Catalyzing CO₂ conversion into fuels and chemicals: Sustainable processes involving renewable energy

We design catalysts and reactors that can couple to renewable energy to convert CO₂ and H₂O into important chemical products. For example:

\[
CO₂ + H₂O + \text{renewable energy} \rightarrow \text{Chemicals}
\]

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Slag to PCC pilot plant

Mika Järvinen
Utilization of steel slag and CO2

We used ammonium chloride (salmiak) water solution to dissolve calcium from the slag powder with 0.25 mm particle size (annual slag production 150 Mt).

We filter the mixture to get a clean solution.

We bubble CO₂ through this clean calcium ritch solution and as product of reaction we get precipitated calcium carbonate PCC.

Produced PCC can be sold to paper, plastic or medical industry.

Annual global need 14 Mt heavily increasing.
What key reactions affect the safety and efficacy of geologic CO₂ sequestration?

Wet scCO₂-driven interactions

- Reacted mica: pits and new layer inside of pits

Wellbore interactions

- CO₂ injection
- H₂S
- CO₂
- Cement grout
- Well
- Cement well plug

Caprock layer

Acidified brine induced reactions

- Pre-existing rocks
- Secondary minerals

Acidified brine regime

- CO₂ dissolution
- Acidified brine regime

Pristine formation rock & brine regime

Young-Shin Jun
Washington University in St. Louis
Optimizing a Time-variant Electricity Tariff for Demand Response in Smart Grids

András Kovács
Institute of Computer Science and Control, Budapest, Hungary

- Demand response management
  - To balance electricity demand & supply

- Stackelberg game model
  - Grid operator (leader) announces tariff
  - Consumers (followers) respond by consumption

- Bilevel programming model
  - Successive linear programming solution approach
Can we move beyond thermal-based separation processes?

Ryan P. Lively, School of Chemical & Biomolecular Engineering, Georgia Institute of Technology

- **Ashkelon Desalination Plant**
  - ~2.0 Mbbl/day
  - State-of-the-art membrane plant
  - Seawater reverse osmosis (SWRO) has displaced thermal methods

- **World scale refineries**
  - ~1.0 Mbbl/day
  - Atmospheric distillation of crude: ~130 GWTh

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Can engineering solutions—inspired by SWRO—be applied to organic liquid feeds?

2. WJ Koros, RP Lively. *AIChE J.* 2012, 58(9)
Demand for wireless broadband is exploding

Spectrum is a limited resource

**How do we increase the spectral efficiency per unit area?**
- Massive multiple-input multiple-output (MIMO)
- New frequencies
  - Millimeter wave
- Dealing with EM exposure constraints
- Leveraging many devices/nodes for distributed MIMO
- Spectrum sharing and software radio
Improved access to diagnosis through computer vision, clinical informatics, and artificial intelligence

Lundin Group at FIMM
- Digital diagnostics
- Deep learning
- Connected devices
- Big image data
- Big clinical data

Johan Lundin, MD, PhD
My research goal is to address scientific questions to enhance understanding of complex systems.

The research hypothesis is that we can reverse the physical bottom-up emergence and develop decentralized control algorithms to optimize and control complex systems.

The emphasis is on applications related to energy and transportation.
Fe@CNT catalysts for CO₂ conversion to hydrocarbons – Davide Mattia

Fe@CNT: iron nanoparticle – carbon nanotube catalyst prepared in a single-step reaction on cordierite supports:
- direct conversion to hydrocarbons in one reactor
- high olefin/paraffin ratio
- high conversion to hydrocarbons
- low pressure drop and high mechanical stability

MEETING WATER & ENERGY DEMAND IN A CARBON CONSTRAINED WORLD

Re-think the Policies
Optimization of emerging energy and water infrastructure networks

Re-define the Process
Integration and process intensification of separations in water and energy systems

Re-envision the Materials
Membrane development to enable energy efficient processes

Aligned Nanocomposites for High Flux, High Selectivity Separations

Nanoscale Heterogeneities for Antifouling Membrane Surfaces

High Porosity Aerogels for Membrane Distillation
Biomechanics of bone and joints

Mehran Moazen (contact: m.moazen@ucl.ac.uk)

Aim: to understand the underlying mechanisms of bone and joints growth, adaptation and repair.

challenges/ questions

example of computational and experimental methods used

- image processing
- multibody dynamic analysis
- laser speckle interferometry
- finite element analysis
- nanoindentation
- pressure measurement
Use of microneedles for drug delivery and sensing

• we have examined the drug delivery and biosensor applications of polymeric microneedle arrays with a goal of creating sense-treat devices

• we have examined creating arrays of microneedle sensors that may used for real-time detection of pH and physiologically-relevant molecules in a minimally invasive manner

• for example, we have used microneedles for detection of glutamate and glucose with high selectivity, sensitivity, and stability in undiluted human serum

• in another study, selective and simultaneous monitoring of glucose, lactate, and pH in complex media was demonstrated

• devices that can determine patient chemistry in a real-time manner may facilitate understanding of both acute and chronic medical conditions as well as facilitate personalized treatment
Disarming the Trolley Problem
- Why Self-driving Cars do not Need to Choose Whom to Kill

Dr. Jonas Nilsson
Dependability for Highly Automated Driving
Volvo Car Group
Rapid prototyping of medical devices

- use of rapid prototyping technologies such as two photon polymerization (2PP), laser printing, stereolithography, and inkjet printing to create novel medical devices, such as:
  - 2PP of tissue engineering scaffolds with precise geometries (e.g., scaffolds made of hydrogels, zirconium oxide hybrid materials, and elastomers)
  - 2PP of ossicular prostheses
  - 2PP of microscale tissue joining barbs
  - laser printing of cells and scaffolds
  - inkjet printing of adhesives (e.g., mussel adhesive proteins)
  - inkjet printing of drugs (including drugs with poor solubility in water such as miconazole) on microneedles for transdermal delivery; this approach may be used for creating devices for personalized dosing