WILLIAM G. LOWRIE DEPARTMENT OF CHEMICAL AND BIOMOLECULAR ENGINEERING

— 2019 ANNUAL REPORT —

THE OHIO STATE UNIVERSITY
COLLEGE OF ENGINEERING

Message from the chair

Spring, 2020

Friends and Colleagues,

During 2019, we were encouraged by a number of interesting developments within the William G. Lowrie Department of Chemical and Biomolecular Engineering:

- A breakthrough injectable gene-therapy that can target and reprogram cells in any part of the body, including the brain;
- High-efficiency membranes that can keep CO_2 out of the atmosphere;
- A liquid biopsy providing faster results with less discomfort;
- An on-site therapeutic manufacturing platform that could transform patient care;
- The creation of another endowed professorship;

...and the discovery that the first female chemical engineering Ph.D. in the nation graduated from Ohio State.

I hope you'll be able to take a few moments to learn more about these and other promising developments within our department. Best wishes!

Umit S. Ozkan
College of Engineering Distinguished Professor
and Chair

Contents

OHIO STATE CHEMICAL ENGINEERING **2019 PROGRAM OVERVIEW**

23 tenure-track Faculty

13% NAE Members

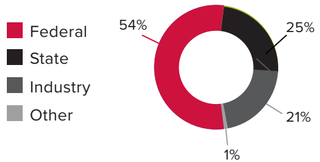
- **4** endowed chairs
- **3** professorships
- **4** distinguished professors

9 new faculty hired in the last four years

Research Expenditures

$10.1M

$440,112 per faculty



Graduate Program

15 PhDs
.65 per faculty

18 MS Degrees
.78 per faculty

6 National Awards
AIChE • AAAR
NAMS • SFB

U.S.News & World Report RANKINGS

Chemical Engineering

#28 GRADUATE

#21 UNDERGRADUATE

College of Engineering

#1 GRADUATE

#1 UNDERGRADUATE

168 Peer-reviewed Articles

3 Books
2 authored
1 edited
13 chapters

12 Awards
National / Int'l
ACS • AIChE • IAS
INA • ORSC • RSC

Patents
8 issued
-26 filed-
3 Startups

93 active Grants

Undergraduate Program

248 BS Degrees

8 National Awards
AIChE • Astronaut Scholar •
ENGIE Challenge • Goldwater

3 AIChE Chem-E Car Regional Awards, including 1st and 2nd Place

FACULTY


Aravind Asthagiri
Associate Professor


Bhavik Bakshi
Professor


Robert Brodkey
Professor Emeritus


Nicholas Brunelli
H.C. Slip Slider Professor


Jeffrey Chalmers
Professor


John Clay
Professor of Practice


Stuart Cooper
Distinguished Professor


Paul Dubetz
Adjunct Asst. Professor


Ilham El-Monier
Asst. Professor of Practice


Liang-Shih Fan
Dist. Univ./CJ Easton Prof.


Martin Feinberg
Professor Emeritus

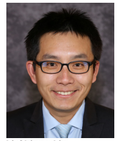

Lisa Hall
Associate Professor


W.S. Winston Ho
Distinguished Professor of Engineering


Kurt Koelling
Professor


Isamu Kusaka
Associate Professor


L. James Lee
Professor Emeritus


Li-Chiang Lin
Assistant Professor


Andrew Maxson
Asst. Professor of Practice


Umit Ozkan
Disting. Prof. of Eng.; Chair


Andre Palmer
Professor


Joel Paulson
Assistant Professor


James Rathman
Professor

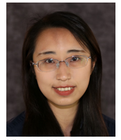

Eduardo Reátegui
Assistant Professor


Katelyn Swindle-Reilly
Assistant Professor


David Tomasko
Professor


Andrew Tong
Research Asst. Professor


William Wang
Assistant Professor


Xiaoxue Wang
Assistant Professor


Jessica Winter
Professor


David Wood
Professor


Barbara Wysiouzil
Professor


Shang-Tian Yang
Professor

NATIONAL ACADEMY OF ENGINEERING

3 Elected Members

National Science Foundation
WHERE DISCOVERIES BEGIN

8 NSF CAREER Awards

AIMBE
AMERICAN INSTITUTE FOR MEDICAL AND BIOLOGICAL ENGINEERING

- 6 Fellows
- 1 Founding Fellow

AIChE
The Global Home of Chemical Engineers

42 Awards, including:

- 5 Fellows
- 5 Particle Technology Awards
- 4 Sustainable Engineering/Green Process Awards
- 2 Wilhelm Awards
- 1 Founders Award
- 1 Institute Lecturer Award

ACS
Chemistry for Life®

11 Awards, Including:

- 3 Influential/Rising Researcher Awards
- 3 Energy & Fuels Awards
- 3 Fellows
- 1 Murphree Award
- 1 Chemistry of Thermoplastic Elastomers Award

Society For Biomaterials
Giving life to a world of materials

- 1 Fellow/President
- 1 Founders Award
- 1 Clemson Award
- 1 Program Chair

APS physics

- 3 Fellows
- 1 Five Sigma Physicist Award

ASEE
AMERICAN SOCIETY FOR ENGINEERING EDUCATION

3 Lectureship and Research Awards

AAAS
AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

7 Fellows

RESEARCH HIGHLIGHTS

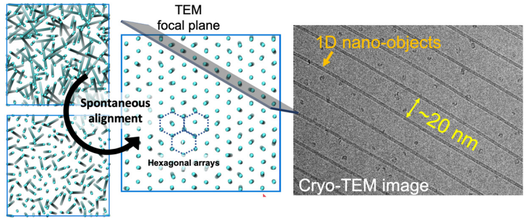
Advanced Materials

Innovations and Discoveries

SPONTANEOUS SUPER-ALIGNMENT OF NANO-OBJECTS

Innovation: In an international collaborative effort, the Lin group and collaborators identified a unique mechanism, offered in nature, to spontaneously super-align nano-objects.

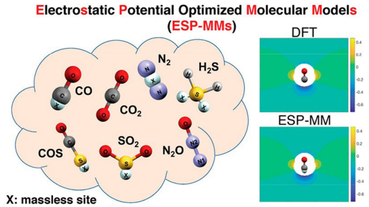
Impact: Potential applications for the novel method include visible-UV photonics, nanolithography, and nanorobotics.



ELECTROSTATIC POTENTIAL OPTIMIZED MOLECULAR MODELS

Innovation: The Lin group also developed a set of molecular models - so-called electrostatic potential optimized molecular models (ESP-MMs) - to enable accurate predictions made by molecular simulations.

Impact: This set of molecular models can be utilized by researchers in the computational materials community to facilitate the exploration of promising material candidates for gas separations.



