DREXEL UNIVERSITY
Chemical and
Biological Engineering
College of Engineering

DEPARTMENT OF

Chemical & Biological Engineering

ANNUAL REPORT

JULY 1, 2018 – JUNE 30, 2019




DREXEL UNIVERSITY
Chemical and Biological Engineering
College of Engineering

WELCOME to the 2019 Annual Report of the Department of Chemical and Biological Engineering at Drexel. In these pages, you will find updates on the accomplishments of all our faculty and highlights from our students, as well as quick facts attesting to what a successful year this has been.

From the center-level effort in additive manufacturing of thermosetting polymers led by Profs. Palmese and Alvarez to the many collaborative and individual research grants, our research supports this year reached record levels. Our community of PhD students and postdocs continues to grow, and undergraduate participation in research projects remains high.

We just completed the fourth year of our five-year transition to a new undergraduate curriculum for the Chemical Engineering major, which includes enhanced incorporation of computation, better integration of lab experiments with courses, and training in chemical process safety spread throughout. Continuous curricular improvement is an important element of the culture in CBE, and this revision marks an important milestone.

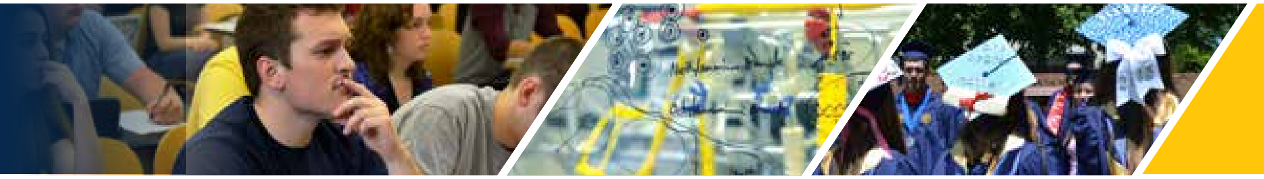
Support from our professional staff remains excellent, with Andrea Falcone now leading as Director of Undergraduate Affairs and Samantha Pearsall taking over as Program Coordinator (and a main reason this report exists!).

So, please join us in celebrating another successful year in CBE!

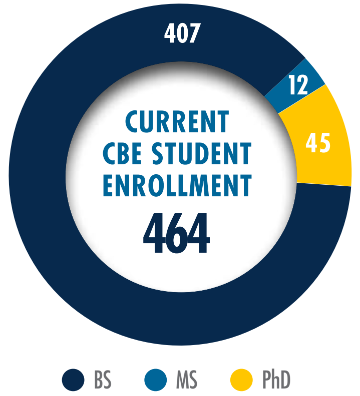
Sincerely,

Cameron F. Abrams
Professor and Department Head

FACTS & FIGURES



The Department of Chemical and Biological Engineering (CBE) at Drexel University consists of 13 tenure and tenure-track faculty members, 3 teaching faculty, 45 PhD students, 12 MS students, and 406 undergraduate students. The department is currently engaged in externally funded research with over $5.2 million in annual research expenditures using state-of-the art facilities. CBE's research program is built upon the following areas of core competency: (a) chemical kinetics, transport and thermodynamics, (b) polymer science and engineering and (c) systems engineering, modeling and computation. These competencies support the research themes of Energy and Sustainability and Health and Medicine, which are directly linked to solving present-day societal challenges. Funding sources for research include NSF, NIH, DOD, USDA, EPA, CertainTeed Corporation, DuPont, Environmental Fuel Research, Exxon Mobil, FMC, General Motors, PPG, TDL Innovations, W.L. Gore and Associates, Zzyzx Polymers, American Chemical Society Petroleum Research Fund and The Electrochemical Society.



ENROLLMENT STATISTICS

	UNDERGRADUATE	GRADUATE MS	GRADUATE PhD
DREXEL UNIVERSITY	15,325	5,470	3,047
COLLEGE OF ENGINEERING	3,144	415	267
CHEMICAL ENGINEERING	406	12	45

NEW CBE ENROLLMENT DIVERSITY STATISTICS

	UNDERGRADUATE	GRADUATE MS	GRADUATE PhD
UNDERREPRESENTED MINORITY	7%	33%	0%
OTHER/WHITE	78%	67%	25%
INTERNATIONAL	15%	0%	75%
WOMEN	33%	33%	33%
MEN	67%	67%	67%

CURRENT CBE ENROLLMENT DIVERSITY STATISTICS

	UNDERGRADUATE	GRADUATE MS	GRADUATE PhD
UNDERREPRESENTED MINORITY	36	1	1
OTHER/WHITE	313	6	18
INTERNATIONAL	58	5	26
WOMEN	136	5	15
MEN	271	7	30

RESEARCH IMPACT

EXPENDITURES: $5.2 MILLION

AWARDS: $72,520,666

DEGREES AWARDED

	UNDERGRADUATE	GRADUATE MS	GRADUATE PhD
COLLEGE OF ENGINEERING	695	291	48
CHEMICAL ENGINEERING	87	13	4

DEGREES AWARDED TO UNDER-REPRESENTED MINORITY STUDENTS

	UNDERGRADUATE	GRADUATE MS	GRADUATE PhD
ETHNIC DIVERSITY	5%	8%	0%
GENDER DIVERSITY	34%	15%	25%

UNDERGRADUATE ENTERING STUDENT SAT SCORES

	MATH	VERBAL	TOTAL
COLLEGE OF ENGINEERING	683	646	1329
CHEMICAL ENGINEERING	693	652	1345

GRADUATE ENTERING STUDENT GRE SCORES

	QUANTITATIVE	VERBAL
COLLEGE OF ENGINEERING	161	153
CHEMICAL ENGINEERING	162	152

Data taken from Fall 2018

RESEARCH AREAS

BIOLOGICAL ENGINEERING:

Biochemical Engineering, Biomaterials Engineering, Biological Colloids, Biomedical Engineering, Complex Fluids, Biosensors, Cellular Biophysics

ENERGY & THE ENVIRONMENT:

Solar Cells, Nanowires, Biodegradable Polymers, Renewable Fuels and Energy,Fuel Cells, Electrocatalysts, Polymers and Composites from Renewable Sources

MULTISCALE MODELING & PROCESS SYSTEMS ENGINEERING:

Drug Delivery, Fuel Cells, Process Control and Modeling, Transport Phenomena, Molecular Simulation, Safety Analysis, Fluid Mechanics of Multi-phase Systems

POLYMER SCIENCE & ENGINEERING:

Materials from Renewable Sources, Membranes, Nanomaterials, Polymer Composites, Polymer Processing and Rheology, Polymer Nano-composites, Interfacial Phenomena, Diffusion in Polymers, Pyrolysis of Polymers, Polymer Thermodynamics

FACULTY PROFILES

PROFESSORS

Cameron F. Abrams

Professor and Department Head
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Cameron F. Abrams earned a BS in Chemical Engineering from North Carolina State University in 1995 and a PhD in Chemical Engineering from the University of California, Berkeley in 2000. After two years of postdoctoral work at the Max-Planck-Institute for Polymer Research in Mainz, Germany, he joined the Department of Chemical and Biological Engineering at Drexel as an Assistant Professor in 2002. Abrams was tenured in 2008 and promoted to Full Professor and given a secondary appointment in the Department of Biochemistry and Molecular Biology in 2012. He was appointed Department Head in January 2017. Abrams' research interests involve development of novel molecular simulation methods and their applications in design of high-performance materials, protein-related kinetics and thermodynamics, and HIV-1 entry inhibitor development. Abrams is the recipient of an NSF CAREER Award and an ONR Young Investigator Award. He is a Fellow of the American Institute of Medical and Biological Engineering and is the 2015 Impact Awardee in Computational Molecular Sciences and Engineering from the American Institute of Chemical Engineers. Abrams has authored or co-authored ~100 original articles and has graduated ten PhD students to date. Abrams previously served the University as the founding Chair of the Board of Governance of the University Research Computing Facility.

EXTERNAL RESEARCH FUNDING

"Transition Path Theory and Markovian Milestoning for Prediction of Protein-Ligand Binding Kinetics in Molecular Simulations", NIH R01 GM100472 (1st renewal), (Co-I Eric Vanden-Eijnden, NYU), 9/1/17-5/31/21

"Structure-based antagonism of HIV-1 envelope function in cell entry", NIH P01 GM056550, Co-I (PI: Irwin Chaiken, DUCOM) 9/1/18 – 8/31/23. Abrams is the leader of the Computational Core of this program project.

"Thermosets for Agile Manufacturing," Army Research Lab W911NF-17-2-0227, Co-I (PI: G. R. Palmese). 9/1/17-8/31/20. Abrams' share supports one FTE PhD student and ½ of a postdoc.

JOURNAL PUBLICATIONS (PEER REVIEWED)

Maolin Lu, Xiaochu Ma, Luis R. Castillo-Menendez, Jason Gorman, Nirmin Alsahafi, Utz Ermel1 Daniel S. Terry, Michael Chambers, Dongjun Peng, Baoshan Zhang, Tongqing Zhou, Nick Reichard, Kevin Wang, Jonathan Grover, Brennan P. Carman, Matthew R. Gardner, Ivana Niki-Spiegel, Akihiro Sugawara, James Arthos, Edward A. Lemke, Amos B. Smith III, Michael Farzan, Cameron Abrams, James B. Munro, Adrian B. McDermott, Andrés Finzi, Peter D. Kwong, Scott C. Blanchard, Joseph G. Sodroski and Walther Mothes, "Associating HIV-1 envelope glycoprotein structures with states on virus observed by smFRET", *Nature*, **2019**, 568, 415-149.

