INSTITUTE OF CHEMICAL SCIENCES AND ENGINEERING

NEWSLETTER 2013

ÉCOLE POLYTECHNIQUE
FÉDÉRALE DE LAUSANNE

NEWSLETTER 2013

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MESSAGE FROM ISIC DIRECTOR PAUL DYSON

INSTITUTE OF CHEMICAL SCIENCES AND ENGINEERING CH BUILDING, EPFL, LAUSANNE

The last 12 months has been another exceptional period for ISIC. Like EPFL as a whole, we're continuing to grow. We're adding professors, accumulating more and more external funding and playing an increasingly important role in the satellite campus set to open in Sion. Indeed, given how many exciting things have happened in the last year, it was particularly difficult to select items for this newsletter—we can include only some of the many highlights.

These include the hiring of assistant professor Beat Fierz in biophysical chemistry, thanks to the generous support of the Sandoz Family Foundation. You can read more about his research activities in this issue. We also have two new adjunct professors: Oliver Kröcher, a chemical engineer and head of the Bioenergy and Catalysis Laboratory at the Paul Scherrer Institute, and Dominic Tildesley, who currently heads CECAM, the European Centre of Atomic and Molecular Computations.

You can also find out more about the incredible period we've had in terms of research activities in all domains. The creativity and innovation of our faculty and researchers is breathtaking and this directly transfers into a first-class educational experience for all. External funding continues to grow, which comes as no surprise considering the number and quality of publications and patents from ISIC collaborators. The frequency of publications in *Science*, *Nature* and their sub-journals—a clear indicator of excellence—has reached an all-time high. A few of these papers are highlighted in this issue.

ISIC faculty are also taking a leading role in the new EPFL satellite campus set to open in Sion. The first phase of this exciting development is centered on chemistry for energy: chemical approaches to storing and converting energy will become increasingly vital in an energy landscape that relies on intermittent renewable energies. A unique team of researchers, including a number of new faculty members, will initiate integrated research activities towards the end of 2014.

As always, we distribute this newsletter with great pleasure and hope you enjoy reading it. Please be sure to visit our website http://isic.epfl.ch for more news and information concerning forthcoming events that might interest you. Your comments are welcome, sent either by e-mail to secretariat.isic@epfl.ch or by regular mail at the address below.

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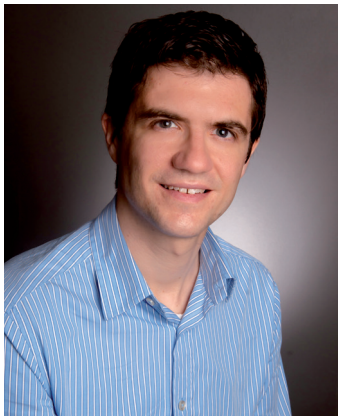
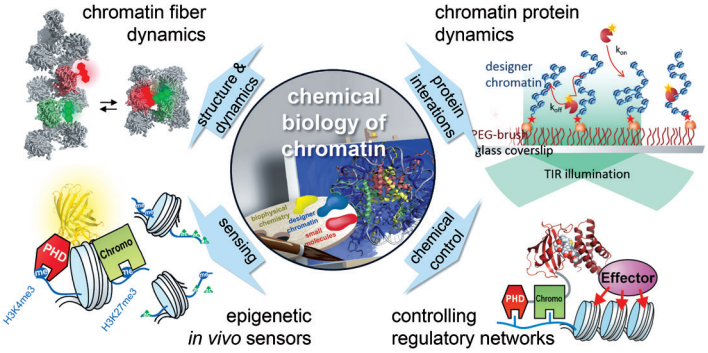
ASSISTANT PROFESSOR FIERZ'S CHROMATIN RESEARCH MAY LEAD TO NEW DRUGS



Beat Fierz, ISIC's new tenure-track assistant professor of Biophysical Chemistry, was once torn between being a doctor and a scientist. Though he eventually realized his interest lie more in understanding why things happen at fundamental levels, his current research may nonetheless contribute to saving lives.

Fierz's work, funded by a generous grant from the Sandoz Family Foundation, looks at how chromatin—the functional form of the genetic material formed by DNA and proteins found in the nucleus of a cell—is regulated by chemical modifications such as methylation, acetylation or even the attachment of small signaling proteins like ubiquitin. What is already clear is that the histone protein, chromatin's main component, is heavily affected by such chemical processes and that these modifications can alter the chromatin structure and protein expression without changing the underlying DNA sequence itself.