Li-Chang Lin
Assistant Professor / Umit S. Ozkan Professor

Publications:

- ***Phys. Rev. Lett.***, 123, 238002, (2019).
- ***J. Chem. Theory Comput.***, 15 (11), 6323-6332, (2019).

Recognition:

- International Adsorption Society: ***Triennial Award for Excellence in Publications by a Young Member of the Society***, 2019
- Named the inaugural holder of the ***Umit S. Ozkan Professorship***.

DEVELOPMENT OF A MACHINE LEARNING-BASED METHOD FOR DESIGNING HIGH-PERFORMANCE CONTROLLERS

Innovation: Joel Paulson created a method for executing advanced control algorithms at a rate faster than the millisecond scale. Inspired from recent advances in machine learning and control theory, the method uses deep learning to efficiently approximate the behavior of complex optimization-based control schemes, while still providing strong theoretical guarantees in the presence of constraints and uncertainty

Impact: The proposed approach provides a path toward achieving high-performance in emerging safety-critical control applications including those that have traditionally been treated as "too challenging" to solve using state-of-the-art control methods. Examples include the control of certain biomedical systems, unmanned vehicles, quadcopters, and humanoid robots. The method was recently demonstrated experimentally on an atmospheric pressure plasma device that can be used for biomedical purposes such as combating antibiotic-resistant bacteria, shrinking cancerous tumors, and accelerating the healing rate in chronic wounds.

Illustration of proposed method

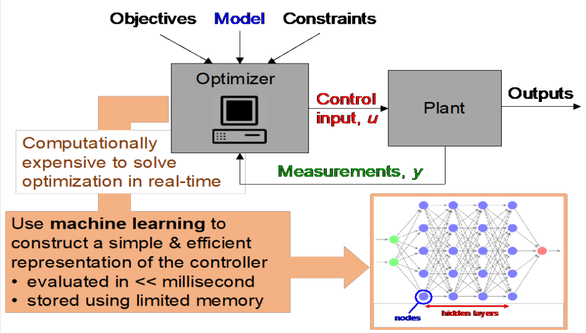
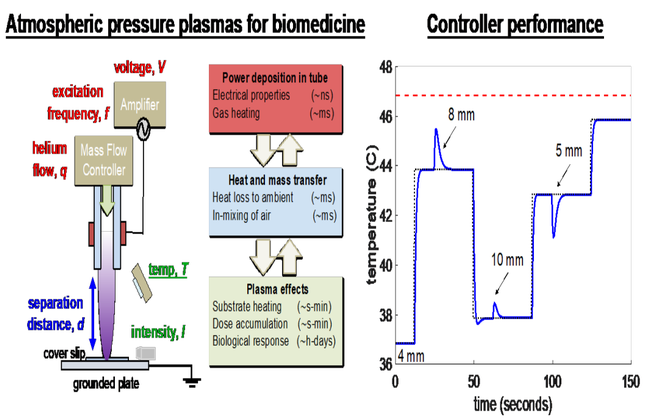


Figure showing application and control performance plot



Joel Paulson
Assistant Professor

Publications:

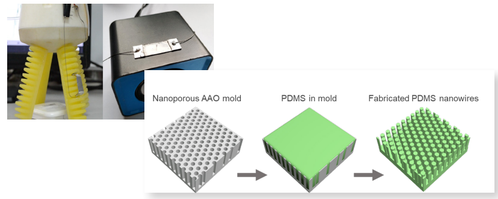
- ***IEEE Control Systems Letters,*** 4:719-724. (2020).
- ***IFAC World Congress***, Accepted. (2020).

COCHLEA-INSPIRED INTERFACIAL NANOWIRE STRUCTURE-ENABLED DESIGN OF STRETCHABLE ELECTRONICS

Innovation: Nature's method of detecting sound waves via the microscopic hairs in the ear inspired William Xiaoguang Wang to develop a material that helps reduce mechanical cracks in stretchable electronics.

With the ultra-stretchability and ultra-sensitivity of these nanowire-structured surfaces, potential applications include the fabrication of wearable electronic devices for motion and sound detection and health monitoring.

Impact: This design improves the maximum detection range of stretchable electronic devices from 30% to 130% uniaxial elongation



HIGHLY EFFICIENT YOLK-SHELL STRUCTURED CATALYSTS

Innovation: Another innovation from Professor Wang was created by hyper cross-linking polymers for synthesis of hollow porous polymeric nanosphere frameworks (HPPNFS).

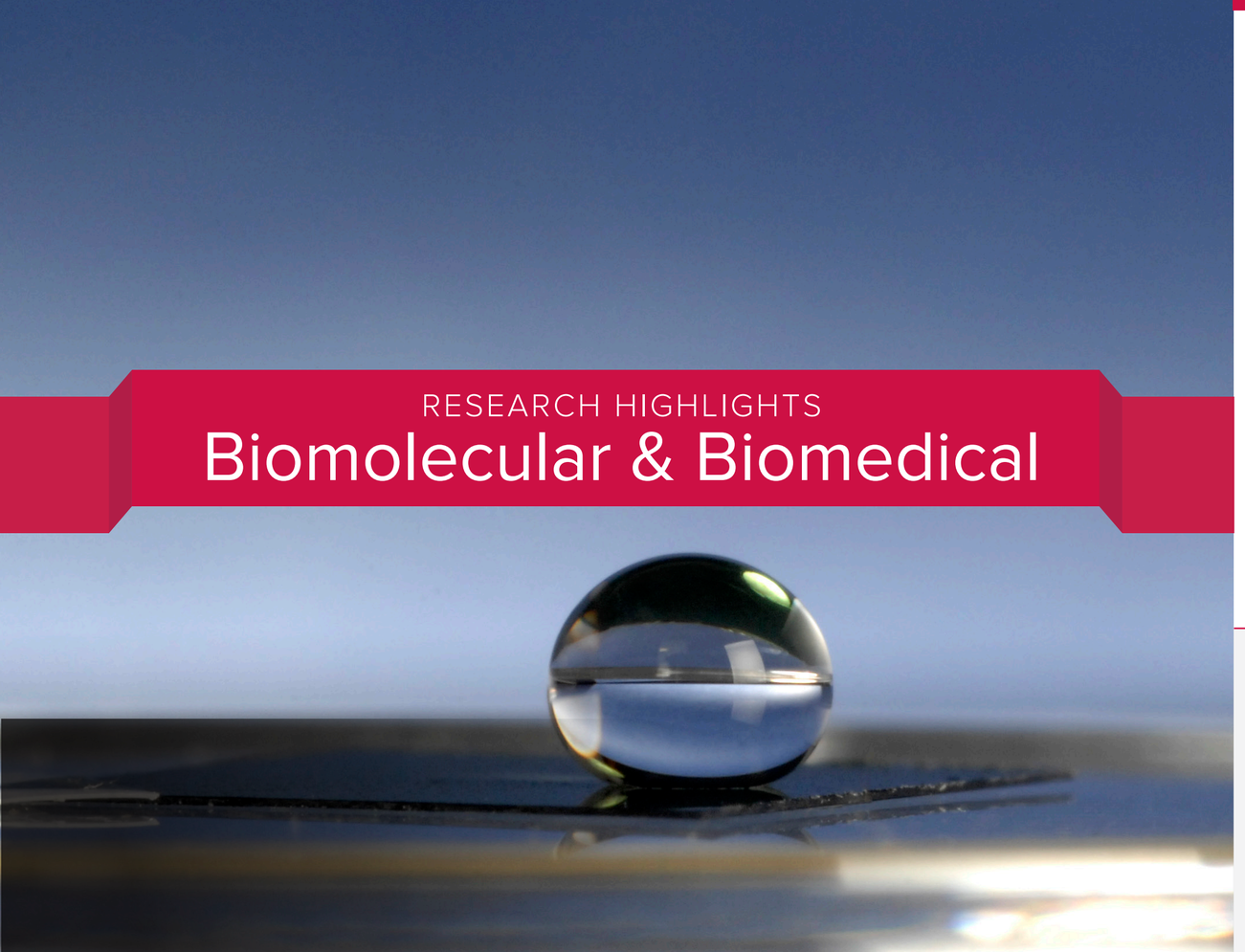
This approach involves encapsulation of ligand-free metal nanoparticles within the hyper-cross-linked HPPNFs, giving rise to remarkable catalytic activity as well as outstanding reusability toward hydrogenation.

