DREXEL UNIVERSITY
Chemical and Biological Engineering
College of Engineering

DEPARTMENT OF

Chemical & Biological Engineering



ANNUAL REPORT

JULY 1, 2016 – JUNE 30, 2017

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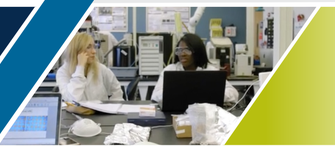


Welcome to the FY2017 Annual Report of the Department of Chemical and Biological Engineering at Drexel. In these pages, you can learn more about our department through metrics and faculty profiles, and get a glimpse of the varied and exciting activities undertaken by members of our community. It has certainly been a memorable year, especially for me, since I took over as Department Head only in January when Giuseppe Palmese was asked to be Interim Dean of the College of Engineering after nearly 12 years as Head. With this change, I and the rest of the faculty and staff have rededicated ourselves to the mission of pursuing excellence in instruction and research. I am particularly proud of the major revision to our undergraduate curriculum that continues its multiyear roll-out this year and features enhanced computation in all courses and new laboratory experiences. And our faculty continue to rack up impressive numbers of grants and publications, training the next generation of research leaders in our discipline. But Drexel moves quickly, so this report offers only a momentary pause for reflection before turning to face the upcoming year with even higher expectations than the last. I hope you find this report enlightening and look forward to the next!

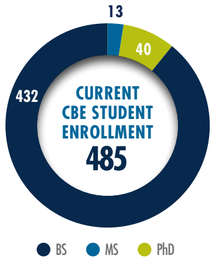
Sincerely,

Cameron F. Abrams
Professor and Department Head
PhD, University of California, Berkeley

FACTS & FIGURES

The Department of Chemical and Biological Engineering (CBE) at Drexel University consists of 14 tenured and tenure-track faculty members. CBE consists of 2 teaching faculty, 40 PhD students, 13 MS students, and 432 undergraduate students. The department is currently engaged in externally funded research with over $4.4 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, ARO, AFOSR, ONR, DOE, USDA, EPA, and NASA. Recently, CBE was awarded a three-year $4 million Center for Sustainable Corrosion Protection grant by the Army Research Laboratory. Additionally, CBE was also awarded a $2.4 million cooperative agreement with Army Research Laboratory entitled "Bio-based Thermosets with Superior Performance Characteristics." Members of the CBE faculty have received multiple young investigator awards, including 7 CAREER Awards and 1 PECASE award.



ENROLLMENT STATISTICS

	UNDERGRADUATE	GRADUATE MS	GRADUATE PhD
DREXEL UNIVERSITY	15,479	5,387	1,019
COLLEGE OF ENGINEERING	3,425	461	294
CHEMICAL ENGINEERING	432	13	40

NEW ENROLLMENT DIVERSITY STATISTICS

	UNDERGRADUATE	GRADUATE MS	GRADUATE PhD
UNDERREPRESENTED MINORITY	11%	0%	0%
OTHER	79%	0%	53%
INTERNATIONAL	10%	100%	46%
WOMEN	39%	40%	46%
MEN	61%	60%	54%

CURRENT ENROLLMENT DIVERSITY STATISTICS

	UNDERGRADUATE	GRADUATE MS	GRADUATE PhD
UNDERREPRESENTED MINORITY	10%	0%	5%
OTHER	76%	14%	55%
INTERNATIONAL	14%	86%	40%
WOMEN	35%	50%	30%
MEN	65%	50%	70%

RESEARCH IMPACT

EXPENDITURES: **$4.4 MILLION**

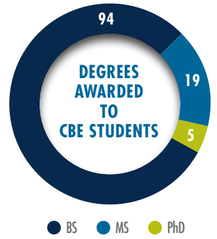
AWARDS: **$3.8 MILLION**

DEGREES AWARDED

	UNDERGRADUATE	GRADUATE MS	GRADUATE PhD
COLLEGE OF ENGINEERING	778	316	52
CHEMICAL ENGINEERING	94	19	5

DEGREES AWARDED TO UNDER-REPRESENTED MINORITY STUDENTS

	UNDERGRADUATE	GRADUATE MS	GRADUATE PhD
ETHNIC DIVERSITY	9%	5%	0%
GENDER DIVERSITY	34%	32%	40%



UNDERGRADUATE ENTERING STUDENT SAT SCORES

	MATH	VERBAL	TOTAL
COLLEGE OF ENGINEERING	646	582	1228
CHEMICAL ENGINEERING	661	590	1251

GRADUATE ENTERING STUDENT GRE SCORES

	QUANTITATIVE	VERBAL
COLLEGE OF ENGINEERING	161	151
CHEMICAL ENGINEERING	163	154

Data taken from Fall 2016

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

Cameron F. Abrams

Professor and Department Head
PhD, University of California, Berkeley

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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 ~90 original articles and has graduated eight 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

"Collaborative Research: On-the-Fly Free Energy Parameterization in Molecular Simulations", National Science Foundation, 9/1/12 – 8/31/16

"Collaborative Research: Multiscale Molecular Simulations of Protein-Based Bilayer Fusion", National Science Foundation, 9/15/13 – 8/31/17

"Molecular Modeling of Self-Assembly", Exxon Mobil Research and Engineering Company, 1/1/14 – 12/31/17

"Dual-action virolytic entry inhibitors against HIV-1", NIH R01 GM115249 S1,700,000, Co-PI (Multiple-PI grant; other Co-PI's are Irwin Chaiken, DUCOM, and Amos B. Smith III, UPenn Chemistry). 7/1/15 – 6/30/19

"Structure-based antagonism of HIV-1 envelope function in cell entry", NIH P01 GM056550 S10,000,000, Co-I (PI: Irwin Chaiken, DUCOM) 9/30/13 – 8/31/18 Abrams is the leader of the Computational Core of this program project.

JOURNAL PUBLICATIONS (Peer Reviewed)

Acharya, K.; Rashad, A. A.; Moraca, F.; Klasse, P. J.; Moore, J. P.; Abrams, C.; Chaiken, I. Recognition of HIV-Inactivating Peptide Triazoles by a Recombinant Soluble Trimer, BG505 SOSIP.664. *Proteins: Structure, Function, and Bioinformatics* **2017**, 85 (5), 843–851.
DOI: 10.1002/prot.25238

Srikanth, A.; Vergara, J.; Palmese, G.; Abrams, C. F. The Effect of Alkyl Chain Length on Material Properties of Fatty-Acid-Functionalized Amidoamine-Epoxy Systems. *Eur. Polymer J.* **2017**, 89, 1–12.
DOI: 10.1016/j.eurpolymj.2017.01.037

Yang, J. H.; Srikanth, A.; Jang, C.; Abrams, C. F. Relationships between Molecular Structure and Thermomechanical Properties of Bio-Based Thermosetting Polymers. *J. Polym. Sci. B Pol. Phys.* **2017**, 55 (3), 285–292.
DOI: 10.1002/polb.24270

Paz, S. A.; Vanden-Eijnden, E.; Abrams, C. F. Polymorphism at 129 Dictates Metastable Conformations of the Human Prion Protein N-terminal β-sheet. *Chem. Sci.* **2017**, 8 (2), 1225–1232.
DOI: 10.1039/C6SC03275C