This epigenetic process is critical because it is involved in cell differentiation, stem cell maintenance and organ development—it is therefore linked to disorders including cancers and neurodegenerative diseases. The pharmaceutical industry has already started using knowledge about chromatin regulation to produce medicines that work in novel ways. New compounds such as histone methyltransferase or bromodomain inhibitors interfere with the machinery that leads to these modifications.



"The recent surge in interest for some epigenetic drugs and their clinical promise has shown that a deeper understanding of chromatin regulatory mechanisms can lead to helpful compounds and treatments," said Fierz, who completed his undergraduate work and PhD at the University of Basel. "I hope that our research shows which parts of this whole machinery are important and what exactly contributes to which biological effects. Hopefully this will help in identifying new targets and understanding disease mechanisms."

While biological experiments are generating more and more data showing clear correlations, the molecular details of the processes are still poorly understood. Fierz is trying to change that with methods he first acquired and developed during his post-doc at Rockefeller University and Princeton University in the U.S. While there, he figured out how to chemically modify synthesized histone proteins at precise spots and how to study chromatin folding using spectroscopic methods in real time. These methods allow researchers to produce a given chromatin state in a test tube, investigate the interactions on the thermodynamic and kinetic levels, and observe what biological effects they have through fluorescent biophysical assays. He has already been able to show that certain modifications have direct effects on the structure of chromatin fibers.

His work at EPFL is focused on the chromatin effect in gene silencing and DNA repair, with a specific emphasis on the kinetic aspects. He wants to know not only whether specific biomolecules interact with chromatin and what structures result from such interactions, but also how tightly these interactions are, and how long they last. A further challenge is relating measured in vitro values of the processes to those that are produced in the living cell. Fierz is therefore designing modular protein-based probes that allow researchers to follow chromatin processes in real time through microscopy.

"Life's never in equilibrium, it's always in flow," he said. "If you really want to understand the system you have to look at the kinetics. If, for example, an enzyme gets recruited to a certain site and has to perform a chemical reaction, how long does it stay there to do what it has to do? These things are best measured in kinetic experiments."

"LIFE'S NEVER IN EQUILIBRIUM, IT'S ALWAYS IN FLOW. IF YOU REALLY WANT TO UNDERSTAND THE SYSTEM YOU HAVE TO LOOK AT THE KINETICS."

The biggest challenges of his work lie in the intricacy of the systems, which feature complexes made up of some 100 proteins. The systems are hard to work with, single experiments have a lot of moving parts and having everything ready at the same time involves considerable work and careful planning, Fierz says. Such approaches are, however, required to address the complexity of biological systems and obtain relevant information about the underlying mechanisms.

"I am fascinated by the complex biological machinery regulating chromatin function," he said. "Now, applying an interdisciplinary approach combining chemistry and biophysics, we can obtain a quantitative understanding of these processes that are integral to life."

ADJUNCT PROFESSOR KRÖCHER LOOKS TO BIOMASS TO PRODUCE LIQUID FUEL

Oliver Kröcher, newly appointed adjunct professor at EPFL, had a chemistry lab in the basement of his parents' house when he was just 12 years old.

"I was doing my own experiments and I loved it because it was a completely new world for me," he said. "This exploration gave me deeper insight into the building blocks of materials all around."

Kröcher followed up on his youthful interest with undergraduate studies at the University of Würzburg in Germany. He wanted to continue with a PhD but, at the time, his alma mater only offered classical courses in organic, inorganic and physical chemistry. Kröcher was more interested in practical, industrial applications and so jumped at the chance to move to ETH Zürich to focus on catalysis. He completed his thesis on "Synthesis of Formic Acid Derivatives by Catalytic Hydrogenation of Carbon Dioxide" under Alfons Baiker at the Department of Chemical Engineering and Industrial Chemistry. Sufficiently enthused by the subject matter, he went into industry, working for Degussa AG and learning more about how catalysts—decisive factors for most industrial processes—are applied practically.

"LIQUID FUELS ARE REALLY THE AIM OF MANY PEOPLE IN OUR SOCIETY—DEVELOPING CATALYTIC PROCESSES AT EPFL THAT PRODUCE LIQUID FUELS FROM BIOMASS IS MY OBJECTIVE FOR THE FUTURE."

He enjoyed the time, and learned a lot, but five years later, he was ready to return to academia. A spontaneous application led him to a group leader position at Paul Scherrer Institute (PSI), where he has been ever since. Now head of the Bioenergy and Catalysis Laboratory, a position he will keep, Kröcher is set to join EPFL, eventually working 20% at the satellite campus that will open in Sion.