Impact: This work informs the design of a class of responsive and functional soft materials for use in catalysis technology. It was featured on the cover of ***ACS Macro Letters.***

William Xiaoguang Wang
Assistant Professor

Publications:

- ***Nature Communications***, 10, 3862, (2019).
- ***ACS Macro Letters***, 8, 1263-1267, (2019). Cover feature.
- ***Soft Matter***, 16, 1463-1472. doi.org/10.1039/C9SM02221J. (2020)



RESEARCH HIGHLIGHTS

Biomolecular & Biomedical

Innovations and Discoveries

INTRINSIC, MAGNETIC CHARACTERIZATION OF HUMAN RED BLOOD CELLS, RBCS

Discoveries:

- A subset of macrophages have significant magnetic susceptibility.
- Red blood cells have significant distributions in hemoglobin concentration.
- Red blood cells from sickle cell anemia patients have a unique magnetic signature.
- Rapid new approaches to separate 5 nm superparamagnetic nanoparticles.

Impact: Exploitation of the magnetic susceptibility of red blood cells could potentially lead to new diagnostic potential and new blood separation technology:

- Understanding hemoglobin distribution concentrations in RBCs could lead to a point of care instrument to detect anemia.
- The unique magnetic signature of red blood cells from sickle cell anemia patients might assist in diagnosis.

CHARACTERIZATION OF THE INTRINSIC MAGNETIZATION OF HUMAN CANCER CELLS

Discovery: With a molecular/cancer biologist, the Chalmers lab demonstrated that not only are human Glioblastoma cells (a type of brain cancer) intrinsically magnetic, but there is a significant difference between the “stem” and “non-stem” cancer cells.

Impact: Chalmers can magnetically separate the “stem” from “non-stem-like” characteristics of these human Glioblastoma cells purely on intrinsic magnetic character.

Jeffrey Chalmers
Professor

Publications:

- ***Analytical Chemistry***, 92(2):1956-1962 (2020)
- ***Biotechnology and Bioengineering***, 116(7):1644-1655 (2019)
- ***Cytometry***, part A, 95(5): 478-487 (2019)
- ***Separation and Purification Technology***, Vol. 248, 117012 (2020).

Funding:

- NIH

BREAKTHROUGH GENE THERAPY: INJECTABLE, PROGRAMMABLE NANOCARRIERS FOR CUSTOM MEDICINE

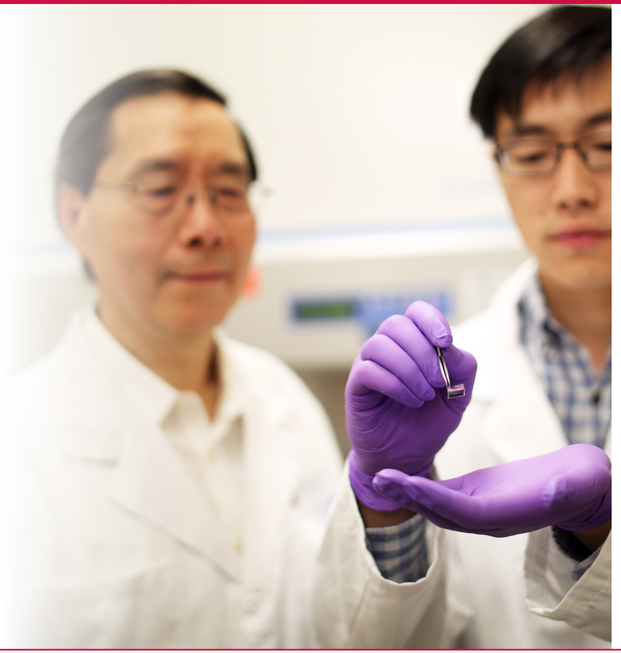
Innovation: Jim Lee's gene-therapy method transforms human cells into mass producers of tiny nano-sized particles containing genetic material with the potential to reverse disease processes, kill cancer cells or regenerate organs, or silence or activate specific genes.

Impact: Potential application in therapeutics that surmounts bio-barriers: Deliverable to any target within the body, including safely accessing the brain, without provoking an immune response.

UNPRECEDENTED EARLY-STAGE CANCER DETECTION: NOVEL EV DIAGNOSTICS IN LIQUID BIOPSY

Innovation: Lee, in conjunction with Eduardo Reátegui, is developing a minimally invasive liquid biopsy that could transform cancer diagnosis and treatment.

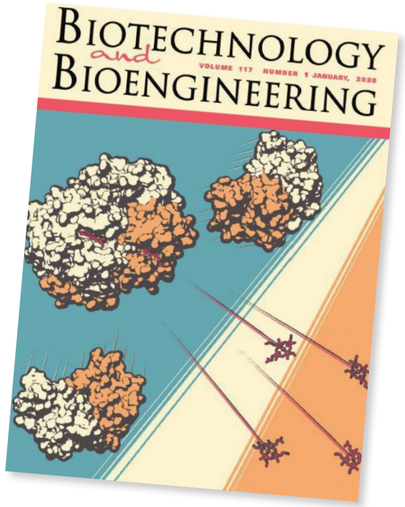
Impact: Provides an accurate and efficient analysis of molecular content within individual extracellular vesicles (EVs) from bodily fluids, creating a faster and pain-free biopsy process.



