MOHAMMAD "MOSI" HEIRANIAN

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PROFESSIONAL TRAINING

Yale University, USA *2021 - Date*
Postdoctoral Associate: Department of Chemical and Environmental Engineering
Adviser: Professor Menachem Elimelech

EDUCATION

University of Illinois at Urbana-Champaign, USA *2016 - 2020*
PhD: Theoretical and Applied Mechanics, Department of Mechanical Science and Engineering
Adviser: Professor Narayana R Aluru
GPA: 4.0/4.0

University of Illinois at Urbana-Champaign, USA *2012 - 2016*
MSc: Theoretical and Applied Mechanics, Department of Mechanical Science and Engineering
Adviser: Professor Narayana R Aluru
GPA: 4.0/4.0

University of Manitoba, Canada *2008 - 2012*
BSc: Mechanical Engineering, Department of Mechanical Engineering
GPA: 4.2/4.5

PUBLICATIONS

Number of First-Author Publications: 13 Citations: >1866 H-index: 15 As of 12/22/2022

28. **M. Heiranian** and M. Elimelech, "Nanofluidic transport in defective graphene oxide nanoslits", in preparation.

27. **M. Heiranian**, H. Fan, L. Wang, and M. Elimelech, "Water transport mechanism in reverse osmosis", in preparation.

26. L. Wu, **M. Heiranian**, L. F. Villalobos, M. Sung, M. Elimelech, and B. Tang, "Color dependent molecular sieving in hybrid graphene oxide", submitted.

25. **M. Heiranian**, C. Violet, M. Elimelech, "Principles of ion-ion selectivity in nanopores", submitted.

24. L. Wang, J. He, **M. Heiranian**, Y. Li, and M. Elimelech, "Why water transport in reverse osmosis is not governed by a solution-diffusion mechanism", submitted.

23. **M. Heiranian** and N. R. Aluru, "Modified Lucas-Washburn theory for fluid filling in nanotubes", *Physical Review E*, Vol. 105, No. 5, Art. No. 055105, **2022**. (link)

22. **M. Heiranian**, R. M. DuChanois, C. L. Ritt, C. Violet, and M. Elimelech, "Molecular simulations to elucidate transport phenomena in polymeric membranes", *Environmental Science & Technology*, Vol. 56 , No. 6, pp. 3313-3323, **2022**. (link)

21. R. M. DuChanois, **M. Heiranian**, J. Yang, C. Porter, X. Zhang, and M. Elimelech, "Designing polymeric membranes with coordination chemistry for high-precision ion separations", *Science Advances*, Vol. 8, No. 9, Art. No. eabm9436, **2022**. (link)

20. X. Zhou, **M. Heiranian**, M. Yang, R. Epsztein, K. Gong, C. E. White, S. Hu, J. Kim, and M. Elimelech, "Selective fluoride transport in sub-nanometer TiO_2 pores", *ACS Nano*, Vol. 15 , No. 10, pp. 16828-16838, **2021**. (link)

19. L. Song, **M. Heiranian**, and M. Elimelech, "True driving force and characteristics of water transport in osmotic membranes", *Desalination*, Vol. 15, No. 520, Art. No. 115360, **2021**. (link)

18. M. T. Hwang, I. Park, **M. Heiranian**, A. Taqieddin, S. You, V. Faramarzi, A. A. Pak, A. M. van der Zande, N. R. Aluru, and R. Bashir, "Ultrasensitive detection of dopamine, IL-6 and SARS-CoV-2 proteins on crumpled graphene FET biosensor", *Advanced Materials Technologies*, Vol. 6, No. 11, Art. No. 2100712, **2021**. (link)

17. **M. Heiranian**, Y. Noh, and N. R. Aluru, "Dynamic and weak electric double layers in ultrathin nanopores", *Journal of Chemical Physics*, Vol. 154, No. 13, Art. No. 134703, **2021**. (link)