The new position will allow him to further develop the research he's doing at PSI, get increased contact with students and give him more opportunities to make critical connections with Swiss industry. EPFL will in turn benefit from his extensive expertise.

Kröcher's original work at PSI was focused on exhaust gas treatment, a field that's relevant to energy production because it involves applying catalysts to clean combustion processes that generate energy. Beyond that, he has for three years been head of the Bioenergy and Catalysis Laboratory that includes groups looking at biomass conversion for energy purposes. This exposure broadened his research interests towards developing processes and catalysts for energy storage and conversion in general.

For his appointment at EPFL, Kröcher had to figure out how to create a research focus that is both new and still strongly linked to his existing activities. The answer lay in expanding PSI's work on the conversion of biomass to biomethane to include the production of liquid fuel—a topic that other groups in Sion will also be working on from different, but related, approaches.

"Not everyone wants to use methane, some people prefer liquid fuels, which may be advantageous, for example for vehicle applications," he said. "Liquid fuels are really the aim of many people in our society—developing catalytic processes at EPFL that produce liquid fuels from biomass is my objective for the future."

This work is, he says, a natural extension of his work at PSI because the intermediates are usually the same. The process starts with biomass gasification and generates an intermediate synthesis gas, a mixture of carbon monoxide and hydrogen, and either methane or liquid biofuel can then be produced from it.

"WORKING AT EPFL IS AN EXCELLENT OPPORTUNITY TO COOPERATE WITH OTHER RESEARCHERS WHO SHARE MY OBJECTIVES OF CREATING ENERGY CARRIERS MUCH MORE EFFICIENTLY THAN WE CAN PRODUCE TODAY."

The liquid biofuels Kröcher would like to target first are polyoxymethylene ethers because they have advantageous combustion properties and do not produce harmful emissions. They are also easy to produce from intermediate gases because they contain a lot of oxygen, which is usually contained in the biomass. Many synthesis processes aim to extract the oxygen from the biomass: if oxygen is, on the other hand, part of the desired final product, it's much easier to just leave it in the biomass conversion route.

These polyoxymethylene ethers also have a high added value because they are meant as a kind of additive to gasoline or diesel. They would be produced in smaller quantities and would be more expensive than gas or diesel—this would in turn be a business case for the Swiss chemical industry.

"In Switzerland, we can't compete with large scale production in the U.S. or in Germany or elsewhere, but Swiss industry is very often interested in having a product that has high added value," he said. "These polyoxymethylene ethers could be such a product that could be produced here."

Indeed, Kröcher plans to meet with industrial partners in the Valais and throughout Switzerland to develop ideas that lead to marketable products. A critical element of process development for liquid biofuels is to design simple production processes, ideally involving one-step syntheses, a feat that could be achieved by catalysis. The challenge here is increasing the overall efficiency of the process and maximizing the energy content of the final products with respect to the energy content of the used biomass feed.

"We have so little biomass, we cannot afford to lose most of the energy content through complicated processes with a lot of different steps," he said. "Working at EPFL is an excellent opportunity to cooperate with other researchers who share my objectives of creating energy carriers much more efficiently than we can produce today."

CECAM'S NEW DIRECTOR TILDESLEY HAS BIG PLANS FOR WORKSHOPS, TRAINING

Dominic Tildesley was a young graduate student when he first visited the European Center for Atomic and Molecular Computation (CECAM) in 1974. Now, nearly 40 years later, he's directing it.

What impressed him so much then—the establishment of an outstanding venue where leading scientists could get together for a period of time, work on challenging problems and try to solve them—continues to motivate him today. This guiding principle still belongs at the very heart of CECAM, whose main mission is to guide the application of powerful computational methods to problems in science and technology, he said.

"I want CECAM to be Europe's leading forum for the discussion and solution of problems in simulation and modeling," he said. "It should also be the leading place for post-graduate training in the field."

Tildesley completed his PhD in liquid state theory at the University of Oxford before postdocing at Penn State University and Cornell in the U.S. He then moved on to professorships at Southampton University and Imperial College before joining Unilever, the world's second-biggest consumer-goods maker, in 1998. He retired from the company last year and then, realizing that he's "not the retiring type," jumped at the opportunity to take over the CECAM directorship.

"CECAM had a significant influence on me when I was a young man," he said. "It's quite a privilege and a pleasure to be back."

