

Green hydrogen @Technion

Prof. Charlotte Vogt (Chemistry)

Prof. David Eisenberg (Chemistry)

Prof. Galia Maayan (Chemistry)

Prof. Avner Rothschild (Mater. Sci. & Eng.)

Prof. Yoed Tsur (Chem. Eng.)

Prof. Gideon Grader (Chem. Eng.)

Prof. Carmel Rotschild (Mech. Eng.)



Charlotte Vogt

Asst. Prof. Chemistry (2021)
Alma mater: Universiteit Utrecht



Core Competencies:

Spectroscopy, operando characterization experiment design, fundamental catalysis and data analysis

Power-to-X - Vogt et al. Nat.Catal. 2018, Vogt et al. Nat.Catal. 2019, Vogt et al. Nat.Comm. 2019.

Steam/dry methane reforming - Vogt et al. ACS Catal. 2020

Solid oxide electrolysis - ongoing research

Ammonia synthesis and decomposition - ongoing research



The Vogt Group
Technion - Israel Institute of Technology
"Catalysis for Fuels of the Future"



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David Eisenberg

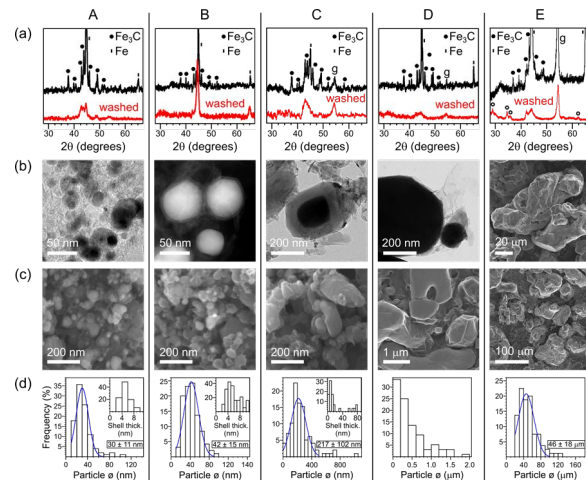
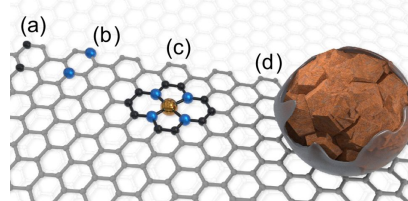
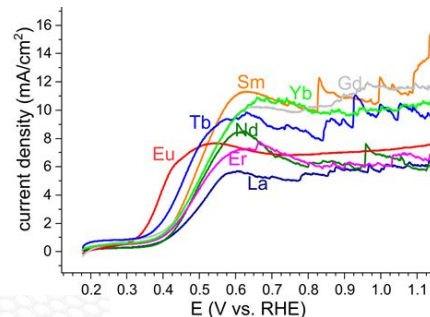
Assoc. Prof. Chemistry (Technion 2017-)
Electrocatalysis for fuel cells and electrolyzers

Core competencies:

- Electrocatalyst development and testing
- Material design, synthesis, characterization

Ongoing projects

- Green H₂ evolving electrolyzer assisted by urea-oxidation (Doral Energy Prize 2022)
- Ultra-stable electrocatalysts for H₂ evolution, O₂ reduction (fuel cell cathode), hydrazine oxidation (fuel cell anode), ammonia oxidation (fuel cell anode).
- Designing high power electrochemical devices by porosity engineering



Eisenberg Lab
Electrochemistry and Energy

www.david-eisenberg.com

Schulich Faculty of
Chemistry, Technion



Galia Maayan

Prof. of Chemistry

Bio-inspired oxidation Catalysis and Electrocatalytic Water Oxidation

- ISF Solar Fuels Research Grant
- Israel Ministry of Energy Grant
- Klein Research Prize for an outstanding research work that contributes to Israel
- Morton and Beverley Rechler Prize for Excellence in Research