16. **M. Heiranian**, A. Taqieddin, and N. R. Aluru, "Revisiting Sampson's theory for hydrodynamic transport in ultrathin nanopores", *Physical Review Research*, Vol. 2, No. 4, Art. No. 043153, **2020**. (link)

15. A. Taqieddin, **M. Heiranian**, and N. R. Aluru, "Interfacial properties of water on hydrogenated and fluorinated graphene surfaces: parametrization of nonbonded interactions", *Journal of Physical Chemistry C*, Vol. 124, No. 39, pp. 21467-21475, **2020**. (link)

14. **M. Heiranian** and N. R. Aluru, "Nanofluidic transport theory with enhancement factors approaching one", *ACS Nano*, Vol. 14, No. 1, pp. 272-281, **2020**. (link)

13. M. T. Hwang[*], **M. Heiranian**[*], Y. Kim[*], S. You, J. Leem, A. Taqieddin, V. Faramarzi, Y. Jing, I. Park, A. M. van der Zande, S. Nam, N. R. Aluru,and R. Bashir, "Ultrasensitive detection of nucleic acids using deformed graphene channel field effect biosensors", *Nature Communications*, Vol. 11, Art. No. 1543, **2020**. (link)
In News: Health Europa, Phys.org, Medical Life and Sciences, EurekAlert, AZO Nano, Materials Today

[*]***these authors contributed equally to this work***

12. P. Snapp[*], **M. Heiranian**[*], M. T. Hwang[*], R. Bashir, N. R. Aluru, and S. Nam, "Current understanding and emerging applications of 3D crumpling mediated 2D material-liquid interactions", *Current Opinion in Solid State & Materials Science*, Vol. 24, No. 3, Art. No. 100836, **2020**. (link)

[*]***these authors contributed equally to this work***

11. S. S. Kwon, J. Choi, **M. Heiranian**, Y. Kim, W. J. Chang, P. M. Knapp, M. C. Wang, J. M. Kim, N. R. Aluru, W. Il Park, and S. Nam, "Electrical double layer of supported atomically thin materials", *Nano Letters*, Vol. 19, No. 7, pp. 4588-4593, **2019**. (link)

10. V. Nandigana, **M. Heiranian**, and N. R. Aluru, "Single ion transport with a single-Layer graphene nanopore", *International Journal of Mechanical and Mechatronics Engineering*, Vol. 13, No. 7, pp. 479-483, **2019**. (link)

9. A. Barati Farimani, **M. Heiranian**, and N. R. Aluru, "Identification of amino acids with sensitive nanoporous MoS_2: towards machine learning-based prediction", *npj 2D Materials and Applications*, Vol. 2, Art. No. 14, **2018**. (link)

8. Y. Zhang, **M. Heiranian**, B. Janicek, Z. Budrikis, S. Zapperi, P. Y. Huang, H. T. Johnson, N. R. Aluru, J. W. Lyding, and N. Mason, "Strain modulation of graphene by nanoscale substrate curvatures: a molecular view", *Nano Letters*, Vol. 18, No. 3, pp. 2098-2104, **2018**. (link)

7. **M. Heiranian**, Y. Wu, and N. R. Aluru, "Molybdenum disulfide and water interaction parameters", *Journal of Chemical Physics*, Vol. 147, No. 10, Art. No. 104706, **2017**. (link)

6. A. Barati Farimani, **M. Heiranian**, K. Min, and N. R. Aluru, "Antibody subclass detection using graphene nanopores", *Journal of Physical Chemistry Letters*, Vol. 8, No. 7, pp. 1670-1676, **2017**. (link)

5. J. Feng, M. Graf, K. Liu, D. Ovchinnikov, D. Dumcenco, **M. Heiranian**, V. Nandigana, N. R. Aluru, A. Kis, and A. Radenovic, "Single-layer MoS_2 nanopores as nanopower generators", *Nature*, Vol. 536, No. 7615, pp. 197-200, **2016**. (link)
In News: VOA (Voice of America), Newsweek, Science Daily, UPI (United Press International), Phys.org