DOI: 10.1038/s41586-019-1101-y

Arun Srikanth Srirdar and Cameron F. Abrams, "Yield and Post-yield Behavior of Fatty-Acid-Functionalized Amidoamine–Epoxy Systems: A Molecular Simulation Study", J. Dyn. Behav. Mater., **2019**, *5*, 143–149.

DOI: 10.1007/s40870-019-00193-z

Ryan Gordon, Spencer Stober, and Cameron F. Abrams, "Counterion Effects on Aggregate Structure of 12-Hydroxystearate Salts in Hexane: A Quantum Mechanical and Molecular Dynamics Simulation Study", J. Phys. Chem. B, **2019**, *123*, 534–541.

DOI: 10.1021/acs.jpcb.8b08477

Gardner, J.; Abrams, C.F. Lipid Flip-Flop vs. Lateral Diffusion in the Relaxation of Hemifusion Diaphragms. *Biochim. Biophys. Acta, Biomembr.* **2018**, *1860*, 1452-1459.

DOI: 10.1016/j.bbamem.2018.04.007

Gossert, S.; Parajuli, B.; Chaiken, I.; Abrams, C.F. Roles of Conserved Tryptophans in Trimerization of HIV-1 Membrane-Proximal External Regions: Implications for Virucidal Design via Alchemical Free-Energy Molecular Simulations. **2018**, *Proteins, 86*, 707–711.

DOI: 10.1002/prot.25504 PMCID: PMC6013385

Paz, S.A.; Maragliano,L.; Abrams, C.F.; The Effect of Intercalated Water on Potassium Ion Transport Through Kv1.2 Channels Studied via On-the-fly Free-Energy Parameterization. *J. Chem. Theory. Comput.* **2018**, *14*, 2743–2750.

DOI: 10.1021/acs.jctc.8b00024

Sridhar, A.; Vergara, J.; Kinaci, E.; Palmese, G.R.; Abrams, C.F. The Effect of Alkyl Chain Length on Mechanical Properties of Fatty-Acid-Functionalized Amidoamine-Epoxy System. *Comput. Mater. Sci.* **2018**, *150*, 70-76.

DOI: 10.1016/j.commatsci.2018.03.073

Paz, S.A.; Abrams, C.F. Testing Convergence of Different Free-Energy Methods in a Simple Analytical System with Hidden Barriers. *Computation* **2018**, *6*, 27.

DOI: 10.3390/computation6020027

Parajuli, B.; Acharya, K.; Bach, H.C.; Parajuli,B.; Zhang, S.; Smith, A.B., III; Abrams, C.F.; Chaiken, I.; Restricted HIV-1 Env Glycan Engagement by Lectin-Reengineered DAVEI Protein Chimera is Sufficient for Lytic Inactivation of the Virus. *Biochem. J.* **2018**, *475*, 931-957.

DOI: 10.1042/BCJ20170662 PMCID: PMC5944358

Moraca, F.; Rinaldo, D.; Smith, A.B.,III; Abrams, C.F. Specific Non-Covalent Interactions Determine Optimal Structure of a Buried Ligand Moiety: QM/MM and Pure QM Modeling of Complexes of the Small-Molecule CD4 Mimetics and HIV-1 Gp120. *ChemMedChem* **2018**, *13*, 627-633.

DOI: 10.1002/cmdc.201700728 PMCID: PMC5901908

Jason B. Baxter

Professor
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Jason B. Baxter earned a BS in Chemical Engineering from the University of Delaware in 2000 and a PhD in Chemical Engineering from the University of California Santa Barbara in 2005. After two years of postdoctoral work at Yale University, he joined the Department of Chemical and Biological Engineering at Drexel as an Assistant Professor in 2007. Baxter was tenured in 2013 and promoted to full professor in 2018. His research group focuses on solar energy conversion, including materials chemistry of thin films and nanostructures, fabrication and characterization of photovoltaic cells and photoelectrochemical cells, and ultrafast photophysics of solar energy materials. Baxter has received the NSF CAREER Award and Drexel's College of Engineering Outstanding Teacher Award. He has authored or co-authored ~50 original articles and has graduated seven PhD students to date. Baxter has led the department's effort to develop the innovative new curriculum that debuted with the 2016 incoming class.

EXTERNAL RESEARCH FUNDING

"Collaborative Research: Ultrafast Carrier Dynamics to Link Processing, Structure and Performance in High-Efficiency Cu2Zn(S,Se)4 Thin Film Photovoltaics", National Science Foundation (DMR), 7/1/15 – 6/30/19

"Collaborative Research: Directing Charge and Energy Flow in Discrete Nanocrystal-Dendrimer Hybrids and in Their

Assemblies", National Science Foundation (CHEM), 7/1/17 – 6/30/20

"Collaborative Research: SusCHEM: Environmental Sustainability of Lead Perovskite Solar Cells", National Science Foundation (CBET), 7/1/17– 6/30/20

JOURNAL PUBLICATIONS (PEER REVIEWED)

S. Li, M.A. Lloyd, H. Hempel, C.J. Hages, J. Marquez, T. Unold, R. Eichberger, B.E. McCandless and J.B. Baxter, "Relating Carrier Dynamics and Photovoltaic Device Performance of Single Crystalline CZTSe," *Phys. Rev. Appl.*, **11**, 034005 (2019).

DOI: 10.1103/PhysRevApplied.11.034005

P. Billen, E. Leccisi, S. Dastidar, S. Li, L. Lobaton, S. Spatari, A.T. Fafarman, V.M. Fthenakis and J.B. Baxter, "Comparative Evaluation of Lead Emissions and Toxicity Potential in the Life Cycle of Lead Halide Perovskite Photovoltaics " *Energy*, **166C**, 1089 (2019).

DOI: 10.1016/j.energy.2018.10.141

Kenneth K. S. Lau

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Kenneth K. S. Lau received a B.Eng. (Chemical) from the National University of Singapore in 1995 and a PhD in Chemical Engineering from MIT in 2000. After postdoctoral work at MIT, he joined the Department of Chemical and Biological Engineering at Drexel University as an Assistant Professor in 2006. Lau was tenured and promoted to Associate Professor in 2012 and promoted to Professor in 2018. He is currently the Ph.D. Program Academic Advisor and Associate Head of the department. Lau's research centers on polymer thin films and devices, particularly pursuing novel chemical vapor deposition pathways for polymer synthesis and device fabrication for applications in energy capture, energy storage, latent heat transfer, biomedicine, and fabrics. Lau is the recipient of an NSF CAREER Award and was the lead PI on a $1.125M NSF Major Research Instrumentation Grant. To date, Lau has produced 81 original research products, including 6 book chapters, 1 co-edited book, and 3 patents, and has graduated four PhD and three MS students. Lau is a member of the International Advisory Committee of the International Hot Wire Chemical Vapor Deposition Conference.

EXTERNAL RESEARCH FUNDING

"Engineering of Polymer Electrolytes for Energy Storage", National Science Foundation, 7/1/15 – 6/30/19

"Spatial Control of Condensate and Wetting Regimes using Heterogeneous and Hierarchical Surface Structures for Enhanced Heat Transfer", National Science Foundation, 9/1/15 – 8/31/19

"Hybrid Carbon-Polymer Supercapacitors for High Energy Storage and Power Delivery", National Science Foundation, 9/1/15 – 8/31/19

"Thermoset Design for Additive Manufacturing", U.S. Army Research Laboratory, 7/1/17 – 6/30/20

"Initiated Chemical Vapor Deposition (iCVD) of Polymers for Surface Engineering of Porous Materials", W. L. Gore and Associates, 1/1/19 – 12/31/19

DOI: 10.1016/j.ces.2018.06.053

JOURNAL PUBLICATIONS (PEER REVIEWED)

Chen, Z.; Lau, K.K.S. Suppressing Crystallinity by Nanoconfining Polymers Using Initiated Chemical Vapor Deposition. Macromolecules 2019.

DOI: 10.1021/acs.macromol.9b00496

Xu, G.-L.; Liu, Q.; Lau, K.K.S.; Liu, Y.; Liu, X.; Gao, H.; Zhou, X.; Zhuang, M.; Ren, Y.; Li, J.; Shao, M.; Ouyang, M.; Pan, F.; Chen, Z.; Amine, K.; Chen, G. Building Ultraconformal Protective Layers on Both Secondary and Primary Particles of Layered Lithium Transition Metal Oxide Cathodes. Nature Energy 2019, 4, 484-494.

DOI: 10.1038/s41560-019-0387-1

Li, X.; Rafie, A.; Smolin, Y.Y.; Simotwo, S.; Kalra, V.; Lau, K.K.S. Engineering Conformal Nanoporous Polyaniline via Oxidative Chemical Vapor Deposition and Its Potential Application in Supercapacitors. Chem. Eng. Sci. 2019, 194, 156-164.