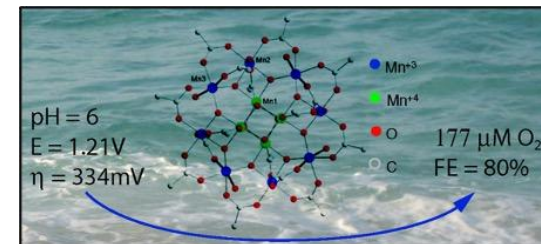
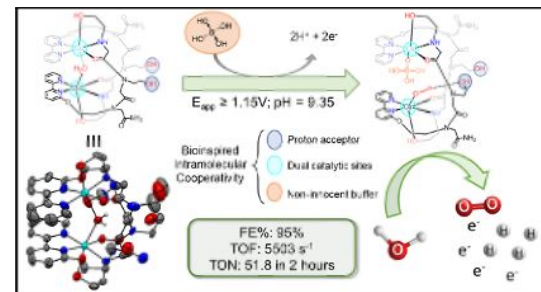
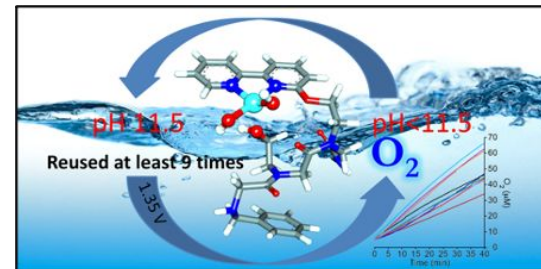
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- Design, synthesis and characterization of metallopeptoids and inorganic clusters
- Oxidation catalysis, electrocatalysis

Projects

- Bio-inspired water soluble and stable Mn-based clusters as homogeneous water oxidation electrocatalysts
- Copper and cobalt-based peptoid complexes as homogeneous electrocatalysts and photocatalysts for water oxidation





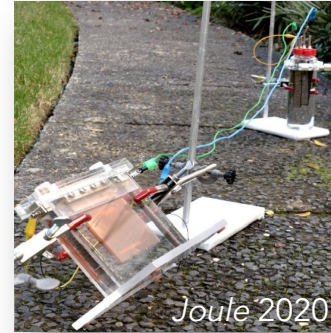
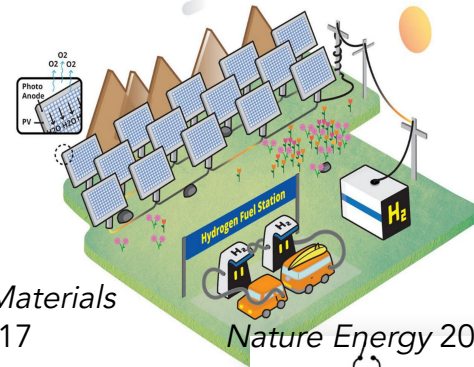
Avner Rothschild

- Prof. of Materials Science & Engineering
- Deputy SVPR for Sustainability
- Co-founder of H₂Pro
- 2× ERC grants on green hydrogen
- 3× EU consortia projects on green hydrogen
- Kavli fellow of the National Academy of Sciences (USA)
- Fellow of the Royal Society of Chemistry
- Israel Breakthrough Research Prize, Climate Solutions Prize (2022)
- Climatchallenge, Environmental Sustainability Innovation Lab (2022)
- RSC Horizon Prize (2022)
- Prime Minister's Prize for Global Innovation in Alternative Fuels for Transportation (2020)

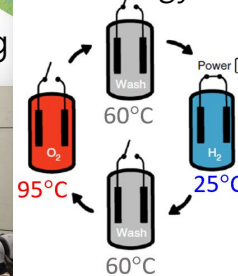
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Advanced materials & transformative processes for membraneless decoupled water splitting

- Centralized hydrogen production for photoelectrochemical solar hydrogen production



- E-TAC water splitting



H₂PRO

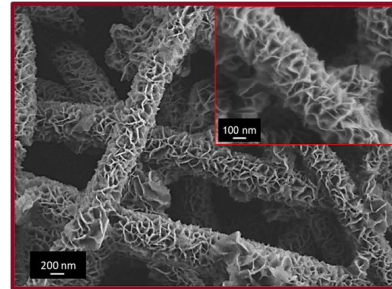


Gideon Grader

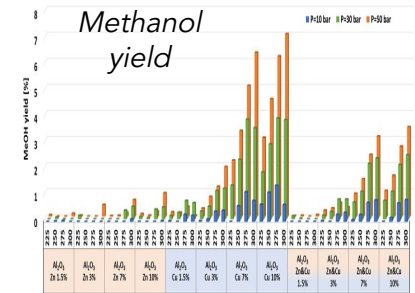
Synthesis and processing of materials for energy applications.
Membrane-free hydrogen generation.