Parajuli, B.; Acharya, K.; Yu, R.; Ngo, B.; Rashad, A. A.; Abrams, C. F.; Chaiken, I. M. Lytic Inactivation of HIV-1 by Dual Engagement of gp120 and gp41 Domains in the Virus Env Trimer. *Biochemistry* **2016**, 55 (44), 6100–6114.
DOI: 10.1021/acs.biochem.6b00570

Moraca, F.; Acharya, K.; Melillo, B.; Smith, A. B.; Chaiken, I.; Abrams, C. F. Computational Evaluation of HIV-1 gp120 Conformations of Soluble Trimeric gp140 Structures as Targets for de novo Docking of First- and Second-Generation Small-Molecule CD4 Mimetics. *J. Chem. Info. Model* **2016**, 56 (10), 2069–2079.
DOI: 10.1021/acs.jcim.6b00393

Yu, T.-Q.; Lu, J.; Abrams, C. F.; Vanden-Eijnden, E. A Multiscale Implementation of Infinite-Swap Replica Exchange Molecular Dynamics. *Proc. Natl. Acad. Sci. USA* **2016**, 113 (42), 11744–11749.
DOI: 10.1073/pnas.1605089113

Jang, C.; Abrams, C. Thermal and Mechanical Properties of Thermosetting Polymers using Coarse-grained Simulation. *Eur. Phys. J. Spec. Top.* **2016**, 225 (8-9), 1775–1783.
DOI: 10.1140/epjst/e2016-60143-0

Gordon, R.; Stober, S. T.; Abrams, C. F. Aggregation of 12-Hydroxystearic Acid and Its Lithium Salt in Hexane: Molecular Dynamics Simulations. *J. Phys. Chem. B.* **2016**, 120 (29), 7164–7173.
DOI: 10.1021/acs.jpcb.6b04193

Gardner, J. M.; Deserno, M.; Abrams, C. F. Effect of Intrinsic Curvature and Edge Tension on the Stability of Binary Mixed-Membrane Three-Junctions. J. *Chem. Phys.* **2016**, 145 (7), 074901.
DOI: 10.1063/1.4960433

Raj Mutharasan

Frank A. Fletcher Professor
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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. Currently he serves as the Program Director of NanoBioSensing 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 is 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.

JOURNAL PUBLICATIONS (Peer Reviewed)

Johnson, Blake N.; Mutharasan, R. Acoustofluidic particle trapping, manipulation, and release using dynamic-mode cantilever sensors. *The Analyst* **2017**, 142 (1), 123-131.
DOI: 10.1039/C6AN01743F

Giuseppe R. Palmese

Professor and Interim Dean
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Giuseppe R. Palmese is interim dean of the College of Engineering after having served 12 years as Head of the Department of Chemical and Biological Engineering at Drexel University. He is a Professor of Chemical and Biological Engineering and a Professor (by courtesy) of Materials Science and Engineering. He holds a BSE ('86) Princeton University and a PhD ('92) from the University of Delaware, both in Chemical 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: 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 200 publications to his credit and is an inventor on 14 issued patents. His intellectual property involving materials from renewable sources has been licensed twice and is being commercialized by Dixie Chemicals. Dr. Palmese's industrial experience includes process engineering for the design, construction and start-up 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 18 PhD students to graduation; two of them now hold faculty appointments at other universities. He currently maintains a research group comprised of six PhD students and two post-doctoral fellows, as well as a selection of talented undergraduates.

EXTERNAL RESEARCH FUNDING

"Center for Sustainable Corrosion Protection", Department of Army, 9/26/13 – 9/25/18

"Materials in Extreme Dynamic Environment (MEDE) Collaborative", University of Delaware, 1/01/17 – 2/31/17

"Materials in Extreme Dynamic Environments (MEDE) Collaborative Research Alliance (CRA)", University of Delaware, 1/1/17 – 12/28/17

"Certain Teed Foams", Certain Teed Corporation", 4/11/17 – 7/10/17

"Tailored Universal Feedstock for Forming (TUFF)", University of Delaware, 3/1/16 – 11/30/17

"Detection and Amplification of DNA", National Science Foundation, 7/1/12 – 6/30/18

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

"Biobased Thermosetting Polymers for Composite, Adhesive and, Coating Applications", Department of Army, 9/28/16 – 9/28/19

JOURNAL PUBLICATIONS (Peer Reviewed)

Srikanth, A.; Vergara, J.; Palmese, G.; Abrams, C. F. The Effect of Alkyl Chain Length on Material Properties of Fatty-Acid-Functionalized Amidoamine-Epoxy Systems. *European Polymer Journal* **2017**, 89, 1–12.
DOI: 10.1016/j.eurpolymj.2017.01.037

Mauck, J. R.; Yadav, S. K.; Sadler, J. M.; La Scala, J. J. L.; Palmese, G. R.; Schmalbach, K. M.; Stanzione, J. F. Preparation and Characterization of Highly Bio-Based Epoxy Amine Thermosets Derived from Lignocellulosics. *Macromolecular Chemistry and Physics* **2017**, 218 (14), 1700013.
DOI: 10.1002/macp.201700013

McAninch, I. M.; La Scala, J. J. L.; Palmese, G. R.; Robinette, E. J. Thin Film Initiation of Cracks for Fracture Toughness Measurements in Epoxy Resins. *Journal of Applied Polymer Science* **2017**, 5, 134(1).
DOI: 10.1002/app.44364

Baroncini, E. A.; Yadav, S. K.; Palmese, G. R.; Stanzione, J. F. Recent Advances in Bio-Based Epoxy Resins and Bio-Based Epoxy Curing Agents. *Journal of Applied Polymer Science* **2016**, 133 (45).
DOI: 10.1002/app.44103

Sukhlaaied, W.; Riyajan, S.-A.; Palmese, G. R. Dynamic Viscosity of Maleate Poly (vinyl alcohol) and its Copolymer Measured by Rheometer. *Polymer Testing* **2016**, 56, 387-393.
DOI: 10.1016/j.polymertesting.2016.10.008

Hong, H.; Harvey, B.; Palmese, G.; Stanzione, J.; Ng, H.; Sakkiah, S.; Tong, W.; Sadler, J. Experimental Data Extraction and in Silico Prediction of the Estrogenic Activity of Renewable Replacements for Bisphenol. *International Journal of Environmental Research and Public Health* **2016**, 13 (7), 705.
DOI: 10.3390/ijerph13070705

Masoud Soroush

Professor
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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, electronic-level modeling of chemical reactions, polymer membranes, process systems engineering, probabilistic modeling and inference, risk assessment, fault detection, 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, and is a Fellow of the American Institute of Chemical Engineers. He has authored or co-authored more than 170 refereed articles and has graduated 13 PhD students to date.

