# Making Materials That Hate Water to Love Water:
# The Transformative Power of Chemistry

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Chemistry plays a key role in keeping us healthy. Some aspects of this are obvious, such as the making of drugs to fight disease or the purifying of water for drinking, but other aspects are much more subtle. This talk will describe one current research project in my laboratory related to human health: the making of better blood collection tubes. Today blood collection tubes are made of plastic, specifically, polyethylene terephthalate (PET). Like Teflon and unlike glass, the surface of PET repels water and causes other molecules that hate water to stick to its surface. This interferes with various blood analyses. I will describe a simple chemical procedure to transform the surface of PET to make it glasslike so that it loves water and prevents sticking.

# Nanoscience and the future of the Carbon Cycle

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Nanoscience provides us with a systematic approach for designing new energy conversion systems, and will be a key component in the effect to establish a balanced global carbon cycle. This talk will show recent work on such examples: a luminescent concentrator that could be used for low cost but highly efficient solar energy conversion, and a catalytic network that could be used for $CO_2$ reduction to hydrocarbons.

# Thin-Film Organic Semiconductors for Energy-Economic Electronics

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Pi-conjugated organic molecules and polymers now provide a set of well-performing semiconductors that support devices, including light-emitting diodes (LEDs) as used in smart-phone displays and lighting, field-effect transistors (FETs) and photovoltaic diodes (PVs). These are attractive materials to manufacture, particularly for large-area applications where they can be processed by direct printing, so that the cost of materials and processing can be very low. This practical success is made possible by breakthroughs in the understanding and engineering of the underlying semiconductor science. The physics of organic semiconductors is often controlled by large electron-hole Coulomb interactions and by large spin exchange energies. Management of excited state spin is fundamental for efficient LED and solar cells operation. I will discuss in particular some recent progress made in splitting high energy singlet excitons to pairs of infra-red triplet excitons and their subsequent use in solar cells.

# From Molecules to Efficiency of Process Units

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The energy efficiency of a process unit, like distillation columns or chemical reactors that are used in engineering flow sheets, arises from the transport phenomena that take place inside the unit on a molecular level. The production or separation of chemical products can, for instance, be hampered by the rate of heat transfer to the distillation column. An efficient design of the column or reactor will have to take this into account. It is well known from an overall point of view that it is better to add heat at the lowest possible temperature and/or extract heat at the highest possible temperature. But not much has been done to actually find the most energy efficient way to operate such process units. In this talk, I will describe how such a state can be found using non-equilibrium thermodynamics. Some surprising properties of the state will be described. There is for instance a "highway in state space" for energy efficient operation in some cases. Materials with properties that lead to higher efficiencies are of interest. Consequences for the society will be discussed.

# The Ribosome: Life's Vital Bonding Machinery

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Ribosomes, the universal cellular machines, possess spectacular architecture accompanied by matching inherent mobility, allowing for their smooth performance as polymerases that translate the genetic code into proteins. The site for peptide bond formation is located at the ribosome core within a universally conserved semi- symmetrical region. The high conservation of this region implies its existence irrespective of environmental conditions and indicates that it may represent a prebiotic RNA entity with catalytic capabilities. This region, alongside other ribosomal functional sites, is targeted by various antibiotics. Attempts at improving these antibiotics, at designing novel therapeutics and combating antibiotics resistance, are in progress. Additionally, as it was found that some of the most problematic mechanisms for acquiring antibiotic resistance are species specific, we recently determined the first high resolution structures of a ribosome from genuine multi-resistant pathogen in complexes with several antibiotics.

# Concentrating Solar Thermal Power - Pros and Cons

Erik Pihl

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Renewable energy is a key solution for supplying a growing world population with energy, while avoiding dangerous climate change. No renewable resource is by far as great as direct sunlight, viewing how much solar radiation that hits Earth and how much land that is available. Wide-scale adoption has historically been hindered by high costs, compared to fossil power. However, the last decades the costs have gone down significantly and solar power is about to be cost-competitive. Other obstacles now become more important to address: the variability of power production over time and, in the long run, scarcity of some of the materials that solar cells are made of.

A solution may be found in the use of concentrating solar power (CSP). CSP systems are based on heat cycles, using mirrors or lenses to focus the sun's radiation to high temperatures (in contrast to solar cells, which use the photovoltaic effect). The concentrated light warms up a heat transfer fluid (HTF), usually oil or salts in a molten state. Heated HTF can be stored in tanks for several hours, to be used when it's needed. With this kind of heat storage, CSP plants can make steam and produce power in the middle of the night. This means that they can balance the daily variations of other renewable energy.

How do CSP relate to material scarcity? We calculated the material used to build two types of commercial CSP plants and compared with the global reserves and production volumes of critical materials. The results show that the material reserves are enough to build a stock of CSP plants that produces at least 5 times the current worldwide electricity production. A scenario was tried where CSP plants grow to reach 8000 TWh/y production by 2050 (35% of current electricity production). Such a growth would mean that CSP eventually consumes 14% of the world's current nickel production, 25% of the niobium, and more than all nitrate salts. Another critical material is silver, used to create high reflectance on all the mirrors.

Material use in plants is likely to change as the technologies develop. High-tech materials are being researched for several applications in CSP. The use of metals will change as superalloys are adopted for the steel components, in light receivers and turbines. By adding nano-scale materials to known fluids, or screening many thousands of mixtures of macro-scale salts, researchers are working to develop heat transfer fluids with higher heat capacitance. For instance, the US National Renewable Energy Laboratory is developing nano-scale structures of embedded metals with a ceramic-like outer coating that can be suspended in fluids. Such materials could increase the heat capacity of HTFs by a factor of 5. There are also suggestions for use of nano-materials to increase receiver absorption or to make self-cleaning mirrors. Although many of these technologies are today based on rare elements, it is likely that the long-term development will enable higher use of solar power technologies and provide a part of the solution to clean energy for all.