- Prof. of Chemical Engineering
- Founder Cellaris (1999)
- Founding Director- Grand Technion Energy Program-GTEP (2007)
- Co-founder of H₂Pro (2018)
- Prime Minister's Samson Prize in Alternative Fuels for Transportation (2021)
- RSC Horizon Prize (2022)
- Charles defforey Grand Prize - Institute of France (2023)

- Hydrogenation of CO₂ to Methanol on Cu-ZnO catalyst



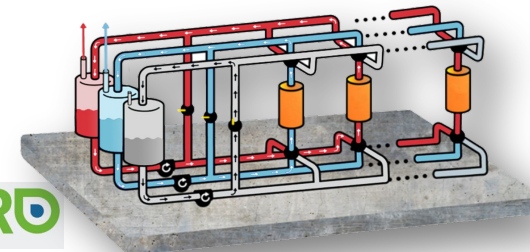
Nanoscale 2022



- E-TAC water splitting



Nature Energy 2019



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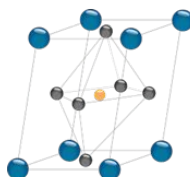
H₂PRO



Yoed Tsur

- Prof. of Chemical Engineering
- Co-director, Israel Research Institute for Energy: Electrochemical Storage.
- Co-editor in Chief, World Scientific Book Series in Current Energy Research and Education
- Director, Grand Technion Energy Program (GTEP) 2016-2023

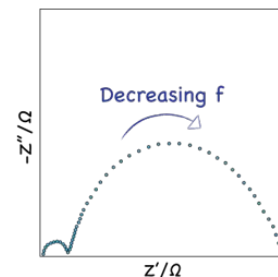
Oxide Materials



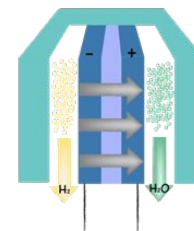
Point-Defect Chemistry



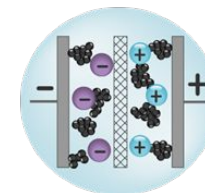
Impedance Measurements and analysis



Electroceramic Devices



Energy Research





Carmel Rotschild

Innovative EXTERNAL-heat engine based on bubbly media
The liquid increase 1000-fold power density (reducing size and costs)
The bubbles expand isothermal (doubling the efficiency)

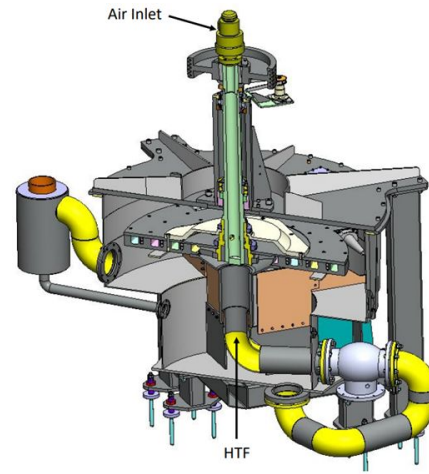
Applications:

- Prof. of Mechanical Engineering
- Co-founder of Luminescent heat engines
- ERC grant on solar energy
- Krill prize, and a few innovation awarded
- >50 patents

- **Waste heat recovery**
- **Carnot Battery for increasing capacity factors >6000 Hr/year of green Hydrogen production**

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Stewart and Lynda Resnick Sustainability Center for Catalysis



Catalysis

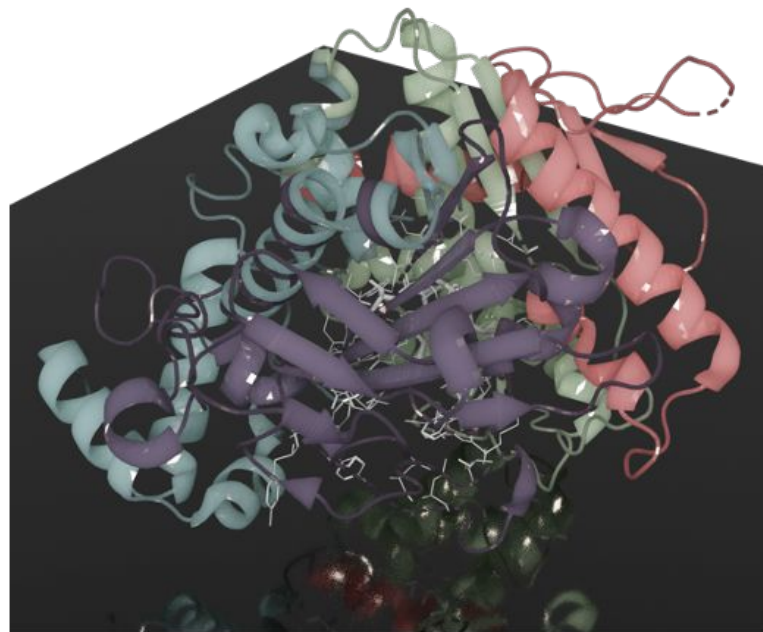
35% of GDP affected by catalysis

80% of the energy demand

75% of GHG emissions

Field of catalysis is split:

- Homogeneous catalysis
- Heterogeneous catalysis
- Biocatalysis
- ...