The simulation and modeling of problems, particularly in chemistry and physics has interested Tildesley throughout his career, and the field is continuing to grow in importance as the number of potential applications continues to soar. "Because Moore's law is still going strong, technology is getting to the point where it is possible to simulate on the timescale of a second, and to follow events such as the folding of a protein," he said.

"Experiment and theory have always stood as the two essential paradigms of science," he said. "Since the invention of computers, speed has increased to the extent that we can expect a third paradigm: computer simulation and modeling will connect experiments and theory even more strongly"

Tildesley's initial focus at CECAM is on building up a series of workshops that bring together people who are "not afraid of white space" to sit and discuss pressing problems in their fields. The challenge is figuring out how to create the sort of atmosphere that allows for this within the time constraints most people face today.

"Time seems to be more precious now than it was in the 1970s," Tildesley said. "Making a commitment to come away for more than three days is difficult, especially for senior people, and we have to find a way of recreating this workshop experience in shorter periods of time."

One approach to accomplishing this may be to have senior people come and join workshops for a few days at a time, providing the expert guidance that may allow more junior researchers to tackle the problems over the longer term. New methods of communication may also mean it is possible to run longer workshops without people having to leave their homes.

"I WANT CECAM TO BE EUROPE'S LEADING FORUM FOR THE DISCUSSION AND SOLUTION OF PROBLEMS IN SIMULATION AND MODELING."

In addition to the workshops, Tildesley also plans to broaden the range and scope of the tutorials CECAM holds for students every year. His plans are big, and he admits that things wouldn't run smoothly without the support of his excellent staff in particular, and from EPFL faculty and administration in general.

Going beyond workshops and conferences, the new director would also like the institute to provide the European research community a "very clear road map" of where the field is going. He hopes CECAM can provide advice not only about the field's future directions, but also about what sort of hurdles may be standing in the way and how the community might look to surmount them. Such advice would be invaluable to those trying to figure out how to allocate research funding, he said.

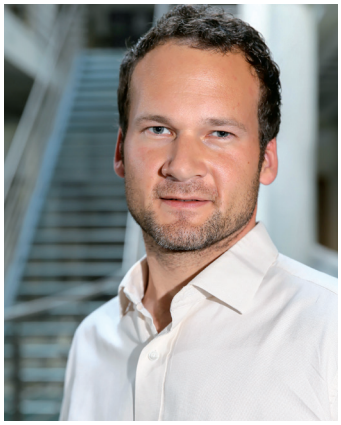
"Being able to have that influence across Europe, helping to shape the direction of the field over the next 10 years or even more—that's what gets me out of bed in the morning," Tildesley said.

The final element of Tildesley's vision for CECAM involves strengthening its relationship with European industry. He hopes that CECAM can eventually support industrial modeling by giving partners a clear view of what can reasonably be accomplished with such techniques. He envisions bringing a series of non-competing industries together, discussing their most serious problems and looking for solutions.

"With access to 500 or 600 academics, there's almost certainly someone who can help with a given topic," he said. "We offer the advantages of first class knowledge, really good advice and introductions to young scientists who they might consider employing in the future."

ISIC PUBLICATIONS IN *SCIENCE, NATURE* REACH ALL-TIME HIGH

Cramer Lab Solves Decades-old Problem with Chiral Catalyst



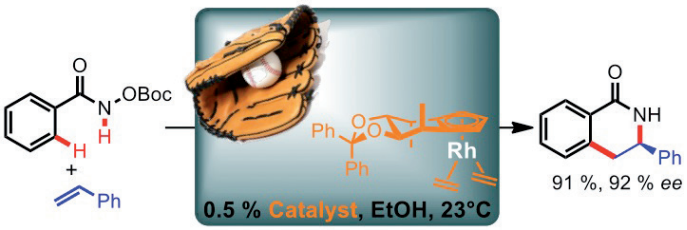
With their novel chiral catalyst, Nicolai Cramer and his PhD student Baihua Ye solved a problem that has vexed organometallic chemists for some 30 years.

A paper published in the October 26 issue of *Science* described their development of chemical modifications that introduce chiral features to cyclopentadienyl (Cp) ligands. The work gives chemists a means of selectively making bioactive enantiomers with one of the most versatile organic ligands for rhodium, itself one of the most synthetically useful transition metal catalysts. This hasn't been possible before.