DEVELOPMENT OF A GENERAL PLATFORM TO PURIFY APO-PROTEINS

Innovation: Andre Palmer developed a general platform to purify apo-proteins (i.e. proteins with no attached co-factors or prosthetic groups). His approach induces partial holo-protein unfolding under mild conditions to release co-factors/prosthetic groups, and subsequent tangential flow filtration to remove the co-factors/prosthetic groups from the apo-protein. The platform is simple to implement, cost-effective, and highly scalable.

Impact: Applied this technology to purify the apo-protein apo-hemoglobin from the oxygen storage and transport protein hemoglobin. Apo-hemoglobin can function as a heme scavenger during states of hemolysis and could be used as a drug delivery vehicle to selectively deliver drugs to CD163+ monocytes and macrophages.



L. James Lee
Professor Emeritus

Publications:
- ***Nature Biomedical Engineering***, DOI https://doi.org/10.1038/s41551-019-0485-1 (2019); 4, 69–83 (2020).

Funding:
- NIH

Andre Palmer
Professor

Publications:
- ***Biotechnology and Bioengineering***, Jan;117(1):125-145. doi: 10.1002/bit.27193 (2020). Cover feature.
- ***Biotechnology Progress***, *Apr 29:e3010. doi: 10.1002/btpr.3010 (2020).*
- ***American Journal of Physiology Heart and Circulatory Physiology***, *May 1;318(5):H1296-H1307. doi: 10.1152/ajpheart.00136 (2020).*

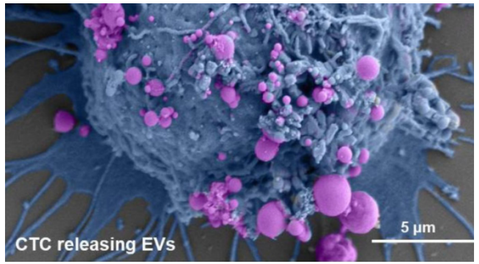
Funding:
- NIH, DOD

Recognition:
- Named ***Fenburr Ohio Eminent Scholar*** in Nanotechnology, Molecular Self-Assembly

NOVEL APPROACH FOR ISOLATION AND ENRICHMENT OF EXTRACELLULAR VESICLES

Innovation: Eduardo Reátegui's approach to isolate and enrich extracellular vesicles (EVs) uses a combination of ultrafiltration and immunomagnetic separation to achieve high levels of specificity and sensitivity when compared to other commercially available methods for EV purification.

Impact: Reátegui's EV purification technique works with either small or large amounts of different types of biofluids (e.g., urine) and removes up to 99.9 % of contaminants present in a sample.



CHARACTERIZATION OF MOLECULAR CARGO OF SINGLE EXTRACELLULAR VESICLES

Innovation: A new in-situ imaging method that enables quantification of protein and RNA cargo in single vesicles. The technology is a combination of advanced surface chemistry, molecular biology, and high resolution microscopy to achieve single vesicle sensitivity and specificity.

Impact: Reátegui is exploring applications for the early diagnosis of cancer with the analysis of biofluids in which EVs are present. The method enables him to quantify therapeutic cargo in engineering EVs to determine efficiency of loading and efficacy after injection in in vivo models. It also aids in predicting the response of patients to immunotherapy by the analysis of EVs present in their biofluids.

Eduardo Reátegui
Assistant Professor

Publications:
- ***Journal of Extracellular Vesicles,*** e60544 (2020).

Patents:
- Two patents issued

Funding:
- NIH

Recognition:
- ***Interview at NIH*** describing his single EV project, December 2019: https://www.youtube.com/watch?v=OeAA-HXVY2U
- Virginia Tech Genetics, ***Bioinformatics and Computational Biology Program Seminar***: "New Technologies for Bulk and In Situ Molecular Analysis of Extracellular Vesicles as Cancer Biomarkers and Mediators of Cell Communication."

DEVELOPMENT OF OCULAR DRUG DELIVERY TECHNIQUES TO TREAT MACULAR DEGENERATION

Innovation: Katelyn Swindle-Reilly developed a drug delivery method to treat macular degeneration.

Impact: Potential to prevent blindness while decreasing frequency of eye injections for patients from once a month to 1-2 times per year.

DEVELOPMENT OF VITREOUS SUBSTITUTES

Innovation: Swindle-Reilly also developed vitreous substitutes that mimic the biochemical and physical properties of the native tissue.

Impact: This has the potential to reduce uncomfortable postoperative patient positioning after vitrectomy and to reduce incidence of cataract after surgery.

Katelyn Swindle-Reilly
Assistant Professor

Publications:
- ***Macromolecular Bioscience,*** 1900305 (2019)
- ***Journal of Controlled Release***, Volume 320, doi.org/10.1016/S0168-3659(20)30153-X, (2020). Cover feature.

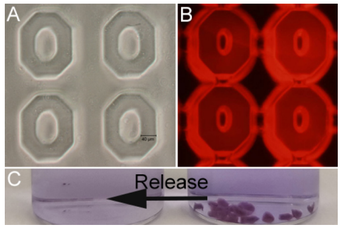
Patents:
- One patent issued and 4 patents filed in 2019.

Recognition:
- Society for Biomaterials: ***Program Chair, Ophthalmic Biomaterials***, 2019-2021
- ARVO: ***Women's Leadership Development Program***, 2019-2020
- OSU ***Innovator of the Year: Named Finalist***, April 2019 for 2018 Early Career Innovator of the Year

SMART RELEASE HYDROGELS DELIVERING NUTRIENTS TO CROPS IN RESPONSE TO METABOLIC CUES

Innovation: Working in concert with soil scientist Dr. Allison Bennett, Jessica Winter is developing hydrogel patches and particles consistent with traditional agricultural practices that will change the way nutrients are delivered. The materials are designed to support fungi that have symbiotic relationships with crop plants, reducing the need for agricultural fertilizers. These materials deliver nutrients to fungi in response to chemicals that they release.

Impact: This approach reduces the need for fertilizer and reduces water use, supporting a sustainable agricultural economy.



Jessica Winter
Professor

Publications:
- ***Nano Letters, Accepted,*** https://doi.org/10.1021/acs.nanolett.9b02786 (2019).

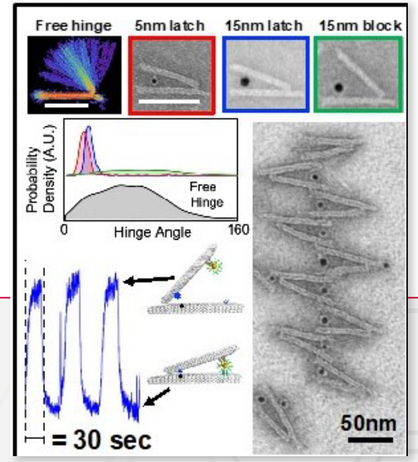
Patents:
- One issued

Funding:
- Center for Applied Plant Sciences (CAPS), Ohio State University seed grant
- CERTAIN grant, Sustainability Institute
- DOE

DEVELOPMENT OF DNA NANOMACHINES

Innovation: Winter and collaborator, Dr. Carlos Castro, developed DNA nanomachines to store and deliver energy at the nanoscale.