Raj Mutharasan

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Raj Mutharasan received his bachelor's degree in Chemical Engineering from the Indian Institute of Technology Madras (India) and a PhD in Chemical Engineering from Drexel University in 1973. After a post-doctoral year at the University of Toronto, he joined Drexel University on the faculty and has been there since 1974. He is the Frank A. Fletcher Professor of Chemical and Biological Engineering. During 2014-2017, he served as the Program Director of NanoBioSensing and managed a new program on Advanced Biomanufacture of Therapeutic Cells at the National Science Foundation. He has served in many administrative capacities at Drexel including as the Interim Dean of College of Engineering (1997-2000). He led Engineering Curriculum Innovation Program — a seven-university coalition on engineering education — at Drexel funded by the National Science Foundation during 1995-2004. He is a Fellow of American Institute of Chemical Engineers (2000), Fellow of American Institute for Medical and Biological Engineering (2006) and Fellow of the American Association of Advancement of Science (2011). He serves on the Editorial Board of Applied Biochemistry and Biotechnology, a Springer journal. His research interests are in biosensors and process biotechnology. He has published extensively in the areas of biosensors, bioreactors and materials processing. He has directed 29 PhD and 47 MS students. At Drexel, Raj directs research on cantilever, fiber optic and magneto-elastic sensors for detecting pathogens, proteins and DNA. His biosensors research was funded by the NSF, USDA, EPA, Pennsylvania Department of Health, and by the Department of Transportation/Department of Homeland Security. Mutharasan's inventions have resulted in several patents — in the area of aluminum processing and biosensors. The biosensor patents have been licensed by two start-up companies.

Giuseppe R. Palmese

Distinguished University Professor of Chemical Engineering
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Giuseppe R. Palmese is the George B. Francis Professor of Engineering and Distinguished University Professor of Chemical Engineering. He is also Professor (by courtesy) of Materials Science and Engineering. Palmese holds a BSE ('86) Princeton University and a PhD ('92) from the University of Delaware, both in Chemical Engineering. He has served as department head of CBE, associate dean for finance and administration, and interim dean of the College of Engineering. Before joining Drexel University in 2000, he was the Assistant Director of University of Delaware's Center for Composite Materials. Dr. Palmese's research focuses on processing-structure-property relationships of thermosetting polymer systems. Current research thrusts include: additive manufacturing, multifunctional systems, nanocomposites, materials from renewable sources and materials for biomedical applications. While at Drexel, Dr. Palmese has obtained grants from agencies including ARO, AFOSR, ARL, NASA, DARPA and USDA. He was the PI and Director of the Army Materials Center of Excellence (MCOE) for polymers. Dr. Palmese has more than 250 publications to his credit and is an inventor on 19 issued US patents. His intellectual property involving materials from renewable sources has been licensed twice. Dr. Palmese's industrial experience includes process engineering for the design, construction and startup of a 100 Kg/h polyolefin pilot plant, participation in numerous successful SBIR and STTR projects and consulting work in the field of polymers. Dr. Palmese has mentored 20 PhD students to graduation; two of them now hold faculty appointments at other universities. He currently maintains a research group comprised of nine PhD students and two post-doctoral fellows, as well as numerous talented undergraduates.

EXTERNAL RESEARCH FUNDING

"SERDP MDA-Free Polyimides", Department of Army, 1/16/15 – 1/15/19

"Materials in Extreme Dynamic Environments (MEDE)Collaborative Research Alliance (CRA)", University of Delaware, 1/1/18 – 12/31/19

"Tailored Universal Feedstock for Forming (TUFF)", University of Delaware - DARPA, 3/1/16 – 12/30/19

"Biobased Thermosetting Polymers for Composite, Adhesive and, Coating Applications", Department of Army, 9/28/16 – 9/28/21

"Thermosets for Agile Manufacturing", PPG – Department of Army, 10/10/17 – 9/30/22

"Advancing Structural Materials for Army Modernization Priorities Via Direct Write Approaches", Rowan University – Department of the Army 5/31/19 – 5/30/24

JOURNAL PUBLICATIONS (PEER REVIEWED)

Henry, C.K., Palmese G.R., Alvarez, N.J.; The evolution of crystalline structures during gel spinning of ultra-high molecular weight polyethylene fibers, *Soft Matter*, **2018**, *14*(44), 8974-8985.

DOI: 10.1039/c8sm01597j

Palmese G.R.; Yadav S.; Hu F.; Toughening of Epoxy Thermosets, **U.S. Patent 10253135**, April 9, 2019.

Palmese G.R.; Hu F.; Geng X., La Scala J.J.; Toughening of Epoxy Thermosets, **Australian Patent 2015334010**, July 11, 2019.

Palmese G.R.; Yadav S.; Hu F.; Toughening of anhydride cured thermosetting epoxy polymers using grafted triglycerides, **Australian Patent 2015315051**, February 21, 2019.

Palmese G.R.; La Scala J.J.; Sadler, J.; Thy Lam, A-P.; Renewable Bio-based (Meth) Acrylated Monomers as Vinyl Ester Cross-linkers, **U.S. Patent 10053529**, August 21, 2018.

Masoud Soroush

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Masoud Soroush received his BS in Chemical Engineering in 1985 from Abadan Institute of Technology, Iran, his MS in Chemical Engineering in 1988, a second MS in Electrical Engineering: Systems in 1991, and a PhD in Chemical Engineering in 1992, all from the University of Michigan, Ann Arbor. After one year of postdoctoral research in systems engineering at Michigan, in 1993 he joined Drexel University where he is now a Professor of Chemical and Biological Engineering. He was a Visiting Scientist at DuPont Marshall Lab, Philadelphia, 2002-03 and a Visiting Professor at Princeton University in 2008. His current research interests are in polymer reaction engineering, polymer membranes, process systems engineering, probabilistic modeling, inference and risk assessment, model-predictive safety systems, and mathematical modeling, analysis and optimization of renewable power generation and storage systems. Masoud is the recipient of an NSF CAREER Award and the O. Hugo Schuck Best Paper Award of the American Automatic Control Council, an elected Fellow of the American Institute of Chemical Engineers, and a senior member of the Institute of Electrical and Electronics Engineers. He has edited or co-edited 5 books, has authored or co-authored more than 190 refereed articles, and has supervised 20 PhD students to date.

EXTERNAL RESEARCH FUNDING

"GOALI: Collaborative Research: On-Demand Continuous-Flow Production of High-Performance Acrylic Resins: from Electronic-Level Modeling to Modular Process Intensification", National Science Foundation, August 2018–July 2021

"GOALI: Collaborative Research: Model-Predictive Safety Systems for Predictive Detection of Operation Hazards", National Science Foundation, September 2017–August 2020

JOURNAL PUBLICATIONS (PEER REVIEWED)

Mozafari, M., S.F. Seyedpour, S. Khoshhal Salestan, A. Rahimpour, A.A. Shamsabadi, M. Dadashi Firouzjaei, M. Rabbani Esfahani, A. Tiraferri, H. Mohsenian, M. Sangermanob, and M. Soroush, "Cu-BTC Surface Modification of Thin Chitosan Film Coated

DOI: 10.1016/j.memsci.2019.117200

Polyethersulfone Membranes with Improved Antifouling Properties for Sustainable Removal of Manganese," *J. of Membrane Science*, Pub Date: **2019-06-19**

DOI: 10.1016/j.memsci.2019.117200

Smolin, Y., K.K.L. Lau, and M. Soroush, "First-Principles Modeling for Optimal Design, Operation and Integration of Power Generation and Storage Systems," *AIChE J.*, **2018**

DOI: 10.1002/aic.16482

Dadashi Firouzjaei, M., A. Arabi Shamsabadi, S. Aghapour Aktij, S. F. Seyedpour, M. Sharifian Gh., A. Rahimpour, M. Rabbani Esfahani, M. Ulbricht, and M. Soroush, "Exploiting Synergetic Effects of Graphene Oxide and a Silver-based Metal-Organic Framework to Enhance Antifouling and Anti-biofouling Properties of Thin Film Nanocomposite Membranes," *ACS Applied Materials and Interfaces*, 10(49), 42967–42978, **(2018)**

DOI: 10.1021/acsami.8b12714

Saberi, S., A. Arabi Shamsabadi, M. Shahrooz, M. Sadeghi, and M. Soroush,"Improving Transport and Antifouling Properties of Poly(Vinyl Chloride) Hollow Fiber Ultrafiltration Membranes by Incorporating Silica Nanoparticles," *ACS mega*, 3 (12), 17439–17446, **(2018)**

DOI: 10.1021/acsomega.8b02211

Shamsabadi, A.A., M. Sharifian Gh., B. Anasori, and M. Soroush, "Antimicrobial Mode-of-Action of Colloidal Ti3C2Tx MXene Nanosheets," *ACS Sustainable Chemistry & Engineering*, 6(12), 1658–16596 **(2018)**

DOI: 10.1021/acssuschemeng.8b03823

Laki, S., A. Arabi Shamsabadi, F. Seidi, and M. Soroush, "Sustainable Recovery of Silver from Deactivated Catalysts Using a Novel Process Combining Leaching and Emulsion Liquid Membrane Techniques," *Ind. & Eng. Chem. Research*, 57(41), 13821–13832, **(2018)**