4. A. Barati Farimani, **M. Heiranian**, and N. R. Aluru, "Nano-electro-mechanical pump: Giant pumping of water in carbon nanotubes", *Scientific Reports*, Vol. 6, Art. No. 26211, **2016**. (link)

3. G. A. Venkatesan, J. Lee, A. Barati Farimani, **M. Heiranian**, C. P. Collier, N. R. Aluru, and S. A. Sarles, "Adsorption kinetics dictate monolayer self-assembly for both lipid-in and lipid-out approaches to droplet interface bilayer formation", *Langmuir*, Vol. 31, No. 47, pp. 12883-12893, **2015**. (link)

2. **M. Heiranian**, A. Barati Farimani, and N. R. Aluru, "Water desalination with a single-layer MoS_2 nanopore", *Nature Communications*, Vol. 6, Art. No. 8616, **2015**. (link)
In News: Business Insider, Quartz, Yahoo News, Business Standard, Science Daily, IEEE Spectrum, Phys.org

1. A. Barati Farimani[*], **M. Heiranian**[*], and N. R. Aluru, "Electromechanical signatures for DNA sequencing through a mechanosensitive nanopore", *Journal of Physical Chemistry Letters*, Vol. 6, No. 4, pp. 650-657, **2015**. (link)

[*] ***these authors contributed equally to this work***

RESEARCH ACCOMPLISHMENTS

• Developed membrane material design principles for ion-ion selective transport using extensive multiscale computational tools and machine learning techniques.

• Developed several nanofluidic transport theories through analytical and computational modifications of continuum-based hydrodynamic theories such as Hagen-Poiseuille, Sampson, and Lucas-Washburn laws.

• Guided experimentalists by molecular-scale modeling as a co-first author on a project that led to the patented discovery of crumpled graphene channel field effect biosensors for ultrasensitive detection of nucleic acids and disease biomarkers.

• Discovered MoS_2 as a novel material for potential applications in water desalination, nanopower generation, and single-biomolecule detection by using extensive multiscale computational tools and machine learning techniques.

GRANTS AND PROPOSALS

Research Grant Proposals:

3. Currently contributing to a **National Science Foundation (NSF)** proposal in the Elimelech Lab by conceptualizing research ideas and writing several sections of the proposal document, in preparation.

2. Contributed to "EFRC: A Center for Enhanced Nanofluidic Transport (CENT^2)", **US Department of Energy (DOE)**, by conceptualizing research ideas and writing several sections of the proposal document, awarded, 2022-2026.

1. Contributed to "MRSEC: Illinois Materials Research Center", **National Science Foundation (NSF)**, awarded, 2018-2022.

Computational Resource Proposals:

9. Wrote "Computational nanoscience: fundamental studies of chemical and morphological functionalization of 2D materials ", **XSEDE (Stampede2 and Comet)**, awarded, 2020-2021.

8. Wrote "Large-scale simulations of soft/hard interfaces: interfacial science, ionic conductivity and fluidic transport", **Blue Waters**, 435,000 node-hours awarded, 2019-2020.

7. Wrote "Computational studies in nanofluidic transports, heterogeneous biological and 2D materials, modeling of Lennard-Jones mixtures, proton and ion oxide transports in SOEC and electronic structure of graphene nano ribbons", **XSEDE (Stampede2 and Comet)**, awarded, 2019-2020.

6. Wrote "Large-scale simulations of biological and 2-dimensional heterogeneous nano-interfaces, nanopores and nanochannels", **Blue Waters**, 377,800 node-hours awarded, 2019-2020.

5. Wrote "Computational nanoscience: fundamental studies in ion conductors, synthetic membranes, dissipation mechanisms and exfoliation of 2D materials", **XSEDE (Stampede2 and Comet)**, awarded, 2018-2019.

4. Wrote "Machine learning assisted protein sequencing with highly sensitive MoS_2 nanopore", **Blue Waters**, 135,000 node-hours awarded, 2017-2018.

3. Wrote "Systematic thermodynamically consistent structural-based coarse graining of room temperature ionic liquids", **Blue Waters**, 200,000 node-hours awarded, 2017-2018.

