BIOGRAPHICAL SKETCH

NAME: Mahmud, Alam

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POSITION TITLE: Postdoctoral Scholar, School of Engineering – Chemical Engineering, Stanford University

EDUCATION/TRAINING

INSTITUTION AND LOCATION	DEGREE (if applicable)	END DATE MM/YYYY	FIELD OF STUDY
Bangladesh University of Engineering and Technology, Dhaka, BD	BScEng	09/2015	Electrical & Electronic Engineering
University of Waterloo, Waterloo, ON	MASc	11/2018	Electrical & Computer Engineering (Nanotechnology)
McGill University, Montreal, QC	Mini-MBA	06/2021	Business Administration
University of Toronto, Toronto, ON	PhD	11/2023	Electrical & Computer Engineering
Northwestern University, Evanston, IL	Predoctoral	09/2023	Chemistry
Stanford University, Stanford, CA	Postdoctoral	present	Chemical Engineering

A. Personal Statement

My research builds electronic–molecular interfaces that read molecular events as electronic signals in living systems. My program asks whether continuous molecular measurement can reveal physiological and treatment transitions that intermittent sampling misses, and what limits how much molecular information an interface can access. My vision is symbiotic electronics: beginning with continuous readout and advancing toward adaptive, bidirectional interaction between electronics and biology.

I am an electrical engineer whose training moved from materials to molecules to living systems. My Ph.D. with Ted Sargent and Shana Kelley was based in the Leslie Dan Faculty of Pharmacy, where I contributed to the development of the molecular pendulum, a reagent-free transduction mechanism, and generalized it across receptor classes to measure cardiac biomarkers in whole blood and intact SARS-CoV-2 in patient saliva. With Zhenan Bao at Stanford, I developed carbon electronics, which pairs defect-engineered graphene with transition-resolved interrogation to isolate cortisol's intrinsic electrochemistry from competing reactions without a receptor, and implanted it to track stress responses *in vivo*.

My laboratory will pursue three thrusts. (I) Predictive interfaces: co-designing interface chemistry, excitation waveforms, and physics-informed machine learning to recover molecular information obscured by competing interfacial processes, validated on interfaces held out from training. (II) Stress–sleep dynamics: soft implants that measure cortisol and melatonin together, first asking whether the speed of cortisol recovery after a controlled stressor predicts later sleep disruption beyond what autonomic measures capture. (III) Resistance dynamics: extending reagent-free readout from viruses to bacteria, we will track bacterial burden, *bla*KPC transcripts, and known resistance variants during ceftazidime–avibactam treatment in infection models, testing whether these trajectories anticipate treatment failure, with sequencing and susceptibility testing as references.

BTS joins molecular engineering with therapeutics, and continuous molecular time series would give therapeutic bioengineering and systems pharmacology data that snapshots cannot. The exchange would run both ways. I envision working with Professor Ying-Hui Fu, whose genetic models of natural short sleep and circadian variation define the biology, to add continuous endocrine readout that tests how sleep traits shape stress physiology, and with Professor Shuvo Roy to combine these interfaces with implantable and wireless device platforms for fully wireless molecular monitors. BTS pharmacologists would extend the approach to drug exposure and response, and the Chan Zuckerberg Biohub San Francisco, where I already collaborate, would anchor pathogen studies. HIVE, UCSF Health, and the UCSF–UC Berkeley Joint Ph.D. Program in Bioengineering would connect the work to clinicians and trainees.

I have mentored undergraduates through postdoctoral scholars at five institutions, developed Stanford's graduate course BIOS 405, and received Stanford's 2024 Postdoc JEDI Champion Award. I will pursue NIH (NIBIB, NIGMS, NIMH, NIAID) and NSF support.