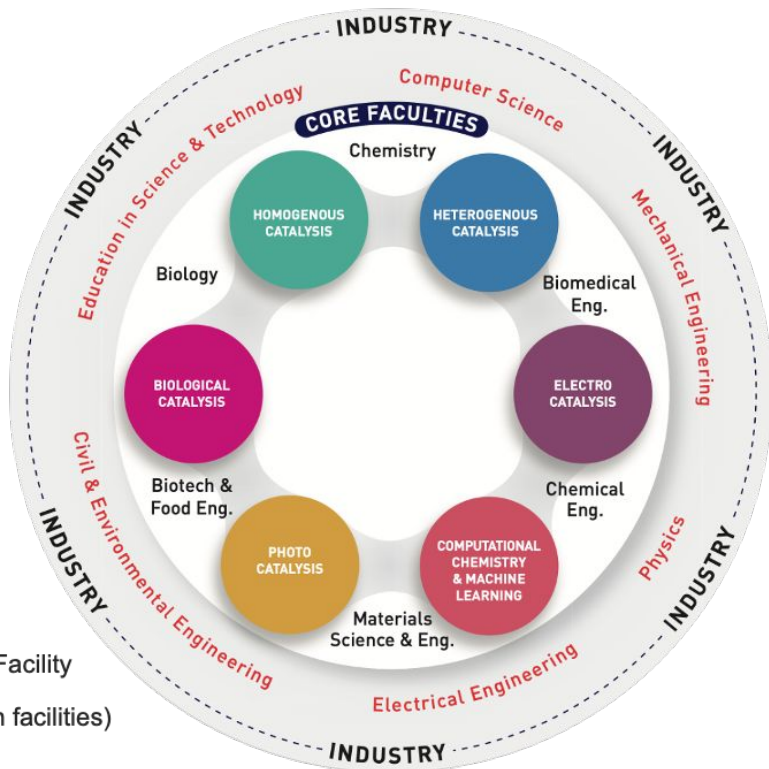


Enzymes – Nature's fully optimized catalysts

Catalysis at the Technion

Interdisciplinarity

- IRIS - Innovative Research Ideas Start-Up
- Industry-Academia Research Incubator
- Advanced Analytical and Spectroscopy Facility
- Heterogeneous Processes Facility
- Computational Chemistry and Big Data Facility
- Reaction Discovery and Catalyst Development Facility
- Incubator of young talents (open space research facilities)



Grand Technion Energy Program

Hydrogen lab

- § Gas-Chromatograph (GC) - Agilent 7890A.
- § Controlled Intensity Modulated Photocurrent Spectroscopy (CIMPS - Zahner Elektrik).
- § Solar Simulator - Abet, USA.
- § Kelvin Probe - NRH020 KP Technologies.
- § Ultrasonic Spray Deposition - ExactaCoat, Sono-Tek.
- § Electrochemical AFM, Asylum Research Cypher ES
- § Ivium nStat Potentiostat/ Galvanostat impedance analyzer.
- § Profilometer - DekTak Bruker + monochromator.
- § AutoChem 2920 Chemisorption Analyzer -Micromeritics + Mass spec.
- § TGA - SETSYS Evolution.
- § Vinyl anaerobic chamber - Coy lab products.
- § FTIR - Nicolet iS50 with ATR VEEMAX™ III, Pike technologies.

Fuel cells lab

- § Rotating Ring Disk Electrode (ALS)
- § Gravimetric Vapor Sorption Analyzer (TA Instruments)
- § Conductometer – Membrane Test System (Scribner)
- § SOFC Tester – High Temperature Test Station (Greenlight)
- § Polymer Electrolyte Membrane FC Test Stations (Scribner)
- § Dilatometer (Netzsch)
- § Semi-automatic Screen Printer (HMI)
- § Laser Cutter (Universal Laser Systems)
- § Planetary mono mill (Fritsch)
- § Glove Box (VTI)

Points for discussion (and follow-up)

- Academic research collaboration between Technion and Dutch universities:
 - Promotion of relationship through green hydrogen symposium (perhaps series of webinars); including seed funds for stimulation of collaboration.
 - To be followed up perhaps by other important topics.
- Tech-transfer and academia – industry relations
 - Learning from EIRES experience and extrapolation to Technion possibilities
 - Synergy through joint-use facilities
 - Understanding tech-transfer best practices
- Hydrogen valleys
 - Establish understanding on academia involvement in promoting the hydrogen valleys in the Netherlands
 - Pilot facility localization to enforce tech-transfer
- Joint educational programs: innovation (e.g., hackathons), lifelong education