EXTERNAL RESEARCH FUNDING

"Collaborative Research: Optimal Design and Operation of Dye Sensitized Solar Cells Using an Integrated Strategy Involving First-Principles Modeling and Simulation, Synthesis, and Characterization", National Science Foundation, August 2012 – July 2017

"GOALI: Collaborative Research: Acrylic Resins Product and Process Design through Combined Use of Quantum Chemical Calculations and Spectroscopic Methods", National Science Foundation, September 2012 – August 2016

JOURNAL PUBLICATIONS (Peer Reviewed)

Shamsabadi, A. A.; Seidi, F.; Salehi, E.; Nozari, M.; Rahimpour, A.; Soroush, M. Efficient CO2-Removal Using Novel Mixed-Matrix Membranes with Modified TiO2 Nanoparticles. *J. of Materials Chemistry A* **2017**, 5 (8), 4011–4025.
DOI: 10.1039/C6TA09990D

Zirehpour, A.; Rahimpour, A.; Shamsabadi, A. A.; Gh., M. S.; Soroush, M. Mitigation of TFC-Membrane Biofouling via Immobilizing Nano-Sized Biocidal Reservoirs in the Membrane Active Layer. *ACS Environmental Sci. & Technol.* **2017**, 51 (10), 5511–5522.
DOI: 10.1021/acs.est.7b00782

Mokhtari, S.; Rahimpour, A.; Shamsabadi, A. A.; Habibzadeh, S.; Soroush, M. Enhancing Performance and Surface Antifouling Properties of Polysulfone Ultrafiltration Membranes with Salicylate-Alumoxane Nanoparticles. *Applied Surface Sci.* **2017**, 393, 93–102.
DOI: 10.1016/j.apsusc.2016.10.005

Smolin, Y. Y.; Soroush, M.; Lau, K. K. S. Oxidative Chemical Vapor Deposition of Polyaniline Thin Films. *Beilstein J. of Nanotechnology* **2017**, 8, 1266–1276.
DOI: 10.3762/bjnano.8.128

Smolin, Y. Y.; Soroush, M.; Lau, K. K. S. Influence of oCVD Polyaniline Film Chemistry in Carbon-Based Supercapacitors. *Ind. & Eng. Chem. Research* **2017**, 56 (21), 6221–6228.
DOI: 10.1021/acs.iecr.7b00441

Smolin, Y. Y.; Aken, K. L. V.; Boota, M.; Soroush, M.; Gogotsi, Y.; Lau, K. K. S. Engineering Ultrathin Polyaniline in Micro/Mesoporous Carbon Supercapacitor Electrodes using Oxidative Chemical Vapor Deposition. *Advanced Materials Interfaces* **2017**, 4 (8), 1601201.
DOI: 10.1002/admi.201601201

Johnson, N. M.; Smolin, Y. Y.; Hagaman, D.; Soroush, M.; Lau, K. K. S.; Ji, H.-F. Suitability of N-Propanoic Acid Spiropyrans and Spirooxazines for Use as Sensitizing Dyes in Dye-Sensitized Solar Cells. *Phys. Chem. Chem. Phys.* **2017**, 19 (4), 2981–2989.
DOI: 10.1039/C6CP07853B

Smolin, Y. Y.; Janakiraman, S.; Soroush, M.; Lau, K. K. Experimental and Theoretical Investigation of Dye Sensitized Solar Cells Integrated with Crosslinked Poly(vinylpyrrolidone) Polymer Electrolyte Using Initiated Chemical Vapor Deposition. *Thin Solid Film* **2016**, 635, 9-16.
DOI: 10.1016/j.tsf.2016.12.034

Kubo, A. G.; Smolin, Y. Y.; Soroush, M.; Lau, K. K. Synthesis and Integration of Poly(1-Vinylimidazole) Polymer Electrolyte in Dye Sensitized Solar Cells by Initiated Chemical Vapor Deposition. *Chemical Engineering Science* **2016**, 154, 136–142.
DOI: 10.1016/j.ces.2016.05.007

Ahooyi, T. M.; Soroush, M.; Arbogast, J. E.; Seider, W. D.; Oktem, U. G. Model-Predictive Safety System for Proactive Detection of Operation Hazards. *AIChE Journal* **2016**, 62 (6), 2024–2042.
DOI: 10.1002/aic.15152

Moskowitz, I. H.; Seider, W. D.; Arbogast, J. E.; Oktem, U. G.; Pariyani, A.; Soroush, M. Improved Predictions of Alarm and Safety System Performance through Process and Operator Response-Time Modeling. *AIChE Journal* **2016**, 62 (9), 3461–3472.
DOI: 10.1002/aic.15419

Nozari, M.; Jasinski, J. P.; Kaur, M.; Addison, A. W.; Shamsabadi, A. A.; Soroush, M. Crystal structure of 5,7,12,14-tetrahydro-5,14:7,12-bis([1,2] benzeno) pentacene-6,13-dione. *Acta Crystal E.* **2016**, 72 (12), 1734–1738.
DOI: 10.1107/S2056989016017461

Nozari, M.; Kaur, M.; Jasinski, J. P.; Addison, A. W.; Shamsabadi, A. A.; Soroush, M. 5,7,12,14-Tetrahydro-5,14:7,12-bis([1,2]benzeno)pentacene-6,13-diol Dimethylformamide Disolvate. *IUCrData* **2016**, 1 (7).
DOI: 10.1107/s2414314616011305

Steven P. Wrenn

Professor
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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 theranostic 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 50 original articles and has graduated nine PhD students to date.

EXTERNAL RESEARCH FUNDING

"Alginate Distribution and Extraction Characterization for Luminaria Hyperborean Seaweed", FMC Corporation, 3/15/17 – 9/15/17

"Ultrasound Assisted Technologies for Improving Food Quality and Safety", United States Department of Agriculture (via University of Maryland), 1/01/16 – 12/31/17

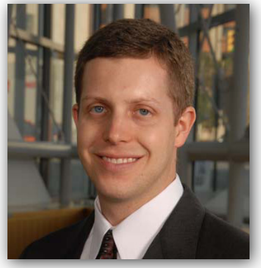
"Collaborative Research: Acoustic Micro-Streaming in the Aqueous Core of Bubble-Containing Liposomes for Controlled Release Via Shear-induced Bilayer Reorganization", National Science Foundation, 7/01/16 – 6/30/19

"Physiologically-Activated Intravenous Ultrasound Contrast Agent", Coulter-Drexel Translational Research Partnership, Collaborative Translational Research Grant, 7/1/16 – 6/30/18

"GAANN: Engineering for Pharmaceutical Applications", United States Department of Education, 9/1/15 – 8/31/18

JOURNAL PUBLICATIONS (Peer Reviewed)

Nguyena, A.T.; Sunnya, Y.; Bawieca, C.; Lewina, P.A.; Wrenn, S.P. Investigating the Spatial Extent of Acoustically Activated Echogenic Liposomes. *Ultrasonics* **2017**, 77, 176–182.
DOI: 10.1016/j.ultras.2017.01.022



Jason B. Baxter

Associate Professor
PhD, University of California, Santa Barbara

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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. His research group focuses on solar energy conversion, including materials chemistry of oxide and chalcogenide thin films and nanostructures, fabrication and characterization of photovoltaic cells and photoelectrochemical cells for solar water splitting, 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 six PhD students to date. Baxter is the Chair of CBE Undergraduate Committee, where he 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 in Semiconductor Nanocrystal Solar Cells," National Science Foundation (CBET), 9/1/13 – 8/31/17

"Collaborative Research: Ultrafast Carrier Dynamics to Link Processing, Structure and Performance in High-Efficiency $Cu_2Zn(S,Se)_4$ Thin Film Photovoltaics," National Science Foundation (DMR), 7/1/15 – 6/30/18

"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

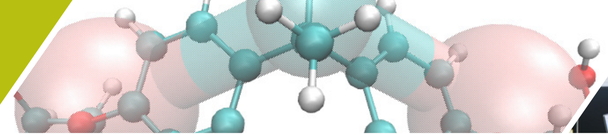
JOURNAL PUBLICATIONS (Peer Reviewed)