2. Wrote "Large-scale simulations of droplet interface bilayers with functional imbedded protein channels", **Blue Waters**, 975,000 node-hours awarded, 2016-2017.

1. Wrote "Large-scale simulations of DNA nanostructures for drug delivery and applications of novel synthetic membranes for protein/DNA integration", **Blue Waters**, 700,000 node-hours awarded, 2015-2016.

PATENTS

M. Hwang, R. Bashir, **M. Heiranian**, S. Nam, N. Aluru, A. van der Zande, C. J. Murphy, J. Choi, Y. Kim, "Ultrasensitive Biosensor Using Bent and Curved Field Effect Transistors by Debye Length Modulation", **World Intellectual Property Organization (WIPO)**, Publication No. WO/2021/174068, Serial No. PCT/US2021/020006, Publication Date 09/02/2021.

AWARDS

- *Nature Water* Best Poster Award at the Lake Tahoe 2022 Nanofluidics Conference *2022*
- Michael Sutton Memorial Award for Outstanding Research in Mechanical Engineering *2018*
- John Shewchuk Engineering Design Award *2012*
- Shell Canada Mechanical and Manufacturing Design Competition Award *2012*
- International Undergraduate Student Scholarship *2012*
- University of Manitoba Students' Union (UMSU) Scholarship *2012*
- International Undergraduate Student Scholarship *2011*
- University of Manitoba Students' Union (UMSU) Scholarship *2011*
- Randy Futros Memorial Award *2011*
- Technical Communication Report Prize in Engineering *2011*
- International Undergraduate Student Scholarship *2009*
- International Undergraduate Student Entrance Scholarship *2008*

ORAL PRESENTATIONS

11. **M. Heiranian**, "Revisiting Hagen-Poiseuille law for flow in nanopores", ***Statistical Thermodynamics and Molecular Simulations (STMS) Virtual Seminar Series***, 2022.

10. **M. Heiranian**, "Nanoscale fluidic theory for flow in carbon-based nanopores", ***Soft, Fluid, and Living Matter Seminars***, Department of Mechanical Engineering & Materials Science, Yale University, 2022.

9. **M. Heiranian**, "Nanoscale fluid mechanics and molecular transport for applications at the water-energy nexus", ***Mechanical Engineering & Materials Science Seminars***, Department of Mechanical Engineering & Materials Science, Washington University in St. Louis, 2022.

8. **M. Heiranian** and N. R. Aluru, "Nanofluidic transport theory with enhancement factors approaching one", ***Fluid Mechanics Seminars***, Department of Mechanical Science and Engineering, University of Illinois at Urbana-Champaign, 2020.

7. **M. Heiranian**, "Molecule transport in nanopores with applications to water purification, power generation, and disease diagnosis ", Department of Chemical & Environmental Engineering, Yale University, 2020.

6. **M. Heiranian** and N. R. Aluru, "Thickness dependent nanofluidic transport in nanopores and nanochannels", ***APS March Meeting***, 2019.

5. **M. Heiranian**, A. Barati Farimani and N. R. Aluru, "Protein identification using a single-layer MoS_2 nanopore: towards machine learning-based predictive models", ***APS March Meeting***, 2018.

4. **M. Heiranian**, J. Feng, M. Graf, K. Liu, D. Ovchinnikov, D. Dumcenco, V. Nandigana, N. R. Aluru, A. Kis and A. Radenovic, "Single-layer MoS_2 nanopores as power generators", ***NCSA Blue Waters Symposium for Petascale Science and Beyond***, 2017. Watch Online

3. **M. Heiranian**, Y. Wu and N. R. Aluru, "Parameterization of nonbonded interactions between molybdenum disulfide and water", ***APS March Meeting***, 2017.