B. Positions, Scientific Appointments and Honors

Positions and Scientific Appointments

2023 – Postdoctoral Scholar, Department of Chemical Engineering, Stanford University, Stanford, CA; affiliated with the Department of Comparative Medicine

2022 – 2023 Predoctoral Fellow, Department of Chemistry, Northwestern University, Evanston, IL

2020 – 2023	NSERC CREATE PROMOTE Fellow, Department of Chemistry, McGill University, Montreal, QC
2020 – 2022	Highly Qualified Personnel, NanoMedicines Innovation Network, University of British Columbia, Vancouver, BC
2019 – 2022	Doctoral Researcher, Leslie Dan Faculty of Pharmacy and Faculty of Applied Science and Engineering, University of Toronto, Toronto, ON
2018 – 2019	Research and Development Specialist, Waterloo Institute for Nanotechnology, Waterloo, ON
2015 – 2016	University Lecturer, Department of Mechanical Engineering, Sonargaon University, Dhaka, BD

Honors

2024	JEDI Champion Award, Stanford University
2022	Predoctoral Fellowship, Northwestern University
2020	NSERC CREATE PROMOTE Fellowship, McGill University
2019	University of Toronto Fellowship, Department of Electrical and Computer Engineering
2019	Edward S. Rogers Sr. Graduate Scholarship, University of Toronto
2017	Teaching Assistantship Excellence Award, University of Waterloo
2017	Faculty of Engineering Award, University of Waterloo
2016, 2017	Nanofellowship, Waterloo Institute for Nanotechnology
2016	International Master's Student Award, University of Waterloo
2015	Dean's List Award and University Merit Scholarship, BUET

C. Contributions to Science

1. **Generalizing reagent-free molecular transduction across receptors.** Most electrochemical biosensors depend on added reagents, labels, or target-specific signaling schemes, which limits continuous use and generalization to new targets. With Shana Kelley and Ted Sargent, I contributed to the development of the molecular pendulum, a reagent-free mechanism in which target binding changes the field-driven motion of an electrode-tethered DNA construct and therefore its electrochemical response. I then generalized the mechanism across receptor classes. As first author, I replaced antibodies with DNA aptamers and quantified cardiac biomarkers of myocardial injury and heart failure directly in whole blood, and I contributed to nanobody-based monitoring of IL-6. These studies showed that one transduction principle can be adapted to antibodies, aptamers, and nanobodies.
    a. Das J†, Gomis S†, Chen JB, Yousefi H, Mahmud A, Zhou W, Sargent EH, Kelley SO. Reagentless biomolecular analysis using a molecular pendulum. Nat. Chem. 2021;13:428–434.
    b. Mahmud A, Chang D, Das J, Gomis S, Chen JB, Yousefi H, Pandey L, Sargent EH, Kelley SO. Monitoring cardiac biomarkers using aptamer-based molecular pendulum sensors. Angew. Chem. Int. Ed. 2023;62:e202213567.
    c. Flynn CD, Wu Z, Bantle A, Isaacson SE, Chang D, Mahmud A, Yousefi H, Das J, Kelley SO. Nanobody receptors enable high-sensitivity monitoring of IL-6 using molecular pendulum bioanalysis. Anal. Chem. 2025;97(14):7825–7832.
2. **Reagent-free detection of intact viral particles in patient samples.** Viral diagnostics typically require sample processing, nucleic-acid amplification, or labeled reagents, which slows testing and limits use outside the laboratory. As co-first author, I helped demonstrate that molecular-pendulum interfaces can detect intact SARS-CoV-2 particles within five minutes in unprocessed patient saliva, using reagent-free electrochemical readout of DNA–antibody conjugate kinetics. The work was validated with clinical samples through collaborators at Sinai Health System and Sunnybrook Research Institute, supported by the Toronto COVID-19 Action Fund, and produced an invention disclosure and a published patent application on reagentless electrochemical biosensing; I presented it as an invited talk at the World Congress on Biosensors. This study showed that electronic interfaces can read whole pathogens without amplification, the foundation for the real-time infection and resistance monitoring in my independent program.
    a. Yousefi H†, Mahmud A†, Chang D†, Das J, Gomis S, Chen JB, et al., Sargent EH, Kelley SO. Detection of SARS-CoV-2 viral particles using direct, reagent-free electrochemical sensing. J. Am. Chem. Soc. 2021;143(4):1722–1727.
    b. Kelley SO, Sargent EH, Das J, Gomis S, Ahmed S, Yousefi H, Chang D, Mahmud A. Reagentless electrochemical biosensor. U.S. Patent Application 17/904,846, published April 6, 2023.