Wu, Y.; Li, S.; Gogotsi, N.; Zhao, T.; Fleury, B.; Kagan, C. R.; Baxter, J. B. Directional Carrier Transfer in Strongly Coupled Binary Nanocrystal Superlattice Films Formed by Assembly and *in Situ* Ligand Exchange at a Liquid-Air Interface. *J. Phys. Chem. C* **2017**, 121 (8), 4146–4157
DOI: 10.1021/acs.jpcc.6b12327

Smolin, S. Y.; Choquette, A. K.; Wilks, R. G.; Gauquelin N.; Felix, R.; Gerlach, D.; Ueda, S.; Krick, A. L.; Verbeeck, J.; Bär, M.; Baxter, J.B.; May, S.J. Energy Level Alignment and Cation Charge States at the $LaFeO_3/LaMnO_3$ (001) Heterointerface. *Adv. Mater. Inter.* **2017**, 1700183.
DOI: 10.1002/admi.201700183

Dillon, A. D.; Quoc, L. L.; Goktas, M.; Opasanont, B.; Dastidar; Mengel, S.; Fafarman, A. T.; Baxter, J. B. Thin Films of Copper Indium Selenide Fabricated with High Atom Economy by Electrophoretic Deposition of Nanocrystals under Flow. *Chem. Eng. Sci.* **2016**, 154, 128-135.
DOI: 10.1016/j.ces.2016.06.056

Edley, M.E.; Guglietta, G.W.; Li, S.; Majidi, H.; Baxter, J.B. Ultrafast Charge Carrier Dynamics in Extremely Thin Absorber (ETA) Solar Cells Consisting of CdSe-Coated ZnO Nanowires. *J. Phys. Chem.* **2016**, 120, 19504-19512.
DOI: 10.1021/acs.jpcc.6b03974



Richard A. Cairncross

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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.

EXTERNAL RESEARCH FUNDING

"Extraction of Lipids from Wastewater to Produce Biofuels", Water Environment Research Foundation, 3/1/14 – 8/31/16

JOURNAL PUBLICATIONS (Peer Reviewed)

Hums, M.; Cairncross, R.A.; Spatari, S. Life Cycle Assessment of Biodiesel Produced from Grease Trap Waste. *Environ. Sci. Technol.* **2016**, 50, 2718-2726.
DOI: 10.1021/acs.est.5b02667

Nily Dan

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Nily Dan received her BS in Chemical Engineering from the Technion, Israel Institute of Technology in 1987 and her PhD in Chemical Engineering from the University of Minnesota in 1992. She had post-doc positions in the Weizmann Institute (Rehovot, Israel), Institut Charles Sadron (Strasbourg, France) and Princeton University. In 1995 she started teaching in the Department of Chemical Engineering in University of Delaware and moved to Drexel in 1999. Since then, she has spent a year as a visiting researcher at Harvard University's School of Engineering and Applied Science and two years as program director at the National Science Foundation's Biology Division. Dr. Dan's research focuses on the development of novel 'functional' materials, that is, materials that can respond to their environment. She has studied polymeric materials for gene therapy applications, a number of drug delivery systems such as liposomes and polymersomes, and environmentally sensitive polymeric materials. Her recent work investigates the response of biomaterials to applied fields for biomedical applications and encapsulation systems for food additives. She has published more than 90 research papers. Recently, she has helped develop and manage the Executive Leadership in Academic Technology and Engineering (ELATE) program, whose goal is to increase the numbers of female university leaders in science and technology fields.

JOURNAL PUBLICATIONS (Peer Reviewed)

Dan, N. Membrane-Induced Interactions between Curvature-Generating Protein Domains: The Role of Area Perturbation. *AIMS Biophysics* **2017**, 4 (1), 107–120.
DOI: 10.3934/biophy.2017.1.107

Dan, N. Bilayer Degradation in Reactive Environments. *AIMS Biophysics* **2016**, 4 (1), 33–42.
DOI: 10.3934/biophy.2017.1.33

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

"Nanofiber-based Novel Electrode Architecture for Li-Air Batteries", National Science Foundation, 9/1/12 – 8/31/16

"CAREER: Highly-ordered Electrode/Catalyst Assembly in Proton Exchange Membrane Fuels for Enhanced Catalyst Utilization", National Science Foundation, 9/1/12 – 8/31/18

"Hybrid Supercapacitators Based on Electroactive Polymer Shrink-Wrapped Mesoporous Carbon Nanofibers", National Science Foundation, 9/1/15 – 8/31/18

"Confined Self Assembly of Conjugated Rod-Rod Diblock Copolymers in Nanofibers: Experiments and Simulations", National Science Foundation, 1/1/16 – 12/31/18

JOURNAL PUBLICATIONS (Peer Reviewed)

Singhal, R.; Kalra, V. Cobalt Nanoparticle-Embedded Porous Carbon Nanofibers with Inherent N- and F-Doping as Binder-free Bifunctional Catalysts for Oxygen Reduction and Evolution Reactions. *ChemPhysChem* **2017**, 18, 223.
DOI: 10.1002/cphc.201600771

Simotwo, S.K.; Kalra, V. Polyaniline-Based Electrodes: Recent Application in Supercapacitors and Next Generation Rechargeable Batteries. *Curr. Opin. Chem. Eng.* **2016**, 13, 150.
DOI: 10.1016/j.coche.2016.09.001

Simotwo, S.K.; DelRe, C.#; Kalra, V. Supercapacitor Electrodes Based on High-Purity Electrospun Polyaniline and Polyaniline-Carbon Nanotube Nanofibers. *ACS Applied Materials and Interfaces* **2016**, 8, 21261.
DOI: 10.1021/acsami.6b03463

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. He was appointed the Graduate Academic Advisor of the department in 2014 and was further appointed the Assistant Department Head in 2017. 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 75 original research products, including 4 book chapters and 2 patents, and has graduated 4 PhD and 3 MS students. Lau is a member of the International Advisory Committee of the International Hot Wire Chemical Vapor Deposition Conference, and chaired the 9th International HWCVD Conference in 2016.

EXTERNAL RESEARCH FUNDING

"Collaborative Research: Optimal Design and Operation of Dye Sensitized Solar Cells Using an Integrated Strategy Involving First-Principles Modeling, Synthesis, and Characterization", National Science Foundation, 8/1/12 – 7/31/17

"Synthesis and Processing of Electroactive Polymers in Nanostructured Energy Devices", National Science Foundation, 7/1/13 – 6/30/17

"Engineering Water and Oil Repellent Coatings for High Performance Fabrics", W. L. Gore and Associates, 7/1/16 – 6/30/18

"Engineering of Polymer Electrolytes for Energy Storage", National Science Foundation, 7/1/15 – 6/30/18

"Spatial Control of Condensate and Wetting Regimes using Heterogeneous and Hierarchical Surface Structures for Enhanced Heat Transfer", National Science Foundation, 9/1/15 – 8/31/18

"Hybrid Carbon-Polymer Supercapacitors for High Energy Storage and Power Delivery", National Science Foundation, 9/1/15 – 8/31/18

JOURNAL PUBLICATIONS (Peer Reviewed)