2. **M. Heiranian**, A. Barati Farimani and N. R. Aluru, "Molybdenum disulfide (MoS_2) as a novel 2D nano-porous membrane for water desalination", ***NCSA Blue Waters Symposium for Petascale Science and Beyond***, 2016. Watch Online

1. **M. Heiranian**, A. Barati Farimani and N. R. Aluru, "Water purification across MoS_2 nano-porous membranes", ***APS Division of Fluid Dynamics***, 2015.

POSTER PRESENTATIONS

3. **M. Heiranian**, R. M. DuChanois,X. Zhou, and M. Elimelech "Role of ion-membrane interactions in selective ion transport", ***Lake Tahoe 2022 Nanofluidics Conference***, 2022.

2. **M. Heiranian**, M. T. Hwang, N. R. Aluru, and, R. Bashir, "Manipulating ions and nucleic acids distribution on deformed graphene channel field effect transistor", ***I-MRSEC***, 2019.

1. **M. Heiranian**, A. Barati Farimani, and N. R. Aluru, "Functionality of MscL in Droplet Interface Bilayer", ***Biophysical Society***, 2015.

TEACHING AND MENTORING

Teaching at the University of Illinois at Urbana-Champaign:

- Teaching Assistant for TAM 335, Introductory Fluid Mechanics, Jan 2013-May 2013
- Teaching Assistant for TAM 210/211, Statics, Aug 2013-Dec 2013
- Teaching Assistant for TAM 210/211, Statics, Aug 2017-Dec 2017
- Teaching Assistant for TAM 210/211, Statics, Aug 2019-Dec 2019
- Teaching Assistant for ME 200, Thermodynamics, Jan 2020-May 2020

Research Mentoring at the University of Illinois at Urbana-Champaign:

- Paul Arghyadeep, ME PhD Student
- Yechan Noh, ME PhD Student
- Hananeh Oliaei, ME PhD Student
- Payam Dibaenia, ME PhD Student
- Yao Xiao, ME MSc Student
- Qiangqiang Huang, ME MSc Student
- Chengfang Duan, ME MSc Student
- Mohan Teja Dronadula, ME MSc Student
- Anshul Saxena, ME MSc Student

Research Mentoring at Yale University:

- Xuechen Zhou, ChemE and EnvE PhD Student
- Ryan DuChanois, ChemE and EnvE PhD Student
- Camille Violet, ChemE and EnvE PhD Student

ACADEMIC SERVICES AND LEADERSHIP

- Frequent reviewer for scholarly journals of *Science Advances*, *PNAS*, *Microfluidics and Nanofluidics*, *Desalination*, *The Journal of Physical Chemistry*, and *Advanced Theory and Simulations*.

- Consulted the board of International Alliance for Ability in Science regarding engineering topics for the development of educational materials and student researcher aid to make engineering and STEM more accessible for disabled students and disabled lower-income students.
The International Alliance for Ability in Science is a 501(c)(3) non-profit organization run by disabled women in STEM with aims to provide academic and financial aid to disabled students and researchers in STEM fields.

- Served as a PhD student volunteer and organizer with I-MRSEC to device science demos for middle school students from lower income families.

- Provided mentorship for undergraduate students as a part of I-MRSEC Research Experiences for Undergraduates (REU).

• Served by generating supplemental educational materials and individualized course notes for disabled students. Received the Randy Futros Memorial Award for outstanding service for disabled students at the University of Manitoba.

• Collaborated with the International Alliance for Ability in Science to develop 1:1 tutoring programs for students of all ages in STEM courses who have specific learning disabilities, such as dyscalculia and dyslexia.

• Aided in grant writing consultation and fundraising for the International Alliance for Ability in Science, which has resulted in an incoming $15,000. These funds have been used to provide scholarships and financial aid for disabled student researchers across the globe.

CENTER INVOLVEMENT AND COLLABORATIONS

- Center for Enhanced Nanofluidic Transport (CENT) *2020-Date*

- Illinois Materials Research Science and Engineering Center (I-MRSEC) *2018-2020*

PROFESSIONAL SOCIETIES MEMBERSHIP

- Biophysical Society (BPS) *2015-Date*
- American Physical Society (APS) *2015-Date*