Impact: Winter and her team developed nano-hinges made from DNA and gold nanoparticles. The machines were activated by heating and enabled storage and release of energy at the nanoscale. Such machines may provide future thermoresponsive materials, as well as power nanofactories and enable new nanomanufacturing schemes.



Recognition:
- AIChE: ***Vice Chair, Chemical Technology Operating Council***
- Delft Process Technology Institute: ***Jacobus van t'Hoff Lecture***, 2019

DISRUPTIVE TECHNOLOGY FOR PURIFICATION OF RECOMBINANT PROTEINS

Innovation: David Wood has developed a platform for the purification of recombinant proteins based on a self-cleaving affinity tag and founded a company, Protein Capture Science LLC, based on the technology. The technology was largely developed under a DARPA-funded project to develop a laptop-sized "pharmacy in a briefcase," which would deliver a single dose of virtually any protein therapeutic (including insulin) on-site in less than 24 hours. The process could be used in a range of applications, from pure research to being used as a key platform in biopharmaceutical development and manufacturing. The method does not require refrigeration or the large equipment currently required.

Impact: Protein Capture Science will develop, manufacture and directly distribute the technology to a wide variety of potential users. These highly useful biotechnologies are exciting to many people in industry because the technology could dramatically reduce production costs and accelerate biopharmaceutical development from bench to clinic, benefiting patients in need of new therapies.

David Wood
Professor

Patents:
- Two patents issued in 2019.

Funding:
- DARPA

Recognition:
- Featured expert, ***GEN (Genetic Engineering & Biotechnology News)***, "Microbial Culture Systems for Bioprocessing," May 9, 2019

RESEARCH HIGHLIGHTS

Energy & Sustainability

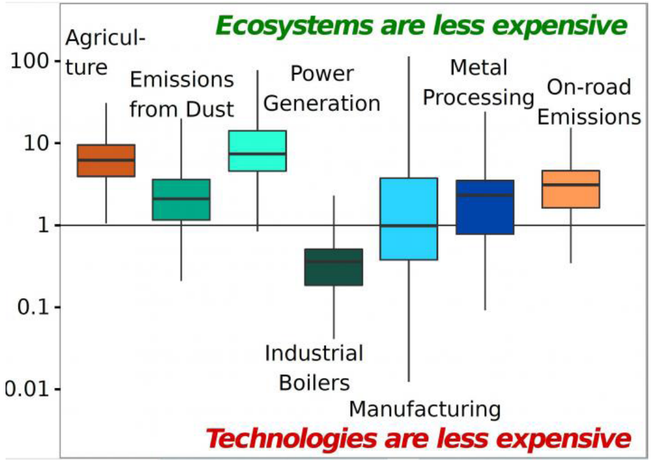
Innovations and Discoveries

MITIGATING AIR POLLUTION WITH NATURE-BASED SOLUTIONS

Discovery: A team led by Bhavik Bakshi demonstrated that nature-based solutions such as vegetation can be more cost-effective than technology-based solutions for mitigating air pollution. This is true in many counties across the U.S. and for several economic activities.

Impact: The potential benefits of explicitly accounting for the role played by ecosystems in supporting industrial activities and seeking synergies between technological and ecological systems include significant cost savings while conserving and protecting valuable natural resources. The results of this study could encourage sustainable engineering by shifting the engineering paradigm from taking nature for granted to accounting for it and respecting its limits.

This work received media coverage in multiple outlets and numerous citations. From the Altemetric journal website: "Altmetric has tracked 14,222,420 research outputs across all sources so far. Compared to these this one has done particularly well and is in the 99th percentile: it's in the top 5% of all research outputs ever tracked by Altmetric."



Bhavik Bakshi
Professor and Richard M. Morrow Endowed Chair

Publications:
- ***Environmental Science and Technology***, 53.22, pp. 13228–13237, (2019).

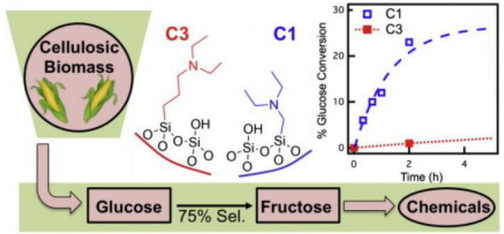
Funding:
- National Science Foundation

Recognition:
- AIChE: 2019 ***Lawrence K. Cecil Award in Environmental Engineering***; ***Cecil Lecture***, AIChE Annual Meeting, Orlando.
- AIChE: 2019 ***Sustainable Engineering Forum Education Award***.
- Interviews on WCMH TV, WV public radio, Sirius XM radio and other media outlets.

HETEROGENEOUS CATALYSTS FOR SELECTIVE BIOMASS CONVERSION

Innovation: Nicholas Brunelli created aminosilica materials capable of selective isomerization of glucose to fructose. This novel design of a bifunctional heterogeneous catalyst increases selective dehydration of fructose to HMF.

Impact: Combined catalysts would enable production of HMF, the most important target for biomass valorization.



Nicholas Brunelli
HC Slip Slider Professor

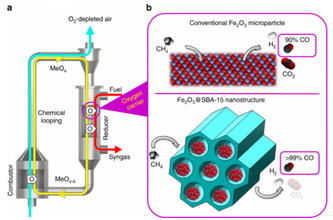
Publications:
- ***AIChE Futures***, AIChE Journal.

Recognition:
- 2019 ***Robert Augustine Award***, Organic Reactions Catalysis Society
- 2019 ***Emerging Investigator Award***, RSC Reaction Chemistry and Engineering
- 2019 ***Lumley Research Award***, The Ohio State University College of Engineering.

DEVELOPMENT OF HIGHLY EFFICIENT MESOPOROUS SILICA-SUPPORTED NANOPARTICLE

Innovation: Liang-Shi (L.-S.) Fan's new oxygen carrier enables a near 100% CO selectivity with high recyclability at a significantly lower temperature range than in conventional oxygen carrier systems.

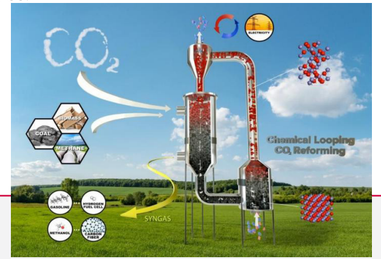
Impact: The value of product selectivity is so far the highest observed for chemical looping systems. These findings contribute to a nanoscale understanding of the underlying metal oxide redox chemistry for chemical looping processes, and provide a systematic strategy toward the design of robust oxygen carrier nanoparticles with superior activity and selectivity at a broader operating temperature window.