Hanak, B.W.; Hsieh, C.-Y.; Donaldson, W.; Browd, S.R.; Lau, K.K.S.; Shain, W. Reduced Cell Attachment to Poly(2-hydroxyethyl methacrylate)-Coated Ventricular Catheters In Vitro. *J. Biomed. Mater. Res., Part B.* **2017**.
DOI: 10.1002/jbm.b.33915

Smolin, Y.Y.; Soroush, M.; Lau, K.K.S. Influence of oCVD Polyaniline Film Chemistry in Carbon-Based Supercapacitors. *Ind. Eng. Chem. Res.* **2017**, 56, 6221–6228.
DOI: 10.1021/acs.iecr.7b00441

Smolin, Y.Y.; Soroush, M.; Lau, K.K.S. Oxidative Chemical Vapor Deposition of Polyaniline Thin Films. Beilstein J. *Nanotechnol.* **2017**, 8, 1266–1276.
DOI: 10.3762/bjnano.8.128

Smolin, Y.Y.; Van Aken, K.L.; Boota, M.; Soroush, M.; Gogotsi, Y.; Lau, K.K.S. Engineering Ultrathin Polyaniline in Micro/Mesoporous Carbon Supercapacitor Electrodes Using Oxidative Chemical Vapor Deposition. *Adv. Mater. Interfaces* **2017**, 4.
DOI: 10.1002/admi.201601201

Ölçeroğlu, E.; Hsieh, C.-Y.; Lau, K.K.S; McCarthy, M.Thin Film Condensation Supported on Ambiphilic Microstructures. *J. Heat Transfer* **2017**, 139, 020910.
DOI: 10.1115/1.4035580

Johnson, N.M.; Smolin, Y.Y.; Hagaman, D.; Soroush, M.; Lau, K.K.S.; Ji, H.-F. Suitability of N-Propanoic Acid Spiropyrans and Spirooxazines for Use as Sensitizing Dyes in Dye-Sensitized Solar Cells. *Phys. Chem. Chem. Phys.* **2017**, 19, 2981–2989.
DOI: 10.1039/C6CP07853B

Kuba, A.G.; Smolin, Y.Y.; Soroush, M.; Lau, K.K.S. Synthesis and integration of Poly(1-vinylimidazole) Polymer Electrolyte in Dye Sensitized Solar Cells by Initiated Chemical Vapor Deposition. *Chem. Eng. Sci.* **2016**, 154, 136–142.
DOI: 10.1016/j.ces.2016.05.007

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

"Tailored Universal Formulation Feedstock", DARPA, 4/1/16 – 3/31/19

"Materials for Extreme Environments", ARL, 1/1/15 – 12/31/19

"Low Temperature Formulation Testing", RideKleen, 9/22/16 – 12/31/16

"Narrow Distribution Polyethylenes - Zpolymers", Zzyzx Polymers LLC, 5/9/17 –12/31/17

"Photo-Deformable Polymer Films from Block Copolymers (Photoswitch)", Technical University of Denmark, 9/1/15 – 8/31/18

JOURNAL PUBLICATIONS (Peer Reviewed)

Hatzell, K. B.; Eller, J.; Morelly, S. L.; Tang, M. H.; Alvarez, N. J.; Gogotsi, Y. Direct Observation of Active Material Interactions in Flowable Electrodes Using X-ray Tomography. *Faraday Discuss.* **2017**, 199, 511–524.
DOI: 10.1039/C6FD00243A

Diguiseppi, D.; Farrell, S.; Alvarez, N.; Schweitzer-Stenner, R. Exploring the Unexpected Gelation of Tripeptides in a Binary Mixture of Water and Ethanol. *Biophysical Journal* **2017**, 112 (3).
DOI: 10.1016/j.bpj.2016.11.2767

Diguiseppi, D.; Kraus, J.; Toal, S. E.; Alvarez, N.; Schweitzer-Stenner, R. Investigating the Formation of a Repulsive Hydrogel of a Cationic 16mer Peptide at Low Ionic Strength in Water by Vibrational Spectroscopy and Rheology. *J. Phys. Chem. B*, **2016**, 120 (38), 10079-10090.
DOI: 10.1021/acs.jpcb.6b07673

Huang, Q.; Agostini, S.; Hengeller, L.; Shivokhin, M.; Alvarez, N. J.; Hutchings, L. R.; Hassager, O. Dynamics of Star Polymers in Fast Extensional Flow and Stress Relaxation. *Macromolecules* **2016**, 49 (17), 6694–6699.
DOI: 10.1021/acs.macromol.6b01348

Huang, Q.; Alvarez, N. J.; Shabbir, A.; Hassager, O. Multiple Cracks Propagate Simultaneously in Polymer Liquids in Tension. *Phys. Rev. Lett.* **2016**, 117 (8).
DOI: 10.1103/PhysRevLett.117.087801

FACULTY PROFILES

TEACHING PROFESSORS

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 three-year postdoctoral position 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 studies new materials and new synthetic processes for high-performance optoelectronic devices. His group is currently developing novel, scalable, solution-based chemical fabrication approaches and is developing an understanding of the structural, compositional and electronic defects that result from them. Additionally, they are actively researching new, fault-tolerant materials. Dr. Fafarman has been recognized for his teaching and research mentorship with a Linus Pauling Chemistry Teaching award from Stanford and an Outstanding STAR Mentor award from Drexel University. He is currently the co-Chair of the Department Safety Committee and is the faculty advisor for the Drexel AIChE Student Chapter. He has authored or co-authored 24 peer-reviewed papers and has four patents issued or disclosed.

EXTERNAL RESEARCH FUNDING

"Low-Voltage, Low-Waste Fabrication of Inorganic Semiconducting Thin Films by Electrophoretic Deposition Under Flow", National Science Foundation, 9/1/15 – 8/31/18

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

JOURNAL PUBLICATIONS (Peer Reviewed)

Dastidar, S.; Hawley, C. J.; Dillon, A. D.; Gutierrez-Perez, A. D.; Spanier, J. E.; Fafarman, A. T. Quantitative Phase-Change Thermodynamics and Metastability of Perovskite-Phase Cesium Lead Iodide. *J. Phys. Chem. Lett.* **2017**, 8 (6), 1278–1282.
DOI: 10.1021/acs.jpclett.7b00134

A.D.; Le Quoc, L.; Goktas, M.; Opasanont, B.; Dastidar, S.; Mengel, S.; Baxter, J.B.; Fafarman, A.T. Thin Films of Copper Indium Selenide Fabricated with High Atom Economy by Electrophoretic Deposition of Nanocrystals Under Flow. *Chem. Eng. Sci.* **2016**, 154-128.
DOI: 10.1016/j.ces.2016.06.056

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

"Electrocatalytic Interface Engineering to Address Scaling Relations in Multi-Intermediate Electrochemical Reactions", Electrochemical Society, 9/1/16 – 8/31/17

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

"Bottom-up Design of Earth-Abundant catalysts for Reversible Hydrogen Oxidation and Reduction in Alkaline", National Science Foundation, 7/1/16 – 6/30/19

"Highly-Accessible Catalysts for Durable High-Power Performance", DOE EERE, 07/01/16 – 06/31/19

JOURNAL PUBLICATIONS (Peer Reviewed)