DOI: 10.1021/acs.iecr.8b02933

Tavasoli, E., M. Sadeghi, H. Riazi, A.A. Shamsabadi, and M. Soroush, "Gas Separation Polysulfone Membranes Modified by Cadmium-based Nanoparticles," *Fibers and Polymers*, 19(10), 2049–2055 **(2018)**

DOI : 10.1007/s12221-018-8424-4

Seyedpour, S.F., A. Rahimpour, A. A. Shamsabadi, and M. Soroush, "Improved Performance and Antifouling Properties of Thin-Film Composite Polyamide Membranes Modified with Nanosized Bactericidal Graphene Quantum Dots for Forward Osmosis," *Chem. Eng. Research and Design*, 139, 321–334, **(2018)**

DOI: 10.1016/j.cherd.2018.09.041

Soroush, M., and K.K. Lau, "Insights into Dye-Sensitized Solar Cells from Macroscopic-Level First-Principles Modeling," in Dye Sensitized Solar Cells: Mathematical Modeling, and Materials Design and Optimization, M. Soroush and K.K. Lau (Eds.), *Elsevier, 1st Edition* **(2018)**

Lau, K.K., and M. Soroush, "Overview of Dye-Sensitized Solar Cells," in Dye Sensitized Solar Cells: Mathematical Modeling, and Materials Design and Optimization, M. Soroush and K.K. Lau (Eds.), *Elsevier, 1st Edition* **(2018)**

Srinivasan, S., A.M. Rappe, and M. Soroush, "Theoretical Insights into Thermal Self-Initiation Reactions of Acrylates," in Computational Quantum Chemistry: Insights into Polymerization Reactions, M. Soroush (Ed.), Elsevier, 1st Edition **(2018)**

Soroush, M. and A.M. Rappe, "Theoretical Insights into Chain Transfer Reactions of Acrylates," in Computational Quantum Chemistry: Insights into Polymerization Reactions, M. Soroush (Ed.), *Elsevier, 1st Edition* **(2018)**

Soroush, M., and M.C. Grady "Polymers, Polymerization Reactions, and Computational Quantum Chemistry," in Computational Quantum Chemistry: Insights into Polymerization Reactions, M. Soroush (Ed.), *Elsevier, 1st Edition* **(2018)**

Arabi Shamsabadi, A., H. Riazi, and M. Soroush, "Mixed-Matrix Membranes for CO2 Separation: Preparation, and Properties," in Carbon Dioxide Separation/Capture by Using Membranes, Basile and E.P. Favvas (Eds.), *Elsevier, 1st Edition*, Published on July 20 **(2018)**

Steven P. Wrenn

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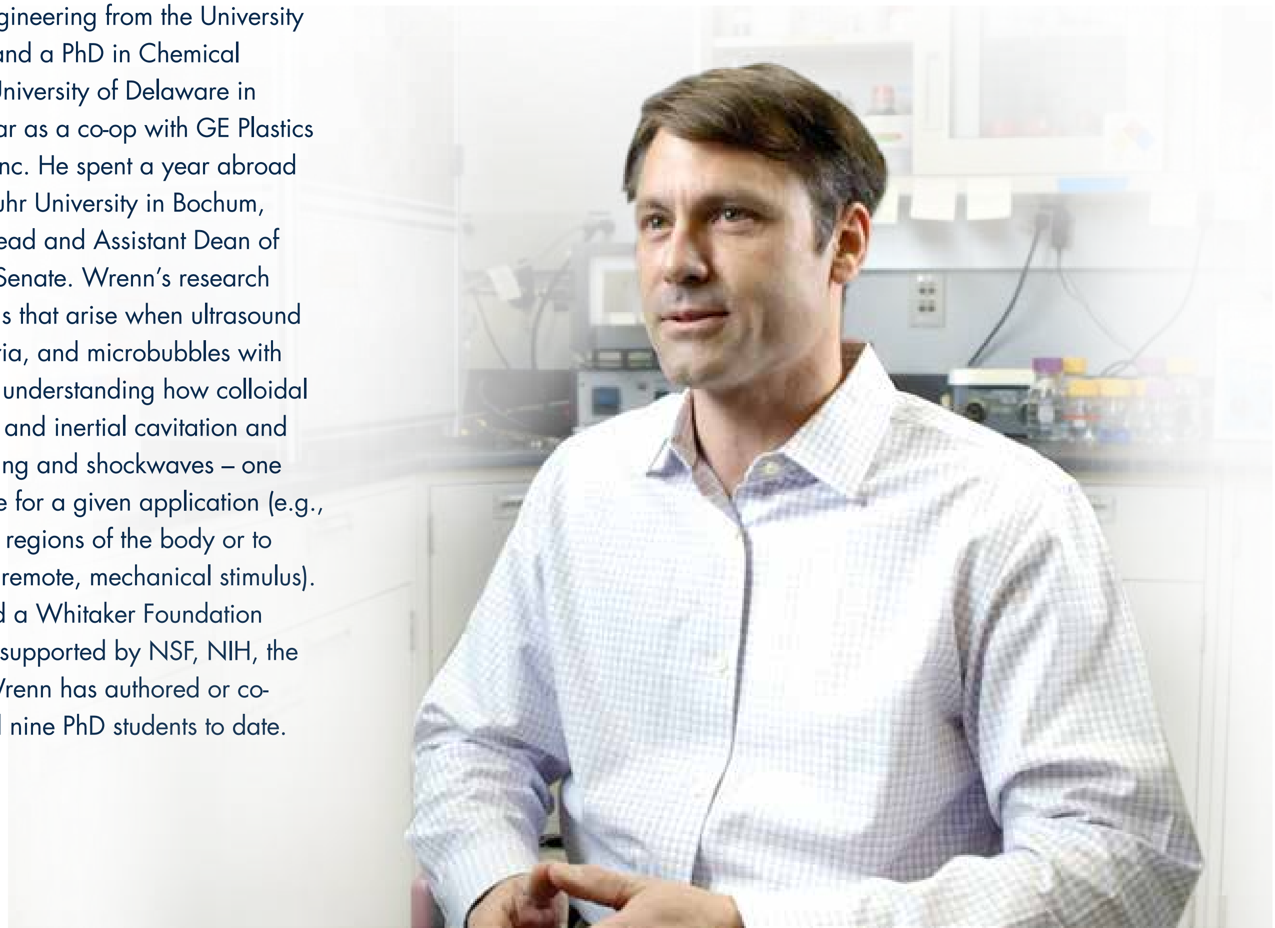
Steven P. Wrenn earned a BS in Chemical Engineering with honors from Virginia Tech in 1991, an MS in Chemical Engineering from the University of Delaware in 1996 and a PhD in Chemical Engineering from the University of Delaware in 1999. Wrenn's industrial experience includes one year as a co-op with GE Plastics and three years as a Process Engineer with Zeneca, Inc. He spent a year abroad as an Alexander von Humboldt Research Fellow at Ruhr University in Bochum, Germany. He has served as Associate Department Head and Assistant Dean of Graduate Affairs and currently serves on the Faculty Senate. Wrenn's research interests involve fundamental studies of the interactions that arise when ultrasound acts on complex fluids, biological membranes, bacteria, and microbubbles with an eye toward clinical applications. For example, by understanding how colloidal systems influence acoustic phenomena such as stable and inertial cavitation and the associated effects arising therefrom - microstreaming and shockwaves – one can tailor colloidal phase behavior and microstructure for a given application (e.g., to achieve enhanced ultrasound contrast in particular regions of the body or to achieve localized drug release using ultrasound as a remote, mechanical stimulus). Wrenn is the recipient of an NSF CAREER Award and a Whitaker Foundation Biomedical Research Grant. Wrenn's work has been supported by NSF, NIH, the USDA, and the Coulter Foundation, among others. Wrenn has authored or co-authored over 50 original articles and has graduated nine PhD students to date.

EXTERNAL RESEARCH FUNDING

"Collaborative Research: Acoustic Micro-Streaming in the Aqueous Core of Bubble-Containing Liposomes for Controlled Release Via Shear-induced Bilayer Reorganization", National Science Foundation, 7/01/16 – 6/30/20

"Physiologically-Activated Intravenous Ultrasound Contrast Agent", Coulter-Drexel Translational Research Partnership, Collaborative Translational Research Grant, 7/1/16 – 9/30/20

"GAANN: Engineering for Pharmaceutical Problems", United States Department of Education, 10/1/18 – 9/30/21



ASSOCIATE PROFFESORS

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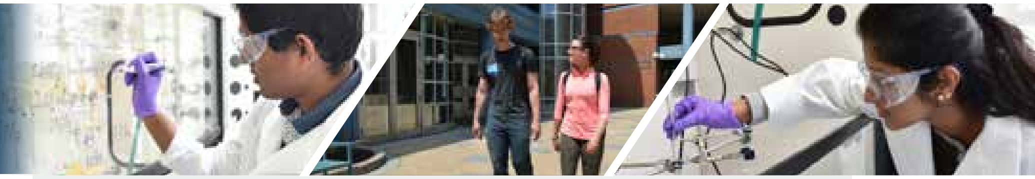
Richard Cairncross earned a BS in Chemical Engineering from the University of Rochester in 1989 and a PhD in Chemical Engineering from the University of Minnesota in 1994. He spent one year as a postdoctoral associate at Sandia National Laboratories and two years as a visiting professor at the University of Delaware before joining Drexel University in 1997. Professor Cairncross' research group works on topics related to sustainability and renewable energy with recent projects focused on developing processes to produce biofuels from waste materials and assessing the techno-economic and environmental impacts of waste-to-fuel processes. Cairncross is a recipient of a PECASE Award, a Fulbright Lectureship (on renewable energy in El Salvador), an EPA P3 (People, Prosperity and the Planet) Award, the LE Scriven Young Investigator Award from the International Coating Science and Technology Society, and the Carl Dahlquist Best Paper Award from the Pressure Sensitive Tape Council. Cairncross has authored or co-authored over 50 original research articles and graduated nine PhD students. Cairncross has been very active in Engineers Without Borders and sustainable development projects in El Salvador. Cairncross is also a partner in Environmental Fuel Research, LLC, a small business that was formed to explore commercialization of waste grease to biodiesel processes based on his research at Drexel.