3. **Receptor-free electrochemical readout of hormones.** Many physiologically important molecules lack robust receptors, and their direct electrochemical signals are often obscured by competing interfacial reactions. Cortisol is a prominent example: its reduction occurs at potentials where hydrogen evolution dominates. With Zhenan Bao, I developed carbon electronics, an integrated materials–measurement strategy that pairs defect-engineered laser-induced graphene with transition-resolved interrogation to isolate intrinsic molecular electrochemistry from background processes. The approach enabled direct, receptor-free cortisol detection at low-nanomolar concentrations, benchmarked against LC–MS/MS, and fully printed implantable sensors that tracked pain-induced stress responses in rodents. This work is the subject of a Stanford provisional patent application. I also contributed to carbon-flower electrodes for sensitive hormone and neurotransmitter detection. These studies established the receptor-free route of my program and showed that measurement design, not only materials, sets what an interface can access.
    a. Mahmud A†, Zhao C†, Uwakwe C, et al., DeSimone JM, Bao Z. Direct electrochemical cortisol detection via transition-resolved interrogation at a defect-engineered graphene interface. bioRxiv 2026.09.13.751286 (2026); under review.
    b. Weber IC, Uruchurtu Patino D, Hsu K-J, et al., Mahmud A, et al., Bao Z. Sensitive hormone and neurotransmitter detection with carbon flower electrodes. Adv. Funct. Mater. 2026;36(40):e28595.
4. **Receptor engineering and frameworks for continuous molecular monitoring.** Continuous measurement in the body requires receptors with tuned affinities and a clear view of what limits sensors *in vivo*. I contributed to a high-dimensional microfluidic approach for selecting aptamers with programmable binding affinities, which allows receptors to be matched to physiological concentration ranges. I also co-authored two reviews that frame the field, on strategies for biomolecular analysis and continuous physiological monitoring and on biomolecular sensors for advanced physiological monitoring. These works examine how receptor chemistry, transduction mechanism, sampling, and interfacial stability constrain continuous measurement, and they identify the problems that motivate my independent program: signal drift, biofouling, calibration, and the scarcity of receptors for small molecules.
    a. Chang D†, Wang DZ†, Flynn CD, Mahmud A, Wang H, Geraili A, Li X, Zhang J, Sargent EH, Kelley SO. A high-dimensional microfluidic approach for selection of aptamers with programmable binding affinities. Nat. Chem. 2023;15:773–780.
    b. Clifford A, Das J, Yousefi H, Mahmud A, Chen JB, Kelley SO. Strategies for biomolecular analysis and continuous physiological monitoring. J. Am. Chem. Soc. 2021;143(14):5281–5294.
    c. Flynn CD, Chang D, Mahmud A, Yousefi H, Das J, Riordan K, Sargent EH, Kelley SO. Biomolecular sensors for advanced physiological monitoring. Nat. Rev. Bioeng. 2023;1:560–575.
5. **Nanostructured devices for self-powered electronics.** Before moving to biology, I worked on how nanostructured materials convert mechanical energy into electrical power, a central problem for autonomous and implantable electronics. With Dayan Ban at the University of Waterloo, I initiated and led an energy-harvesting effort. As first author, I integrated organic and inorganic nanostructures in a hybrid nanogenerator whose components enhanced each other's performance and developed a piezoelectric harvester based on one- and two-dimensional zinc oxide nanostructures; this work led to an issued U.S. patent. I also contributed to a self-powered wireless sensing system built on a triboelectric nanogenerator. This training in device physics and energy-efficient electronics informs how I design implantable bioelectronic systems.
    a. Mahmud A, Khan AA, Voss P, Islam S, Ban D. Integration of organic/inorganic nanostructured materials in a hybrid nanogenerator enables efficacious energy harvesting via mutual performance enhancement. Nano Energy 2019;58:112–120.
    b. Mahmud A, Khan AA, Voss P, Das T, Abdel-Rahman E, Ban D. A high-performance consolidated piezoelectric energy harvester based on one-dimensional/two-dimensional hybrid zinc oxide nanostructures. Adv. Mater. Interfaces 2018;5:1801167.
    c. Khan AA, Mahmud A, Voss P, Islam S, Ban D. A self-powered multi-broadcasting wireless sensing system realized with an all-in-one triboelectric nanogenerator. Nano Energy 2019;62:691–699.
    d. Mahmud A, Khan AA, Ban D, Voss P. 1D/2D hybrid piezoelectric nanogenerator and method for making same. U.S. Patent 12,301,139, issued May 13, 2025.

Complete List of Published Work (Google Scholar): https://scholar.google.com/citations?user=czZw9NsAAAAJ

† equal contribution