Nykaza, J. R.; Li, Y.; Elabd, Y. A.; Snyder, J. Effect of Alkaline Exchange Polymerized Ionic Liquid Block Copolymer Ionomers on the Kinetics of Fuel Cell Half Reactions. *Journal of Electroanalytical Chemistry* **2017**, 783, 182–187.
DOI: 10.1016/j.jelechem.2016.11.024

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. 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 – 6/30/19

"Bottom-up Design of Earth-Abundant Catalysts for reversible hydrogen oxidation and reduction in alkaline electrolytes", National Science Foundation, 7/1/16 – 6/30/19

JOURNAL PUBLICATIONS (Peer Reviewed)

Hatzell, K.B.; Eller, J.; Morelly, S.L.; Tang, M.H.; Alvarez, N.J.; Gogotsi, Y. Direct Observation of Active Material Interactions in Flowable Electrodes Using X-ray Tomography. *Faraday Discuss.* **2017**, 199, 511–524.
DOI: 10.1039/C6FD00243A

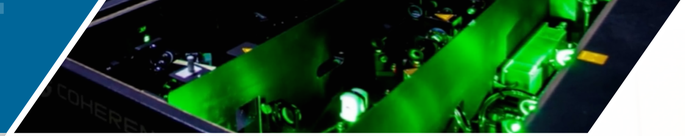
Nykaza, J.R.; Savage, A.M.; Pan, Q.; Wang, S.; Beyer, F.L.; Tang, M.H.; Li, C.Y.; Elabd, Y.A. Polymerized Ionic Liquid Diblock Copolymer as Solid-State Electrolyte and Separator in Lithium-Ion Battery. *Polymer* **2016**, 101, 311–318.
DOI: 10.1016/j.polymer.2016.08.100

Michael J. Walters

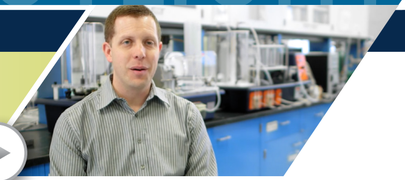
Michael J. Walters earned a BS in Chemical Engineering from Bucknell University in 2000. He earned his MS in Chemical Engineering from Northeastern University in 2005, and a PhD in Chemical Engineering from Drexel University in 2010. Additionally, Michael received postdoctoral training in biochemistry 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 various other parts of the undergraduate curriculum.

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. He continued to the Harvey Technical Center near Chicago where he was involved in hydro-desulfurization, isomerization, and catalytic reforming units. From there, he moved to ARCO Chemical (then a division of Atlantic Richfield). At ARCO Chemical, John was involved with technologies such as Olefins manufacturing, Propylene Oxide Production, Butanediol, and their corresponding derivatives. Through acquisitions, the company name changed to Lyondell then Lyondell Basell. John held job titles such as Process Engineer, Senior Process Design Engineer, Process Manager for Asia, and Process Design Manager. John joined the Department of Chemical and Biological Engineering in 2011 as a Teaching Professor. He teaches senior design and chemical process safety.



JASON B. BAXTER, PhD



TRACKING ELECTRONS

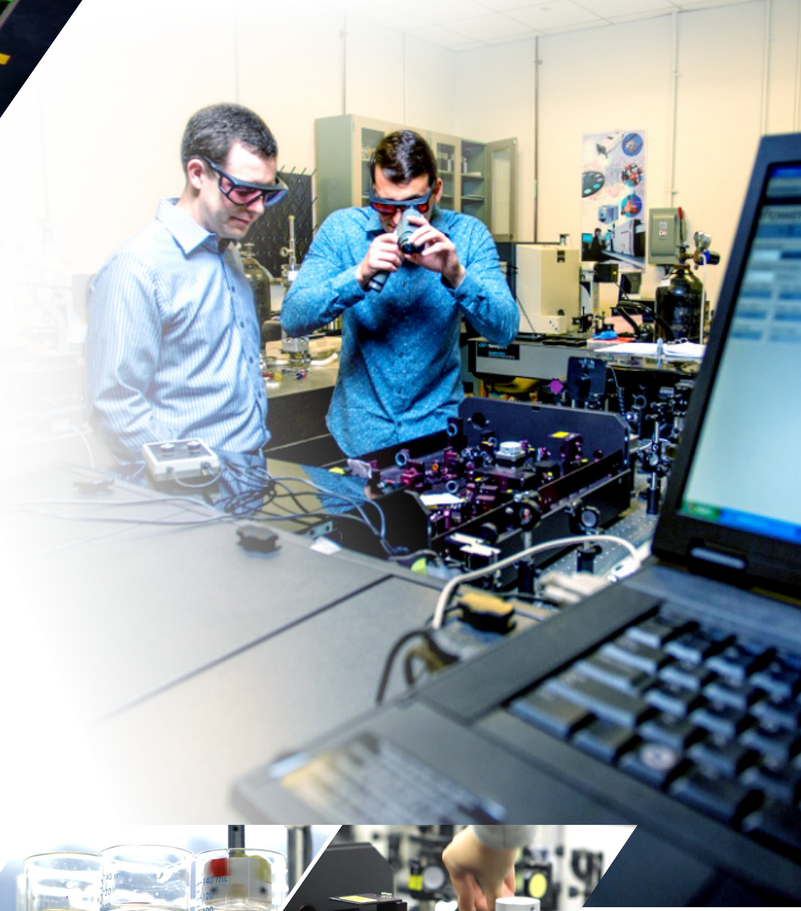
to Develop New Materials for Solar Cells

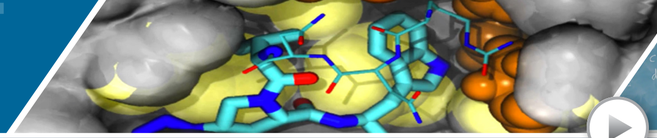
Finding inexpensive, scalable, and renewable energy sources is one of the most important technical challenges of our generation. **Professor Jason Baxter** is one of several CBE faculty working on energy generation and storage. One of his current projects entails investigating earth-abundant, non-toxic materials for thin film photovoltaics that convert sunlight into electricity. One material with great promise is $Cu_2ZnSn(S,Se)_4$, or CZTSSe. CZTSSe-based solar cells have achieved efficiencies of 12.6%. Although this efficiency is only half that of the industry-leading silicon solar cells, 100 times less absorber material is needed in CZTSSe thin films, potentially enabling faster and cheaper processing.

Baxter's efforts focus on understanding the mechanisms that presently limit the efficiency of CZTSSe solar cells, which have maximum theoretical efficiencies of over 30%. One primary limitation identified so far is the short lifetime of photoexcited electrons: <1 nanosecond or <0.000000001 seconds in most films. With such short lifetimes, many electrons cannot reach the contacts to generate electricity. Baxter and his team measure these very fast dynamics using ultrafast pump – probe spectroscopy. By identifying how electron loss mechanisms depend on different material properties and processing parameters, they provide critical feedback to improve the materials and devices.

One key strategy has been to team up with collaborators who make high quality materials and efficient solar cells. The Drexel team has worked with both IBM and DuPont, recent industry leaders in this thin film technology. The work with IBM led to strategies to produce higher voltage solar cells with even thinner films. Predicting the limits of performance using thin films is particularly challenging because they are deposited under highly non-equilibrium conditions and therefore have higher densities of defects and small crystalline grain sizes. To overcome this challenge, the Baxter group is teaming with the University of Delaware Institute of Energy Conversion (IEC). IEC grows single crystals of CZTSSe using quasi-equilibrium processing methods. These crystals have no grain boundaries and fewer point defects, making them ideal for fundamental scientific investigations. Using a carefully designed set of crystals with slightly varying stoichiometries, the Drexel-IEC team has identified optimal compositions that can significantly extend photoexcited electron lifetimes and potentially lead to higher efficiency solar cells.