SCALEUP OF CARBON-DIOXIDE-REDUCING PROCESS TRANSFORMING SHALE GAS INTO PRODUCTS

Innovation: Professor Fan is scaling up his process that transforms shale gas into products such as methanol and gasoline—all while consuming carbon dioxide. This process can also be applied to coal and biomass to produce useful products.

Impact: This process provides a potential industrial use for carbon dioxide as a raw material for producing useful, everyday products. Traditionally, when carbon dioxide is scrubbed from power plant exhaust, it is intended to be stored underground to keep it from entering the atmosphere as a greenhouse gas. Using Fan's method, some of the scrubbed carbon dioxide would be transformed into useful products at low cost and high energy efficiencies.



Liang-Shih Fan
Distinguished University Professor/C.J. Easton Professor

Publications:
- ***Nature Communications***, 10, no. 1, 1-6 (2019).
- A Nature Communications Editors' Highlights webpage featured the article on the Nature Communications homepage as well as on a dedicated page (https://www.nature.com/ncomms/editorshighlights).

Patents:
- 3 patents filed in 2019

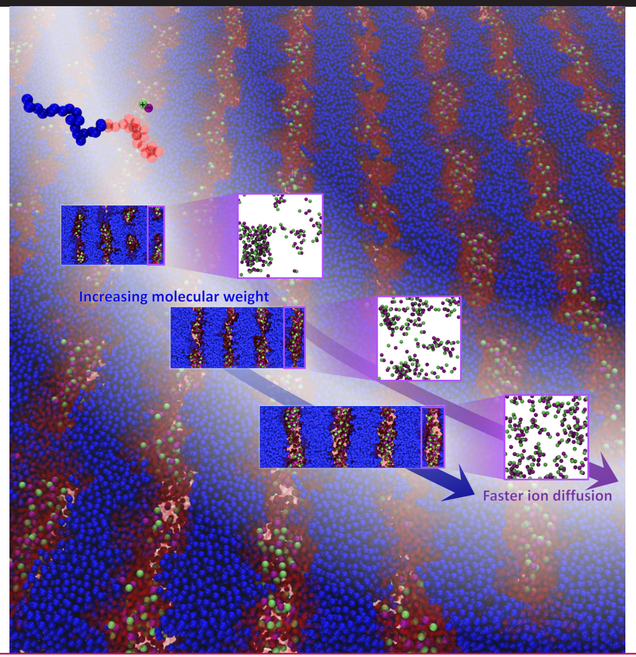
Funding:
- DOE: EERE, NETL; ODA

Recognition:
- A Special Issue in ***Powder Technology*** honoring L.-S. Fan, 2019.
- ***Foreign Fellow, Indian National Academy of Engineering***, 2019.
- ***Invited lecture, ETH Zurich***, "Granular Materials and Multiphase Reaction Engineering: a Gateway to Novel Energy Conversion Systems," April 2019.
- ***Opening Plenary Lecture***, UK/China International Particle Technology Forum VII, July 2019.
- ***Opening Plenary Lecture***, 14th International Conference on Gas-Liquid and Gas-Liquid-Solid Reactor Engineering, Guilin, China, May 2019.
- ***Banquet Speaker***, 16th International Fluidization Conference, Guilin, China, May 2019.

INCREASED UNDERSTANDING OF ION CONDUCTIVITY

Research: Lisa Hall's group applied their recently developed coarse-grained model of salt-doped diblock copolymers to understand why ion conductivity can increase with molecular weight. Across a variety of systems with different chemical parameters, ion conductivity was explained well by the degree of local ion agglomeration.

Impact: By detailing the underlying reasons for decreased ion conduction in certain salt-doped copolymer systems, we can help guide the design of more effective battery electrolytes.

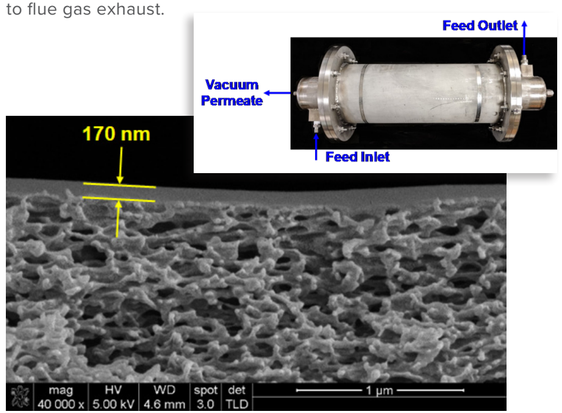


MEMBRANES FOR H_2 PURIFICATION AND CO_2 CAPTURE MEMBRANES FOR H_2 PURIFICATION

Innovation: W.S. Winston Ho's group has synthesized and demonstrated novel amine-containing membranes capable of possessing high CO_2 permeability and CO_2/H_2 and CO_2/N_2 selectivities at relatively high temperatures (100 – 180°C) for H_2 purification for fuel cells and CO_2 capture from flue gas in coal- and natural gas-fired power plants.

Impact: His group was the first to elucidate the unusual phenomenon of both permeability and selectivity increases with temperature and to demonstrate the effect of amine steric hindrance in the solid membrane, showing significant enhancement for CO_2 transport. They also showed the membranes stable to 1 – 5 ppm sulfur dioxide and nitrogen oxides in real flue gas.

One of the membranes is being commercialized by Bloom Energy for zero carbon electricity generation with solid oxide fuel cells, and another is being demonstrated in commercial-size 8-inch diameter membrane modules for flue gas CO_2 capture with support of more than $3.7 million from DOE, American Electric Power, and Ohio. The latter can capture carbon dioxide at a lower price than ever before, around $40 per metric ton, and an even lower cost of less than $30 can be achieved, if it only captures 70 percent of the carbon dioxide. This efficiency could attract more industry interest in applying carbon capture technology to flue gas exhaust.



Lisa Hall
Associate Professor

Publications:
- ***JACS,*** 141, 18455–18466, (2019).

Funding:
- Department of Energy
- National Science Foundation.

W.S Winston Ho
Distinguished Professor of Engineering

Publications:
- ***J. Membr. Sci.***, doi:10.1016/j.memsci.2018.12.028, ***573,*** 476-484 (2019).
- ***J. Membr. Sci.***, doi:10.1016/j.memsci.2019.01.024, ***575,*** 242-251 (2019).
- ***Ind. Eng. Chem. Res.***, doi:10.1021/acs.iecr.9b04839 (2019; invited).
- ***J. Polym. Eng.***, doi:10.1515/polyeng-2019-0298 (2019; invited).
- ***J. Membr. Sci.***, doi:10.1016/j.memsci.2019.117504 (2019).