Aaron Fafarman

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Aaron Fafarman earned a BS in Chemistry from the University of California, Berkeley in 2000 and a PhD in Physical Chemistry from Stanford University in 2010. After a postdoc in Electrical Engineering at the University of Pennsylvania, he joined the Department of Chemical and Biological Engineering at Drexel as an Assistant Professor in 2013. His lab seeks to develop new wet-chemical techniques for the fabrication of energy-conversion materials and to deepen our understanding of the coupling between synthesis, nanoscale structure and function. Of particular interest are the effects of nanostructure and compositional heterogeneity on the density of electronic defects in semiconducting materials and the discovery of novel, defect-tolerant materials. Dr. Fafarman has been recognized with an Outstanding Faculty award from the Delaware Valley Section of AIChE, an Outstanding Early-Career Research Achievement Award from Drexel's College of Engineering, an Outstanding STAR Mentor award from Drexel University and the Linus Pauling Chemistry Teaching award from Stanford University. He is currently the chair of the Electronic and Photonic Materials program of AIChE, co-Chair of the Department Safety Committee and is the faculty advisor for the Drexel AIChE Student Chapter. He has authored or co-authored 33 peer-reviewed papers and has five patents issued.

EXTERNAL RESEARCH FUNDING

"Low-Voltage, Low-Waste Fabrication of Inorganic Semiconducting Thin Films by Electrophoretic Deposition Under Flow", National Science Foundation, 9/1/15 – 8/31/19

"Nanocrystal Precursors to Doped Cesium Metal Halide Perovskite Photovoltaics", National Science Foundation, 6/15/16 – 5/31/19

JOURNAL PUBLICATIONS (PEER REVIEWED)

Dillon, A. D.; Mengel, S.; Fafarman, A. T. Influence of Compact, Inorganic Surface Ligands on the Electrophoretic Deposition of Semiconductor Nanocrystals at Low Voltage. *Langmuir* **2018**, *34*(33), 9598–9605.

DOI: 10.1021/acs.langmuir.8b00787

Dastidar, S.; Li, S.; Smolin, S.; Baxter, J. B.; Fafarman, A. T. Slow Electron–Hole Recombination in Lead Iodide Perovskites Does Not Require a Molecular Dipole. *ACS Energy Lett.* **2017**, *2*(10), 2239–2244

DOI: 10.1021/acsenergylett.7b00606

Vibha Kalra

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Vibha Kalra received her Bachelor of Science in Chemical Engineering from the Indian Institute of Technology, Delhi, India in 2004. She earned her PhD in Chemical Engineering from Cornell University in 2009. Prior to joining Drexel in the Fall of 2010, she worked at Intel Corporation in the electronic packaging research division. Kalra has been an Associate Editor of Chemical Engineering Science since Sept. 2013. Kalra's research interests involve the design of new nanoscale materials for efficient energy storage devices such as batteries and supercapacitors. Her work includes material synthesis, fabrication, characterization, device assembly and testing, and in-situ spectroscopy to understand the physical and chemical phenomena that govern energy storage. She is a recipient of several awards including the NSF CAREER award (2012), ONR summer faculty fellowship award (2013), AICHE DVS Outstanding Faculty of the Year Award (2015), and Outstanding Research Award, COE, Drexel University (2015).

EXTERNAL RESEARCH FUNDING

"Binder- and Current Collector-free Cathodes for Lithium-sulfur Batteries in Commercially-viable Carbonate Electrolyte", National Science Foundation, 8/1/19 –7/31/21

"EAGER/GOALI: 3D Printing of Nanostructured Battery Electrodes", National Science Foundation, 10/1/19-09/30/2020

"Hybrid Supercapacitators Based on Electroactive Polymer Shrink-Wrapped Mesoporous Carbon Nanofibers", National Science Foundation, 9/1/15 – 8/31/20

"Confined Self Assembly of Conjugated Rod-Rod Diblock Copolymers in Nanofibers: Experiments and Simulations", National Science Foundation, 1/1/16 – 12/31/19

"Effects of electrode microstructure and Li2O2 growth on Li-air battery performance", National Science Foundation, 7/1/18 – 6/30/21

JOURNAL PUBLICATIONS (PEER REVIEWED)

Singh, A.; Kalra, V. Electrospun nanostructures for conversion type cathode (S, Se) based lithium and sodium batteries. Journal of Materials Chemistry A, 2019, 7, 11613-11650 (Invited Review).

DOI: 10.1039/c9ta00327d

Li,X.; Rafie, A.; Yuriy, S.; Simotwo, S.; Kalra, V.; Lau, KKS. Engineering Conformal Nanoporous Polyaniline via Oxidative Chemical Vapor Deposition and its Potential Application in Supercapacitors. *Chem. Eng. Sci.* **2019**, *194*, 156-164 (Invited Special Issue Article).

DOI: 10.1016/j.ces.2018.06.053

Dillard, C.; Chung, S-H.; Singh, A.; Manthiram, A.; Kalra, V. Binder-Free, Freestanding Cathodes Fabricated with an Ultra-Rapid Diffusion of Sulfur into Carbon Nanofiber Mat for Lithium Sulfur Batteries. *Materials Today Energy* **2018**, *9*, 336-344.

DOI: 10.1016/j.mtener.2018.06.004

Singh, A.; Kalra, V. TiO Phase Stabilized into Freestanding Nanofibers as Strong Polysulfide Immobilizer in Li–S Batteries: Evidence for Lewis Acid–Base Interactions. *ACS Applied Materials and Interfaces*, **2018**, *10*, 37937-37947.

DOI: 10.1021/acsami.8b11029

Dillard, C.; Singh, A.; Kalra, V. Polysulfide Speciation and Electrolyte Interactions in Lithium–Sulfur Batteries with in Situ Infrared Spectroelectrochemistry. *J. Phys. Chem. C* **2018**, *122*, 18195-18203.

DOI: 10.1021/acs.jpcc.8b02506

ASSISTANT PROFFESORS

Nicolas J. Alvarez

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Nicolas J. Alvarez earned a BS in Chemical Engineering from the University of Florida in 2006 and a PhD in Chemical Engineering from Carnegie Mellon University in 2011. After three years of postdoctoral work at the Technical University of Denmark in Lyngby, he joined the Department of Chemical and Biological Engineering at Drexel as an Assistant Professor in 2014. Alvarez's research interests involve development of unique experimental tools to understand and characterize the behavior of polymers and surfactants in nonlinear flows, at interfaces, and in bulk. These tools are used to understand how certain processing windows lead to advantageous material properties. One such tool, used for the characterization of extensional rheology, has been commercialized by Alvarez and colleagues. Alvarez is developing a consortium of companies interested in the development of analytical tools to better understand the relationship between chemical structure, processing, and material performance. Alvarez teaches an elective course on non-Newtonian fluid mechanics that introduces students to real-world materials encountered in modern day chemical plants.

EXTERNAL RESEARCH FUNDING

"Reinforcements for Additive Manufacturing of Thermoset Resins", ARL, 07/01/19 – 06/30/22

"Formulation, Coating, and Drying of Inks for Scalable Manufacturing of Pervoskite Photovoltaics", NSF, 07/01/19 – 06/30/22

"Exxon Rheological Behavior and Spinnability of Pitch Carbon Fiber Precursors", Exxon, 08/01/19 – 07/31/20

"NIH: An Improved Method of Delivering a Sclerosing Agent", NIH, 09/01/19 – 02/29/24

"REU: CAREER: Influence of Pressure on Surfactant Thermodynamics", NSF, 03/01/19 – 02/29/24

"Correlating Shear and Drying Physics to Carbon Microstructures and Electrochemical Performance in Composite Electrodes", NSF, 08/01/19 – 04/30/19

"Applicability of Extensional Rheology to DuPont Materials", DuPont, 05/01/18 – 04/30/19

"Rheological Behavior and Processing of Pitch Carbon Fiber Precursor", Exxon, 09/01/17 – 08/31/18

"An Improved Method of Delivering a Sclerosing Agent", NIH, 09/01/17 – 08/31/18

"Thermoset Design for Additive Manufacturing", ARL, 07/01/17 – 06/30/22

"Identifying the Rules Governing Tripeptide Gelation in Aqueous Solution", NSF, 07/01/17 – 06/30/20

"CAREER: Surfactant Thermodynamics at High Pressure Fluid-Fluid Interfaces", NSF, 01/01/18 – 12/31/22