This highly collaborative project is funded by the National Science Foundation (DMR-1507988).



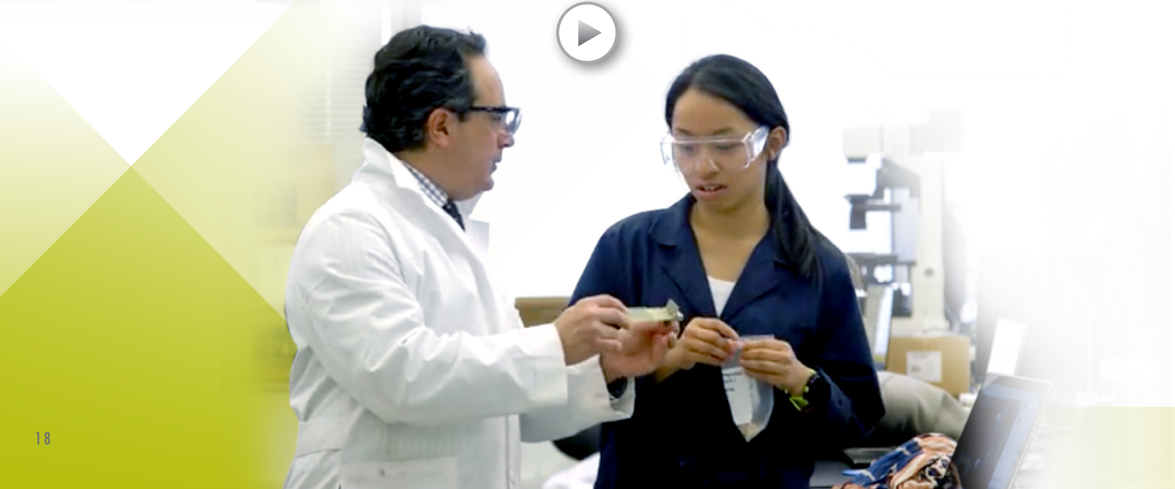


GIUSEPPE R. PALMESE, PhD & CAMERON F. ABRAMS, PhD

Drexel CBE Researchers Palmese & Abrams awarded

$2.4 MILLION COOPERATIVE AGREEMENT

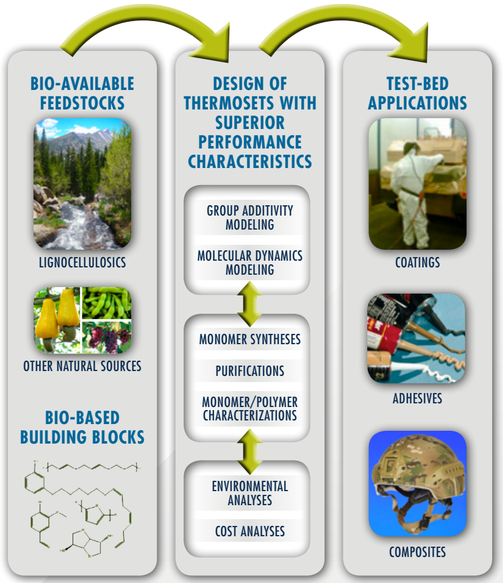
with ARL on Bio-based Polymers



Professors Giuseppe Palmese (PI) and **Cameron Abrams** of Drexel's Department of Chemical and Biological Engineering were awarded a $2.4 million cooperative agreement from ARL entitled "Bio-based Thermosetting Polymers for Composites, Adhesive, and Coating Applications." The project is in collaboration with researchers from ARL, PPG and Prof. Joseph Stanzione III (Drexel '08) of Rowan University. The overarching theme of the proposed work is to gain a fundamental understanding of the processing-structure-property relationships of novel bio-based thermosetting polymer systems, enabling the design of materials with superior performance characteristics specific to their intended applications. The project intends to harness nature's chemistries to improve coatings, adhesives, and composites critical to military and civilian applications. Benefits of this program will be:

1. Expanding the processing-structure-property window of thermosets
2. Producing novel polymers with improved properties
3. Reducing toxicity of monomers and resins
4. Enhancing sustainable development by taking advantage of what nature provides.

The Palmese lab directs synthesis and preliminary characterization of new monomeric molecular building blocks, and many are derived from natural byproduct sources via novel chemistries developed by Stanzione. PPG and ARL use these novel materials in real-world testing conditions. The Abrams' lab effort involves detailed all-atom molecular simulation studies in tandem with the experimental work in order to better understand the structure-function relationships these novel molecules possess in the context of thermosets. This work builds on nearly two decades of work by Palmese and co-workers related to the development of materials from renewable sources including methacrylated fatty acid (MFA) monomers for styrene replacement and grafted triglycerides used as bio-rubber tougheners - two technologies which have been licensed and are being commercialized by Dixie Chemical.



JOSHUA D. SNYDER, PhD & MAUREEN TANG, PhD

DETERMINING THE MECHANISM OF ELECTROCHEMICAL HYDROGEN ADSORPTION

in Alkaline Electrolytes with Single-crystal Experiments and Microkinetic Modeling

Study of the hydrogen electrode has long played a key role in the development of core concepts in electrochemistry and electrocatalysis. The kinetics of the hydrogen evolution and oxidation reactions (HER/HOR) are up to 200 times slower in base than in acid, even on platinum. The mechanistic origins of this difference are hotly debated, with profound implications for electrochemical energy storage and conversion. In their project "Bottom-Up Design of Earth-Abundant Catalysts for Reversible Hydrogen Oxidation and Reduction in Alkaline Electrolytes" (NSF-CBET-1602886), Assistant Professors Joshua Snyder and Maureen Tang aim to identify the reasons for the adverse effects of alkaline pH on hydrogen electrocatalysis. They intend to use the results to design active HER/HOR electrocatalysts from earth-abundant materials, thereby enabling broader utilization of low-cost fuel cell and electrolyzer technologies.

The work will support graduate and undergraduate education and outreach to high school students, all directed toward broader understanding and appreciation of opportunities for electrochemistry to contribute to sustainable methods for the production of energy and chemicals.

Results so far have combined experiment and theory to assess the viability of two pathways for the Volmer step of electrochemical hydrogen adsorption: direct (OH-as-spectator) and indirect (OH-mediated). Experimental cyclic voltammograms on single-crystal Pt(110) and rigorous microkinetic modeling of the two pathways show three critical conclusions. First, while the peak potential position for adsorbed hydrogen/hydroxide exchange (H/OH-X) on Pt(110) can be described by either model, the requisite H and OH binding energies are consistent with existing predictions only for the direct (OH-as-spectator) mechanism. Second, changing electrolyte from KOH to LiOH strengthens OH binding and slows down H-UPD kinetics (Figure 1). This effect cannot be explained with the indirect (OH-mediated) pathway, and is again consistent only with the direct pathway. Finally, H/OH-X kinetics in acid are almost fully reversible despite stronger OH binding than in base. Therefore, slow hydrogen kinetics on platinum at high pH must be caused entirely by higher kinetic barriers to solvent reorganization. Understanding how phenomena as universal as pH affect reactions as "simple" as hydrogen is absolutely critical to electrocatalyst design — not just for HER/HOR, but also for carbon dioxide reduction, nitrogen fixation, and other grand challenges. The present results provide a definitive answer to one of the greatest remaining questions in hydrogen electrocatalysis and identify the solvent reorganization time constant as the key to explaining changes in hydrogen kinetics with pH.

