, where he worked on projects related to computation modelling of HVAC systems and automotive seats. He completed his PhD at the University of Michigan, where he was engaged in research in the field of developing novel organic, and earth abundant inorganic chemistries for RFBs for economical and safe, grid-scale energy storage applications. His research included studies that combined ultraviolet spectroscopy, flow cell analysis and data-driven methods to deconvolute degradation mechanisms in organic redox-active molecules and has studied the effects of functionalization on their stability and electrochemical performance.

Dr. Modak has also worked on testing sodium superionic conductor (NaSICON) membranes due to their ability to prevent reactant crossover, earth-abundant precursors, studied their performance and stability under a wide range of operating conditions, and demonstrated a stable RFB with a low-cost manganese-based cathode chemistry. In addition, he developed physics and controls-based models for simulating the performance and life-cycle of batteries, dropwise and filmwise condensation through porous microstructured wicks, and hybrid-electric vehicle powertrains.

Academic Credentials & Professional Honors

Ph.D., Mechanical Engineering, University of Michigan, Ann Arbor, 2023

M.S.E., Mechanical Engineering, University of Michigan, Ann Arbor, 2019

B.S., Mechanical Engineering, Birla Institute of Tech and Sci, 2017

M.S., Economics, Birla Institute of Tech and Sci, 2014

Academic Appointments

Graduate Student Research Assistant, University of Michigan, Ann Arbor, 2019-2024.

Professional Affiliations

2021-present, Electrochemical society, Member.

Publications

Modak, Sanat, and David G. Kwabi. "A zero-dimensional model for electrochemical behavior and capacity retention in organic flow cells." Journal of The Electrochemical Society 168.8 (2021): 080528.

Modak, Sanat, et al. "Correlating stability and performance of NaSICON membranes for aqueous redox flow batteries." ACS Applied Materials & Interfaces 14.17 (2022): 19332-19341.

Modak, Sanat Vibhas, et al. "Understanding capacity fade in organic redox-flow batteries by combining spectroscopy with statistical inference techniques." Nature Communications 14.1 (2023): 3602.

Ali, Fawaz, Sanat Modak, and David G. Kwabi. "Assessing the Performance Limits of Electrochemical CO2 Separation Using Exergy Loss Analysis and Zero-Dimensional Modeling." ACS Sustainable Chemistry & Engineering (2023).

Owhoso, Fiki V., et al. "Effect of Covalent Modification on Proton-Coupled Electron Transfer at Quinone-Functionalized Carbon Electrodes." The Journal of Physical Chemistry C 127.6 (2023): 3165-3175.

Modak, S., et al. "Numerical analysis of meniscus dynamics in monolayer-wick dropwise condensation." Numerical Heat Transfer, Part A: Applications 76.5 (2019): 301-322.

Hoenig, Sean H., et al. "Role of substrate thermal conductivity and vapor pressure in dropwise condensation." Applied Thermal Engineering 178 (2020): 115529.

Chen, Zijie, et al. "Direct simulations of biphilic-surface condensation: Optimized size effects." Frontiers in Heat and Mass Transfer (FHMT) 14 (2020).

Modak, Sanat Vibhas, et al. "Substituent Impact on Quinoxaline Performance and Degradation in Redox Flow Batteries." Journal of the American Chemical Society (2024).

Presentations

Ali, Fawaz, Sanat Vibhas Modak, and David G. Kwabi. "Elucidating the Performance Limits for Electrochemical CO2 Separation Using Exergy Loss Analysis and Zero-Dimensional Modeling." Electrochemical Society Meeting Abstracts 243. No. 45. The Electrochemical Society, Inc., 2023.

Modak, Sanat Vibhas, et al. "Evaluating the Stability and Performance of Nasicon in Low-Cost High Charge Density Redox Flow Battery Electrolytes." Electrochemical Society Meeting Abstracts 242. No. 46. The Electrochemical Society, Inc., 2022.

Modak, Sanat Vibhas, et al. "(Digital Presentation) Evaluating Stability and Performance of Nasicon Membranes for Crossover Mitigation in Aqueous Redox-Flow Batteries." Electrochemical Society Meeting Abstracts 241. No. 48. The Electrochemical Society, Inc., 2022.

Modak, Sanat Vibhas, and David G. Kwabi. "Using Bayesian Inference to Understand Capacity Fade in Organic Redox-Flow Batteries." 240th ECS Meeting (October 10-14, 2021). ECS, 2021.

Modak, Sanat Vibhas, and David G. Kwabi. "A Zero-Dimensional Electrochemical Model for Organic Flow

Cells." Electrochemical Society Meeting Abstracts prime2020. No. 41. The Electrochemical Society, Inc., 2020.