JOURNAL PUBLICATIONS (PEER REVIEWED)

DiGuiseppi, D.; Thursch, L.; Alvarez, N.J.; Schweitzer-Stenner, R. Exploring the Thermal Reversibility and Tunability of a Low Molecular Weight Gelator Using Vibrational and Electronic Spectroscopy and Rheology. *Soft Matter.* **2019**, *15*, 3418–3431
DOI: 10.1039/C9SM00104B

Beck, T.N.; Deneka, A.Y.; Chai, L; Kanach, C.; Johal, P.; Alvarez, N.J.; Boumber, Y.; Golemis, E.A.; Laub, G.W. An Improved Method of Delivering a Sclerosing Agent for the Treatment of Malignant Pleural Effusion. *BMC Cancer.* **2019**, *614*
DOI: 10.1186/s12885-019-5777-z

Carey, M.; Hinton, Z.R.; Sokol, M.; Alvarez, N.J.; Barsoum, M.W. Nylon-6/Ti3C2Tz MXene Nanocomposites Synthesized by in Situ Ring Opening Polymerization of -Caprolactam and Their Water Transport Properties. ACS Appl. Mater. *Interfaces.* **2019**, *11*, 22, 20425–20436
DOI: 10.1021/acsami.9b05027

Hinton, Z.R.; Alvarez, N.J. The Trade-off between Processability and Performance in Commercial Ionomers. *Rheologica Acta.* **2019**, *58*, 8, 499–511
DOI: 10.1007/s00397-019-01159-7

Hinton, Z.R.; Shabbir, A.; Alvarez, N.J. Dynamics of Supramolecular Self-Healing Recovery in Extension. *Macromolecules.* **2019**, *52*, 6, 2231–2242
DOI: 10.1021/acs.macromol.8b02423

DiGuiseppi, D.; Thursch, L.; Alvarez, N.J.; Schweitzer-Stenner, R. Tuning and Exploring the Reformation Process of a Cationic Tripeptide Hydrogel. *Biophysical Journal.* **2019**, *116*, 3, 1, 348a
DOI: 10.1016/j.bpj.2018.11.1896

Hesser, M.; DiGuiseppi, D.; Thursch, L.; Alvarez, N.J.; Schweitzer-Stenner, R. Exploring the Unexpected pH Triggered Self-Assembly and Gelation of the GHG Tripeptide in Water. *Biophysical Journal.* **2019**, *116*, 3, 1, 350a
DOI: 10.1016/j.bpj.2018.11.1905

Thursch, L.; Alvarez, N.J.; DiGuiseppi, D.; Schweitzer-Stenner, R. Exploring the Tunability of the Aggregation and Gelation Process of the Tripeptide GAG. *Biophysical Journal.* **2019**, *116*, 3, 1, 349a
DOI: 10.1016/j.bpj.2018.11.1902

Morelly, S.L.; Palmese, L.; Watanabe, H.; Alvarez, N.J. Effect of Finite Extensibility on Nonlinear Extensional Rheology of Polymer Melts. *Macromolecules.* **2019**, *52*, 3, 915–922
DOI: 10.1021/acs.macromol.8b02319

Morelly, S.L.; Gelb, J.; Iacoviello, F.; Shearing, P.R.; Harris, S.J.; Alvarez, N.J.; Tang, M.H. Three-Dimensional Visualization of Conductive Domains in Battery Electrodes with Contrast-Enhancing Nanoparticles. ACS Appl. *Energy Mater.* **2018**, *1*, 9, 4479–4484
DOI: 10.1021/acsaem.8b01184

Wagner, M.H.; Wingstrandt, S.L.; Alvarez, N.J.; Narimissa, E. The Peculiar Elongational Viscosity of Concentrated Solutions of Monodisperse PMMA in Oligomeric MMA. *Rhelogica Acta.* **2018**, *57*, 8–9, 591–601
DOI: 10.1007/s00397-018-1098-4

Joshua D. Snyder

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Joshua D. Snyder earned a BS and MS in Chemical and Biological Engineering from Drexel University in 2006 and a PhD in Chemical and Biomolecular Engineering from Johns Hopkins University in 2012. After two years at Argonne National Lab as a Director's Postdoctoral fellow, he joined the Department of Chemical and Biological Engineering at Drexel University in 2014. Professor Snyder's research interests include the study of interfacial phenomena in nanoscale materials and development of catalysts for next generation renewable energy conversion and storage technologies. Professor Snyder was awarded the 2016 Electrochemical Society Toyota Young Investigator Award and has authored or co-authored more than 20 peer reviewed publications.

EXTERNAL RESEARCH FUNDING

"Bottom-up Design of Earth-Abundant Catalysts for Reversible Hydrogen Oxidation and Reduction in Alkaline", National Science Foundation, 7/1/16 – 6/30/20

"Electrochemical Reformation of Methane to High Purity Hydrogen", American Chemical Society Petroleum Research Fund, 9/1/17 – 8/31/19

"Highly-Accessible Catalysts for Durable High-Power Performance", DOE EERE, 07/01/16 – 03/31/20

"PILBCP-IL Composite Ionomers for High Current Density Performance", DOE EERE, 01/01/19 – 12/31/20

JOURNAL PUBLICATIONS (PEER REVIEWED)

Chatterjee, S., Griego, C., Hart, J., Li, Y., Taheri, M., Keith, J., Snyder, J.; Free Standing Nanoporous Pd Alloys as CO Poisoning Tolerant Electrocatalysts for the Electrochemical Reduction of CO2 to Formate, *ACS Catalysis.* **2019**, *9*, 5290-5301.
DOI: 10.1021/acscatal.9b00330

Intikhab, S., Natu, V., Li, J., Li, Y., Tao, Q., Rosen, J., Barsoum, M., Snyder, J.; Stoichiometry and Surface Structure Dependence of HER Activity and Stability of MoxC MXENEs, *J. Catal.* **2019**, *371*, 325-332.
DOI: 10.1016/j.jcat.2019.01.037

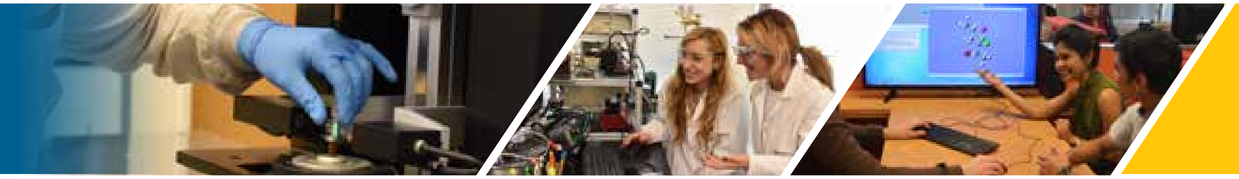
Li, Y.; Polakovic, T.; Curtis, J.; Shumlas, S.; Chatterjee, S.; Intikhab, S.; Chareev, D.; Volkova, O.; Valsiliev, A.; Karapetrov, G.; Snyder, J.; Tuning the Activity/Stability Balance of Anion Doped CoSxSe2-x Dichalcogenides. *J. Catal.* **2018**, *366*, 50-60.
DOI: 10.1016/j.jcat.2018.07.030

Meshkian, R.; Dahlqvist, M.; Lu, J., Wickman; B., Halim, J., Thornberg, J.; Tao, Q.; Li, S.; Intikhab, S.; Snyder, J.; Barsoum, M.; Yildizhang, M.; Palisaitis, J.; Hultman, L.; Persson, P.; Johanna, R.; W-Based Atomic Laminates and Their 2D Derivative W1.33C MXene with Vacancy Ordering. *Adv. Mater.* **2018**, *30*, 1706409.
DOI: 10.1002/adma.201706409

Intikhab, S.; Snyder, J.; Tang, M.H.; Adsorbed Hydroxide does not Participate in the Volmer Step of Alkaline Hydrogen Electrocatalysis. *ACS Catal.* **2017**, *7*, 8314-8319.
DOI: 10.1021/acscatal.7b02787

Li, Y.; Hart, J.; Taheri, M.; Snyder, J. Morphological Instability in Topologically Complex, Three-Dimensional Electrocatalytic Nanostructures. *ACS Catal.* **2017**, *7*, 7995-8005.
DOI: 10.1021/acscatal.7b02398

Kim, Y.; Lopes, P.; Park, S.; Lee, A.; Lim, J.; Lee, H.; Back, S.; Jung, Y.; Danilovic, N.; Stamenkovic, V.; Erlebacher, J.; Snyder, J.; Markovic, N. Balancing Activity, Stability and Conductivity of Nanoporous Core-Shell Iridium/Iridium Oxide Oxygen Evolution Catalysts. Nat. *Commun.* **2017**, *8*, 1449.
DOI: 10.1038/s41467-017-01734-7



Maureen Tang

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Maureen Tang joined the faculty of Chemical and Biological Engineering at Drexel University in fall 2014. She received her BS in Chemical Engineering from Carnegie Mellon University in 2007 and her PhD from the University of California, Berkeley in 2012. While at Berkeley, she received a NSF Graduate Research Fellowship, an NSF East Asia Pacific Summer Fellowship, and the Daniel Cubiciotti Student Award of the Electrochemical Society. Dr. Tang completed postdoctoral work at Stanford University and research internships at Kyoto University, the University of Dortmund, and DuPont. She is the recipient of a 2018 NSF CAREER award, the 2019 College of Engineering Early Career Research Award, and a 2018 Award for Excellence in Peer Review from the ACS PRF. Her research at Drexel develops materials, architectures and fundamental insight for electrochemical energy storage and conversion.