Patents:
- Four patents issued, 11 submitted

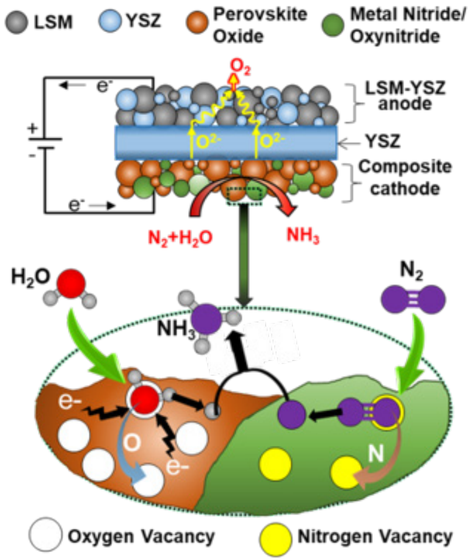
Funding:
- DOE-NETL, ODSA, AEP

Recognition:
- International Scientific Committee: ***Invited Member***, 12th International Congress on Membranes and Membrane Processes, London, UK (selected in 2019; scheduled: December 2020).
- 8th Symposium for Innovative CO_2 Membrane Separation Technology: ***Invited Keynote Lecture***, "New Amine-Based Facilitated Transport Membranes for CO_2 Capture, Tokyo, Japan, January 2019.

COMPOSITE CATHODE DEVELOPMENT FOR ELECTROCATALYTIC NH_3 SYNTHESIS

Innovation: Ozkan group developed composite cathodes that contain two phases, i.e., perovskite oxide and metal nitride/oxynitride to provide oxygen and nitrogen mobility/activation on the electrode surface for electrocatalytic NH_3 synthesis from N_2 and H_2O at atmospheric pressure. A patent was filed for the development of these composite cathodes.

Impact: High-temperature electrocatalytic production of NH_3 from N_2 and H_2O at atmospheric pressure in which the only byproduct is pure oxygen will allow a path for less energy-intensive, economically more feasible and environmentally friendlier production of ammonia compared to Haber-Bosch process.



INSIGHT INTO HETEROGENEOUS CONDENSATION OF CO_2 ONTO ALKANE

Discovery: Barbara Wyslouzil explored the heterogeneous condensation of CO_2 onto alkane nanodroplets and found that CO_2 does not condense until the pressures and temperatures are close to CO_2's extrapolated vapor-liquid equilibrium line and the alkane particles have started to freeze. Depending on the formation process, the resultant particles can adopt a core-shell structure or have CO_2 domains in the form of cubes or needles.

Impact: Natural gas can contain significant amounts of CO_2 as well as higher hydrocarbons. Supersonic separation is an alternative method to remove condensable material from natural gas. Understanding how and when different constituents in the mixture condense is important to improving the design and operation of these devices.

Umit Ozkan

Chair; College of Engineering Distinguiahed Professor

Honors:

- An endowed professorship in CBE was created in the name of Umit S. Ozkan with funds from a private donor.
- Honored by a special publication of ***Catalysis Today***, Volume 323, 270 pages, (2019)

Patents:

- Two patents filed in 2019-20.

Publications in:

- *Industrial & Engineering Chemistry Research,*
- *Applied Catalysis B:*
- *Catalysis Letters*
- *Catalysis Today*
- *International Journal of Chemical Reactor*
- *ChemCatChem.*
- *Advances in Catalysis.*

Barbara Wyslouzil

Professor, Chemical & Biomolecular Engineering, Professor, Chemistry and Biochemistry

Publications:

- ***Physical Chemistry Chemical Physics***, Journal of Chemical Physics
- ***Journal of Chemical Physics***, Editors' Choice Lecture, American Physical Society March meeting: "Nucleation of the short-chain n-alkanes from the vapor phase: Experiments and Monte Carlo simulations."

Recognition:

- ETHZ (top technical university in Switzerland), ***Guest professorship***, 2019.

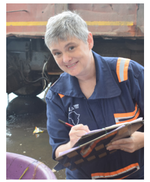
Alumni Highlights

AISHA BARRY, '95

The list of *2019 Most Influential Women in Corporate America* by ***Savoy*** magazine included CBE alumna and Advisory Board member Aisha Barry.

Barry is vice president/general manager and patient monitoring category leader at Philips Hospital & Health Care. Most recently, she was general manager and vice president for patient management in Medtronic's Cardiac Rhythm and Heart Failure Division. She held previous leadership roles at Deere and Company as well as key product development positions at Procter & Gamble.

JILL BOUGHTON, '88



After becoming intrigued by the problem of overseas waste management, Jill Boughton left a successful career at Procter & Gamble to found "Waste2Worth," which is helping to solve trash problems in the Philippines, Indonesia, Africa, India, and Thailand. Ingeniously, W2W converts waste into valuable resources that help local businesses, while simultaneously creating jobs. Her work was featured in the October 2019 issue of ***National Geographic***.

JOHN KUHN, '07 Ph.D.

Associate Professor John Kuhn, who also serves as associate chair of graduate studies, was one of 12 University of South Florida faculty to receive USF's *2019 Outstanding Research Achievement Award*.

Kuhn's research on heterogeneous catalysis and chemical reaction engineering applied towards upgrading waste gases, including biogas and carbon dioxide, has garnered national and international acclaim. He is currently leading a multi-centered research project funded with $1.8M by the Department of Energy.

KUNAL PARIKH, '12

Entrepreneur Kunal Parikh was named to ***Forbes*** magazine's 2020 list of *30 Under 30 - Healthcare*.

Parikh leads a team at Johns Hopkins that finds and commercializes biomedical solutions for unmet needs. Parikh founded his first company, Core Quantum Technologies, while working as an undergraduate in the lab of CBE's Jessica Winter. He recently created another company, Eyedea Medical, which aims to improve access for corneal transplants.

"I'm convinced that technology + entrepreneurship + compassion is the formula for transformative, long-term impact," said Parikh, who in 2015 won a Roche/ARCS Scholar Award at the National Academy of Sciences for the second year in a row.

Alumni Engagement

Loyal generosity

In 2019, alumni and donors contributed $2.6M in funds to the department. Average giving for the past three years has been $1.4M per year, with a median gift of $655 per donor.

Increasing commitment

Since 2017, annual giving from alumni has increased from $392,000 a year to $2.6M in 2019.