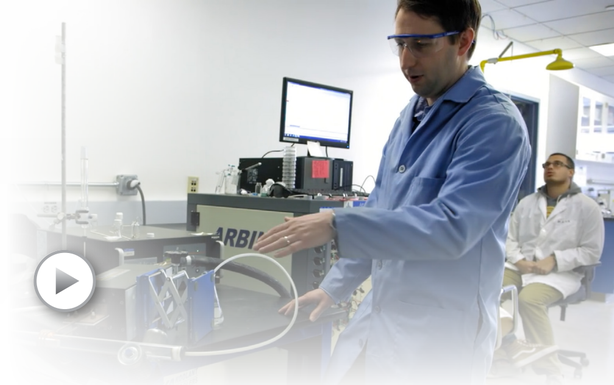
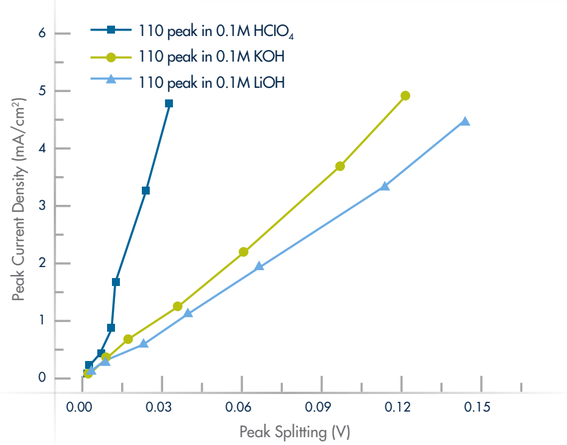
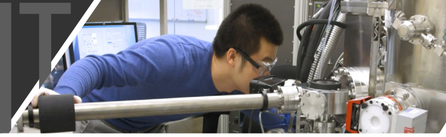


Figure 1:
Effect of Electrolyte on H/OH Exchange Kinetics on Single-Crystal Pt(110)





KENNETH K.S. LAU, PhD

Prof. Kenneth Lau (CBE) Hosts

HOT WIRE (CAT) & INITIATED CHEMICAL VAPOR International Conference

Prof. Ken Lau, associate professor of Chemical and Biological Engineering, chaired the 9th International Conference on Hot Wire (Cat) and Initiated Chemical Vapor Deposition (HWCVD9) from September 6-9, 2016 at the Chemical Heritage Foundation, Philadelphia. The conference attracted 65 scientists and engineers from countries that included the U.S., Canada, Mexico, Netherlands, Germany, Austria, Spain, Japan, South Korea, India, and South Africa. The participants came from academic institutions, corporations, and government agencies that included Drexel University, MIT, University of Southern California, Lawrence Livermore National Laboratory, Naval Research Laboratory, TU Eindhoven, TU Graz, Japan Advanced Institute of Science and Technology (JAIST), Seoul National University, Indian Institute of Technology Bombay, Applied Materials, Tokyo Electron Limited, and GVD Corporation.

This international conference provided an engaging forum for researchers and students to discuss the latest discoveries and findings with chemical vapor deposition processes and materials that utilized filament heating for activating and catalyzing reactions. The conference covered a broad range of areas from fundamentals of chemical kinetics and reaction pathways to applications and commercialization of solar cells, batteries, supercapacitors, nuclear fusion, and electronics. Plenary lectures by Profs. Karen Gleason (MIT), Ruud Schropp (TU Eindhoven), and Hideki Matsumura (JAIST) described the current state and latest developments of HWCVD technologies around the world. As part of the overall conference experience, the participants also had an evening at Hotel du Pont for a conference banquet and a social excursion to Longwood Gardens for the Nightscape garden and lights display.

Prof. Ken Lau successfully received funding through Drexel University, MIT, GVD Corporation, Blue Wave Semiconductors, and Tokyo Electron Limited. In addition, he received a conference grant through the U.S. National Science Foundation to further support this event. The findings and work presented at the HWCVD9 conference have been published in a Special Issue of the peer-reviewed scientific journal, Thin Solid Films (volume 635, year 2017).

CBE Alumni Events

A YEAR IN REVIEW

Four years ago, the Department of Chemical and Biological Engineering (CBE) hosted the first CBE Annual Alumni Event. This event has grown in attendance from single digits to over a hundred alumni and guests.

At last year's event on October 8, 2016, alumnus Stanley W. Silverman, BS '69, MBA '74, Vice Chair of Drexel's Board of Trustees, delivered the keynote lecture, "From Chemical Engineering Undergraduate to CEO, to Syndicated Columnist on Effective Leadership." The former CEO of PQ Corporation, Silverman also writes for the Philadelphia Business Journal and 42 affiliated business publications across the United States. His weekly column discusses leadership, entrepreneurship, and corporate governance.

As part of the day's celebration, Dr. Giuseppe Palmese, interim dean, presented Mr. Michael Treat, BS '79, MS '08 with the Alumni of the Year award, highlighting his outstanding engagement efforts and commitment to the department.

On Saturday, April 29, 2017, the department, along with the student chapter of AIChE, organized the third CBE Spring Panel Event, entitled "Pharmaceuticals and Biotechnology in Chemical Engineering," with the support of ExxonMobil and International Academy of Automation Technology (IAEE). Ninety students and alumni attended the event, which included a moderated panel discussion. Panelists included Ed Andjeski (Endo Pharmaceuticals), Ron Connolly (Frontida BioPharm), Youssef El-Bahtimy (Horizon Controls Group), Ron Pollack (Janssen Pharmaceuticals), and Dr. Eleanor Small (Johnson & Johnson Consumer), with Dr. John Via III (Drexel) as moderator. The event featured a lively discussion among students and alumni that centered on questions ranging from professional accomplishments, leadership styles, academic degrees, workplace personnel issues, career advancement, and the pharmaceutical and biotechnology industries.

In the last three years, the CBE department and the Drexel student chapter of AIChE partnered to implement an alumni-mentoring program. In this student-alumni program, chemical engineering alumni visit the campus to offer their professional expertise to undergraduate students in a lecture series. This year, we organized four CBE Alumni Mentoring seminars. Mitchell Maurstad BS '04 presented a lecture titled "High Level Process Flow Mapping to Understand Opportunities and Constraints." Alumna Padma Narayan, PhD '99, presented "Big Companies/Small Companies, How to stay Marketable as a Chemical Engineer." Chris Owens BS '03 and Executive Coach Lise Schwartz presented "Networking Basics: Communicate like a Professional." The last presentation included Cynthia Spade DeBisschop BS '93 on "Cyber Physical Attacks."

For more information about our alumni programs, please reach out to Jenn Bing at **jlb453@drexel.edu** or **215.895.1855**.

PANEL EVENT SPONSORED BY: IAAE® International Academy of Automation Engineering ExxonMobil

We would like to recognize our Industrial Advisory Board members for their dedication to the Drexel University Department of Chemical and Biological Engineering.

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