EXTERNAL RESEARCH FUNDING

"Functional Carbon Surfaces for Stable Passivation of sodium-ion Battery Electrodes", National Science Foundation, 7/1/16 – 6/30/20

"Bottom-up Design of Earth-Abundant Catalysts for Reversible Hydrogen Oxidation and Reduction in Alkaline Electrolytes", National Science Foundation, 7/1/16-6/30/20

"CAREER: Predicting Battery Lifetime from Direct Measurements of Inter-Electrode Communication," National Science Foundation, 1/1/2018-12/31/2022

"PILBCP-IL Composite Ionomers for High Current Density Performance", Department of Energy, 9/1/2018-8/31/2020

JOURNAL PUBLICATIONS (PEER REVIEWED)

Sophia E. Lee, Maureen H. Tang. "Electroactive Decomposition Products Cause Erroneous Intercalation Signals in Sodium-Ion Batteries. " *Electrochem. Comm.* 100: 7073, 2019.
DOI: 10.1016/j.elecom.2019.01.024

Cassandra M. Lees, James Lansing, Sophia Lee, Samantha L. Morelly, Maureen H. Tang. "Electrodeposited Ni-Sb-SnO2 electrodes with high selectivity for electrochemical ozone production." *J. Electrochem. Soc.*, 165 (16): E833-E840, 2018.
DOI: 10.1149/2.0051816jes

Luis Rebollar, Saad Intikhab, Joshua Snyder, Maureen H. Tang. "Determining the viabilityof hydroxide-mediated bifunctional HER/HOR mechanisms through single-crystal voltammetry and microkinetic modeling." *J. Electrochem. Soc.* 165 (15): J3209-J3221, 2018.
DOI: 10.1149/2.0271815jes

Samantha L. Morelly, Jeff Gelb, Francesco Iacoviello, Stephen J. Harris, Paul Shearing, Nicolas Alvarez, Maureen H. Tang. "Three-dimensional visualization of conductive domains in battery electrodes with contrast-enhancing nanoparticles." *ACS. App. Energy Mat.* 1 (9):4479-4484, 2018.
DOI:10.1021/acsaem.8b01184

Oliver Harris, Maureen H. Tang. "Molecular probes reveal chemical selectivity of passivation by the Solid-Electrolyte-Interphase." *J. Phys. Chem. C.* 122: 2063220641, 2018
DOI: 10.1021/ACS.JPCC.8B06564

TEACHING PROFFESORS

John Speidel

John Speidel earned his BS degree in Chemical Engineering from the University of Delaware and his MS degree in Chemical Engineering from Illinois Institute of Technology. John's career path began in the local Philadelphia refinery of Atlantic Richfield. From there, he moved to the Harvey Technical Center near Chicago, IL where he was involved in the design of hydrodesulfurization, isomerization, and catalytic reforming units. From there, he moved to ARCO Chemical (then a division of Atlantic Richfield) in Pa. At ARCO Chemical, John was involved with designing plants for Olefins manufacturing, Propylene Oxide Production, Butanediol, and a number of the associated derivatives and polymers. Through acquisitions, the company name changed to Lyondell then Lyondell Basell. John held job titles such as Process Engineer, Technical Services Engineer, Senior Process Design Engineer, Process Manager for Asia, and Process Design Manager. During his career, John produced six patents and was the owner of the company's "Relief System Manual". John joined the Department of Chemical and Biological Engineering in 2011 as a Teaching Professor. He teaches Seniors; Process Design I, II and III and Chemical Process Safety and Juniors; Integrated Case Studies.

Michael J. Walters

Michael J. Walters earned a BS in Chemical Engineering from Bucknell University in 2000. He earned his MS in Chemical Engineering from Northeastern University in 2005 and a PhD in Chemical Engineering from Drexel University in 2010. Additionally, Michael received postdoctoral training in biochemistry and pathology at the University of Pennsylvania. He also worked in the pharmaceutical industry at Merck in a management rotational program and as a vaccine-manufacturing supervisor. Michael's research experience includes liposome colloid science, atherosclerosis pathophysiology, protein purification, and lipid-protein interactions. In 2016, he joined the Department of Chemical and Biological Engineering at Drexel as an Assistant Teaching Professor, where he focuses on the undergraduate fluid mechanics, heat transfer, and mass transfer laboratory courses and has also taught Process Energy Balances and Freshman Design. In 2017 Michael received the Drexel Chemical and Biological Engineering Outstanding Teaching Award.

RESEARCH SPOTLIGHT

Dr. Fafarman Receives NSF-CAREER Award

Professor Aaron Fafarman received a five-year National Science Foundation Faculty Early Career Development grant (NSF-CAREER), supported by the Solid State and Materials Chemistry program in the Division of Materials Research, for his research that will fundamentally expand the palette of materials available for solar cells and other applications by rendering metastable structures stable. Metastable structures exist only temporarily before reverting to their "preferred" stable structure. In spite of this drawback there exist a vast number of metastable materials with otherwise ideal properties for a variety of technological applications. For example, among the diverse class of materials known as metal halide perovskites there exist metastable variants that combine ideal properties for efficient solar cells (over 23% efficient solar-to-electricity energy conversion) with extremely low-cost, scalable synthesis. This project will provide critical new avenues to exploiting these ideal characteristics in structures that have been newly rendered stable by the techniques proposed herein.

In this work, the hypothesis will be tested that when a piece of metastable material is made very small--one ten-thousandths of the thickness of a human hair--it will be possible to selectively enhance its stability. The tremendous social dividends of the low-cost solar cells that could result from this work include reduced anthropogenic emission of green-house gases, increased domestic energy security, a sustainable energy economy and growth of jobs in the development and manufacture of an important high-tech commodity. Undergraduate and graduate students will receive interdisciplinary training in chemistry, solid-state physics and electrical engineering tools and concepts, emerging with skills for a twenty first century manufacturing economy. As part of this work, local, public junior high students will get hands-on experience synthesizing solar energy conversion materials in a format designed to bolster their creation of a positive identity as practitioners of STEM.

A Stabilizing Influence Enables Lithium-Sulfur Battery Evolution

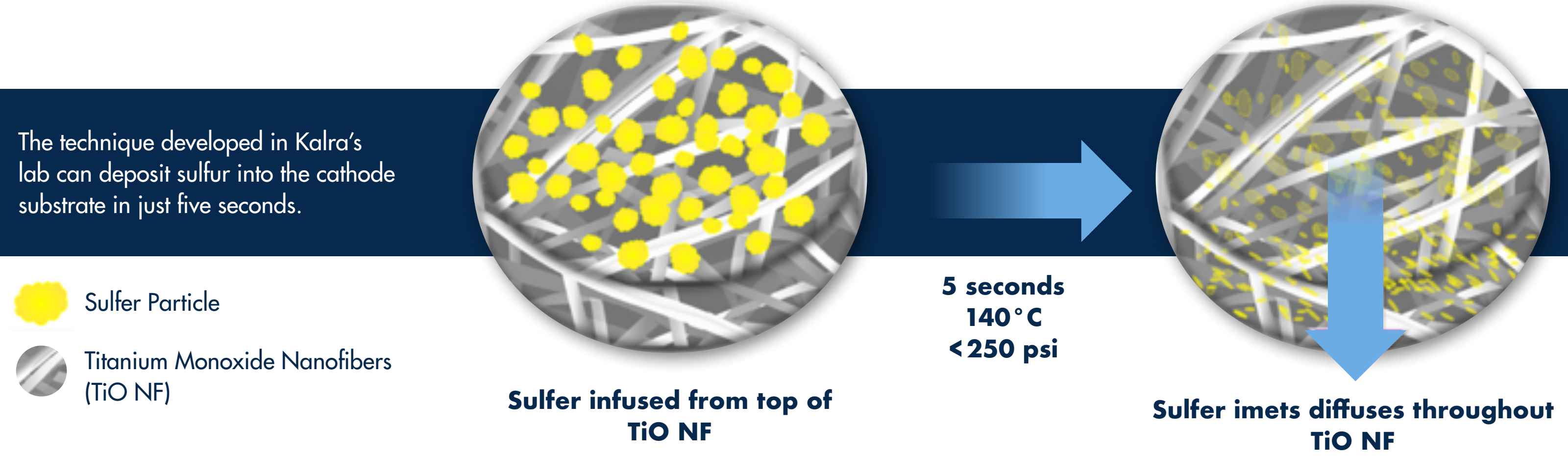
In late July of 2008 a British solar plane set an unofficial flight-endurance record by remaining aloft for more than three days straight. Lithium-sulfur batteries emerged as one of the great technological advances that enabled the flight —powering the plane overnight with efficiency unmatched by the top batteries of the day. Ten years later, the world is still awaiting the commercial arrival of "Li-S" batteries. But a breakthrough by researchers at Drexel University has just removed a significant barrier that has been blocking their viability.

Technology companies have known for some time that the evolution of their products, whether they're laptops, cell phones or electric cars, depends on the steady improvement of batteries. Technology is only "mobile" for as long as the battery allows it to be, and lithium-ion batteries — considered the best on the market — are reaching their limit for improvement.