CBE Industrial Advisory Board Members

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Vice President and General Manager, Patient Monitoring Category Leader
PHILIPS

Rich Brandon
Global Supply Chain Director, Mergers & Acquisitions (ret)
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Linda Broadbelt
Sarah Rebecca Rowland Professor and Associate Dean for Research
NORTHWESTERN UNIVERSITY

Denise Burcham
Venture Manager
EXXONMOBIL CORPORATION

Terry Chern
Director of Technology
HONEYWELL INTERNATIONAL

Daniel Coombs
EVP, Global Olefins & Polyolefins and Technology
LYONDELL BASELL

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EVP, R&D (ret); Adjunct Professor
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Alissa Park
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Leonore Witchey-Lakshmanan
Principal Consultant
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Chairman Richard T. Schwarz

CBE Board Members, Fall 2019

Willam G. Lowrie

Nation's first female chemical engineering Ph.D. identified

FOUNDER OF RAMIE FIBER CHEMICAL DEGUMMING TECHNOLOGY WAS OHIO STATE ALUMNA

"A picture can say a thousand words..." But a few words of explanation are sometimes needed.

Such was the case when CBE staff member Geoff Hulse came across a 1929 photograph of AIChE students—which included two women.

Hulse had been perusing University Archives when found the 1929 picture. Chemical engineering was dominated by men at that time, so Hulse was curious. Who were these women?

Hulse found that one woman, Mary Bucher, had obtained her MS degree in 1930--the second woman to do so.

Even more interesting was Yun Hao ("Ruth") Feng, the first woman to graduate with a doctoral degree in chemical engineering at Ohio State—and, as it would later be shown, in the United States at large. Department and University records indicated that she had earned a master of science degree in chemical engineering at Ohio State in 1928, and a doctor of philosophy in chemical engineering in 1931, making her the earliest on record.

As the first US-trained female chemical engineer, Dr. Feng made great contributions to cellulose chemistry and the development and utilization of bast fiber (fiber from plants), promoting the development of China's fiber textile industry, particularly textiles made from the fiber found in ramie plants/grasses.

Dr. Feng devoted her life to the research and production of bast fiber from 1938 to 1988 and founded a ramie fiber chemical degumming and denaturation technology that helped alleviate China's textile shortage while utilizing unexportable ramie stockpiles that had been accumulating due to war.

In China, the fiber from the ramie plant has been used to produce thread and fabrics for thousands of years. The traditional retting method was to score the ramie skin chopped from the field, immerse it in water and allow natural fermentation, then knock, rinse and dry the ramie skin to obtain ramie fiber. Feng found a better method.

Following her training in the United States, Dr. Feng undertook further studies at the University of Berlin, where she conducted tests using samples of bamboo, sorghum stalks, straw, and other bast fiber from China. In 1935, using equipment at the Rayon Machinery Experimental Plant to conduct her research and after two years of painstaking research, she extracted the rayon from the pulp of the grass fiber. She found that ramie, which contains a large amount of colloid, is a good fiber material, but she wasn't able to completely remove the colloid from it, and the problem stuck in her mind.

> "The life of a scientist belongs to science." – Yun-Hao "Ruth" Feng

Returning to China in 1936, she began experimental research on the chemical degumming of ramie. In a later report entitled "The Biography of Yunsi," Dr. Feng described her motivation. She had witnessed the suffering of farmers who, due to war, had been unable to export agricultural products such as bast fiber, and speculated that the excess material could be used as a cotton substitute. Subsequently, "With this emotion and purpose, I determined to engage in fiber production," she wrote.

For the next several years, Yun-Hao Feng used simple and crude chemical equipment to conduct degumming tests, and finally found a method to make the raw ramie material degum uniformly. She summarized it as a process of "acid first, then alkali, boiling twice with bleaching once or twice."

Yun-Hao "Ruth" Feng (Ohio State MS '28, PhD '31) shown left, is believed to be the first woman to obtain a chemical engineering doctoral degree in the United States.

In 1939, she applied her alkaline denaturation method to denature ramie at the Chongqing Southwest Chemical Industry Manufactory to create "Yunsi" fiber. After chemical degumming, the ramie fiber is white, clean, loose, and shiny, and its shape is like clear white clouds. Therefore, the ramie-based cloth alternative she developed was named "Yunsi." It was a revelation—beautiful, smooth, and cool to the touch, "like meeting the spring in the snow."

The factory paid one million yuan to buy a small Indian-style spinning machine with which to make Yunsi towels, cloth, quilts, clothing, pads, and mattresses. For the first time, ramie fiber could be used in spinning and weaving with various fibers on existing machines and produce high-end goods. Yunsi products contributed to solving the clothing shortage during the War of Resistance, just as she had envisioned. The clothing and quilts were especially popular.

Feng's ramie chemical degumming process ended the traditional retting method. Her method was faster, more efficient, and ensured that quality would not be compromised during large-scale production. The process was used commercially in three textile mills in Chungking, China.

Dr. Feng became known as an expert throughout China, and the highest members of government sought her counsel. Chairman Mao Tse-Tung and other senior officials met with her periodically to discuss bast fiber and how to develop the textile industry.

Feng continued her research to further improve the material, and in 1960 developed another way to process ramie fiber: semi-viscous denaturation, i.e., sulfonation denaturation.

In 1980, per her request, the Ministry of Textile Industry and the Shanghai Municipal Planning Commission approved the establishment of a factory that combined research and production of sulfonation-denatured ramie fiber. A year after starting work on the project, she won third prize for the new process in the 1981 National Science and Technology Invention Awards.

By 1985, the Shanghai Ramie New Technology Factory was successfully producing six categories of nearly 200 varieties of fine and coarse textiles, woolen sweaters, T-shirts, shirts, and other denatured ramie fiber-blended products. This enabled the materials to enter the ranks of high-end, exportable textiles.

After 1983, the international demand for bast fiber fabrics increased continuously, and the domestic cultivation of ramie and industrial production of ramie fabrics also expanded.

By this time, Feng was 80 years old, but she still worked day and night, traveling the country to guide the denaturation, spinning, dyeing, and printing of various types of bast fiber such as flax, hemp, and jute.

On her 90th birthday, the Ministry of Textile Industry commended her tireless efforts, saying that she had made remarkable achievements and contributions to China's textile industry. "You are our role model for your perseverance on scientific research and for your painstaking efforts on utilization of the specialty of the homeland, the bast fiber," he wrote.

Dr. Feng died on December 14, 1988 in Guangzhou, having dedicated fifty years of her life to the research and production of bast fiber.

THE OHIO STATE UNIVERSITY
COLLEGE OF ENGINEERING

William G. Lowrie Department of Chemical and Biomolecular Engineering

314 Koffolt Laboratories
CBEC Building
151 W. Woodruff Avenue
Columbus, OH 43210

Phone: 614-292-4000
Fax: 614-292-3769
Email: cbe@osu.edu
Web: cbe.osu.edu

go.osu.edu/CBEfacebook
go.osu.edu/CBEtwitter
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