With battery performance approaching a plateau, companies are trying to squeeze every last volt into, and out of, the storage devices by reducing the size of some of the internal components that do not contribute to energy storage. Some unfortunate side-effects of these structural changes are the malfunctions and meltdowns that occurred in a number of Samsung tablets in 2016.

Researchers and the technology industry are looking at Li-S batteries to eventually replace Li-ion because this new chemistry theoretically allows more energy to be packed into a single battery — a measure called "energy density" in battery research and development. This improved capacity, on the order of 5-10 times that of Li-ion batteries, equates to a longer run time for batteries between charges.

The technique developed in Kalra's lab can deposit sulfur into the cathode substrate in just five seconds.



The problem is, Li-S batteries haven't been able to maintain their superior capacity after the first few recharges. It turns out that the sulfur, which is the key ingredient for improved energy density, migrates away from the electrode in the form of intermediate products called polysulfides, leading to loss of this key ingredient and performance fade during recharges.

For years scientists have been trying to stabilize the reaction inside Li-S battery to physically contain these polysulfides, but most attempts have created other complications, such as adding weight or expensive materials to the battery or adding several complicated processing steps.

But a new approach, reported by researchers in Drexel's College of Engineering in a recent edition of the American Chemical Society journal *Applied Materials and Interfaces*, shows that it can hold polysulfides in place, maintaining the battery's impressive stamina, while reducing the overall weight and the time required to produce them.

"We have created freestanding porous titanium monoxide nanofiber mat as a cathode host material in lithium-sulfur batteries," said Vibha Kalra, PhD, an associate professor in the College of Engineering who led the research. "This is a significant development because we have found that our titanium monoxide-sulfur cathode is both highly conductive and able to bind polysulfides via strong chemical interactions, which means it can augment the battery's specific capacity while preserving its impressive performance through hundreds of cycles. We can also demonstrate the complete elimination of binders and current collector on the cathode side that account for 30-50 percent of the electrode weight — and our method takes just seconds to create the sulfur cathode, when the current standard can take nearly half a day."

Their findings suggest that the nanofiber mat, which at the microscopic level resembles a bird's nest, is an excellent platform for the sulfur cathode because it attracts and traps the polysulfides that arise when the battery is being used. Keeping the polysulfides in the cathode structure prevents "shuttling," a performance-sapping phenomenon that occurs when they dissolve in the electrolyte solution that separates cathode from anode in a battery. This cathode design can not only help Li-S battery maintain its energy density, but also do it without additional materials that increase weight and cost of production, according to Kalra.

To achieve these dual goals, the group has closely studied the reaction mechanisms and formation of polysulfides to better understand how an electrode host material could help contain them.

"This research shows that the presence of a strong Lewis acid-base interaction between the titanium monoxide and sulfur in the cathode prevents polysulfides from making their way into the electrolyte, which is the primary cause of the battery's diminished performance," said Arvinder Singh, PhD, a postdoctoral researcher in Kalra's lab who was an author of the paper.

This means their cathode design can help a Li-S battery maintain its energy density — and do it without additional materials that increase weight and cost of production, according to Kalra.

Kalra's previous work with nanofiber electrodes has shown that they provide a variety of advantages over current battery components. They have a greater surface area than current electrodes, which means they can accommodate expansion during charging, which can boost the storage capacity of the battery. By filling them with an electrolyte gel, they can eliminate flammable components from devices minimizing their susceptibility to leaks, fires and explosions. They are created through an electrospinning process, that looks something like making cotton candy, this means they have an advantage over the standard powder-based electrodes which require the use of insulating and performance deteriorating "binder" chemicals in their production.

In tandem with its work to produce binder-free, freestanding cathode platforms to improve the performance of batteries, Kalra's lab developed a rapid sulfur deposition technique that takes just five seconds to get the sulfur into its substrate. The procedure melts sulfur into the nanofiber mats in a slightly pressurized, 140-degree Celsius environment — eliminating the need for time-consuming processing that uses a mix of toxic chemicals, while improving the cathode's ability to hold a charge after long periods of use.

"Our Li-S electrodes provide the right architecture and chemistry to minimize capacity fade during battery cycling, a key impediment in commercialization of Li-S batteries," Kalra said. "Our research shows that these electrodes exhibit a sustained effective capacity that is four-times higher than the current Li-ion batteries. And our novel, low-cost method for sulfurizing the cathode in just seconds removes a significant impediment for manufacturing."

Since Zephyr-6's record-setting flight in 2008, many companies have invested in the development of Li-S batteries in hopes of increasing the range of electric cars, making mobile devices last longer between charges, and even helping the energy grid accommodate wind and solar power sources. Kalra's work now provides a path for this battery technology to move past a number of impediments that have slowed its progress.

The group will continue to develop its Li-S cathodes with the goals of further improving cycle life, reducing the formation of polysulfides and decreasing cost.

This research was supported by Drexel Ventures Innovation Fund and National Science Foundation (CBET-1150528). Read the full study here: **https://pubs.acs.org/doi/10.1021/acsami.8b11029**

STUDENT SPOTLIGHT

Michael Cimorelli Named a Fulbright Scholar

Michael Cimorelli, a PhD candidate and a GAANN fellow in the Department of Chemical and Biological Engineering (CBE), has been named a Fulbright Scholar to the Netherlands. The award was announced in February.

The Fulbright Program, which aims to increase mutual understanding between the people of the United States and people of other countries, is the flagship international educational exchange program sponsored by the US government. As a Fulbright recipient and a representative of the United States, Cimorelli will have the opportunity to work collaboratively with international partners in educational, political, cultural, economic, and scientific fields.

Cimorelli will travel to Amsterdam to do research at the University of Amsterdam Academic Medical College. There, he'll be working toward developing a biomarker for kidney cancer from processing and analyzing liquid biopsy utilizing novel experimental techniques.

"While I have been at Drexel, both of my parents were diagnosed with cancer," Cimorelli explained. "Watching them overcome their diseases empowered me to consider how I could apply my skill set in hopes that no child ever has to watch their parents suffer. This is the main reason I picked Dr. Nieuwland and his lab (at the University of Amsterdam), as they are at the forefront of novel approaches for preventing these diseases before they begin."

Earlier this year, Cimorelli was awarded the prestigious IIE Graduate International Research Experiences Scholarships, a three-year grant funded by the National Science Foundation in support of international graduate research for exceptional engineering students.

CBE Undergraduate Kristine Loh Receives Society of Women Engineers Guiding Star Award

The Society of Women Engineers' WE Local Awards program recognizes SWE members, women engineers, advocates and groups who are making a difference in their community and among peers in engineering and technology. Kristine Loh, an undergraduate student in the Chemical and Biological Engineering Department is a proud recipient of the Guiding Star Award.

The Guiding Star Award recognizes exceptional collegiate leaders with at least two (2) years of SWE membership at the end of the previous fiscal year who have made outstanding contributions to SWE, the engineering community, their campus, and the community. A maximum of fifteen (15) awards will be presented annually. Only SWE Collegiate Members are eligible for this award.

The award also recognizes Loh's continuing dedication to SWE's mission – striving to highlight the impact and importance of women in engineering across the globe, leading by example, and demonstrating that a career in engineering can be a fulfilling, rewarding pursuit for women of any background.

Earlier this year, Loh was chosen for the Future Leaders Research Symposium at NC State University. The Future Leaders Research Symposium is a highly selective research symposium that's organized by the Department of Chemical and Biomolecular Engineering at NC State University. The 1.5 day symposium is a platform for the finest and brightest undergraduate researchers in the U.S. to present their work and be recognized for their achievements and potential as future leaders in chemical and biomolecular engineering.

ENGAGING ALUMNI

Alumni Annual Event

On Saturday, October 6, 2018 the Department of Chemical and Biological Engineering hosted it's sixth Alumni Annual event. The annual event is one of CBE's many initiatives to unite alumni with the department in efforts to create an atmosphere of community among students, faculty, and alumni.

During the reception, Dr. Cameron Abrams gave a State of the Department address highlighting the departments enrollment numbers, faculty and performance (degrees awarded, papers published, and research expenditures). Assistant Professor and alum Prof. Joshua Snyder delivered the keynote lecture on Bridging the Activity-Stability Gap in Fuel Cell Catalysis.

5th Alumni Spring Panel Event

On Saturday, April 27, 2019, the CBE department in cooperation with Drexel's AIChE student group, hosted CBE's fifth Alumni Spring Panel Event, "Chemical Engineering Safety as a Career Differentiator." The panel event proved once again to be in impactful session of sharing first-hand experience garnered through years of work in industry. Students were given an inside perspective on the importance of safety and the impact it will have on their future careers. Discussion focused on the significance of process and product safety, the evolution of safety culture and opportunities for newly graduating engineers.

This year's moderator was Dr. Patricia McHugh Giordano, Executive Director, Clinical Safety and Risk Management, Medical Lead for Manufacturing at Merck. Panelists included Cait Mullan '13 Ashland, Tim Cunningham 99' PES, Dave Hagan 02' KBR, Matt Snyder 96' CRB, Rich Santo 86' Acu Tech and Chuck Barksdale 80' PES.

Chemical & Biological Engineering

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