Cyclopentadienyl ligands are versatile catalysts that are widely used in organometallic chemistry. While chiral Cp ligands had previously been used for asymmetric catalysis with early transition metals such as zirconium, no one had figured out how to create such ligands for late transition metals such as rhodium. The main hurdle involved designing ligands with substituents that don't compete with reactants for the limited metal coordination sites, but still effectively control the orientation of the reactant.

Cramer and Ye overcame the problem with a rhodium catalyst coordinated by a chiral Cp ligand featuring a symmetrical benzophenone-cyclohexenyl substituent. Selectivity was made possible by three critical features: the use of a C_2-symmetric ligand avoided the formation of two isomeric metal complexes; the bulk of the Cp ligand restricted rotation, allowing for preferential alignment of substrates; shielding from a remote substituent helps guide the approach of reactants so rhodium was bound one side only. This design allowed Cramer and Ye to carry out rhodium-catalyzed carbon-hydrogen (C–H) functionalization reactions to prepare single-enantiomer products. The resulting complexes proved to be highly enantioselective catalysts for directed C–H bond functionalizations of hydroxamic acid derivatives.

"THIS WAS THE FIRST PROOF OF PRINCIPAL THAT THE CHIRAL CP LIGAND WORKS. WE NOW HAVE MANY MORE OPPORTUNITIES."



"This was the first proof of principal that the chiral Cp ligand works," Cramer said. "We now have many more opportunities. It took about 30 years to get to that one transformation but after just another half a year or so, we have another that works equally well with those catalyst families. We can now look at a lot of different metals."

The work has opened the door to a number of potential applications, Honggen Wang and Frank Glorius of the Organisch-Chemisches Institut of the Westfälische Wilhelms-Universität Münster said in an accompanying comment in the publication.

Because Cp is frequently responsible for the stability and reactivity of middle or late transition metal complexes that are synthetically useful, the successful design of chiral Cp derivatives will offer tremendous opportunities, they said.

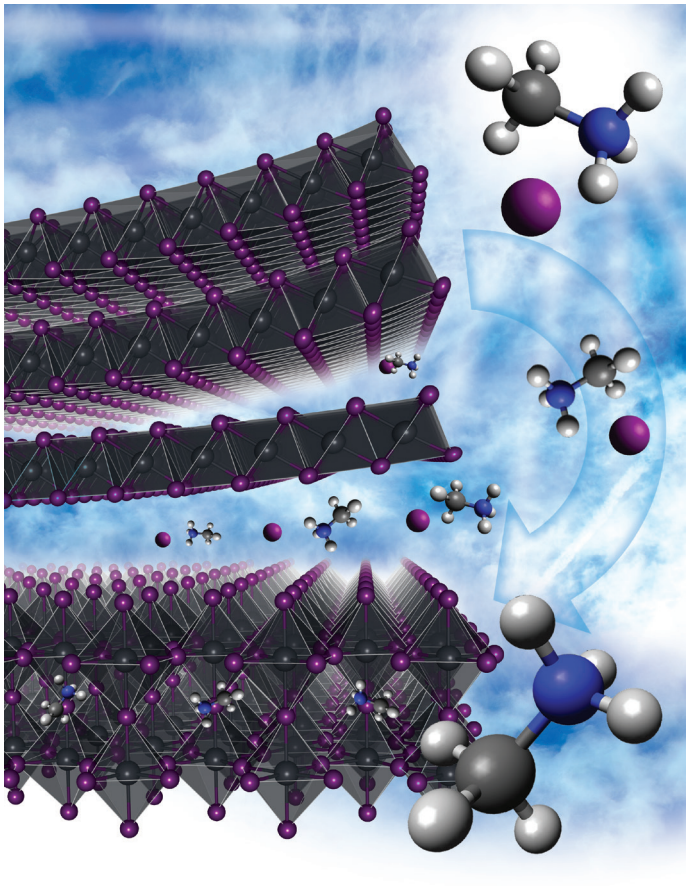
Cramer says more work needs to be done before the catalyst sees widespread use. His group is hoping to show that the ligands can be coordinated to a broad variety of metals for an array of transformations and is also trying to improve the synthesis of the ligands.

"It still takes several steps to make the ligands and they are not commercial yet," he said. "Often people use things they can simply buy out of a catalogue, so for now, if you want to use this technology, you have to make the catalysts yourself—or ask us."

Lab of Photonics and Interfaces Develops Novel Method for Solution-Processable Perovskites

Researchers at the Laboratory of Photonics and Interfaces have developed a novel two-step method for producing solution-processable organic–inorganic hybrid perovskites. The technique, described in the June 27 issue of *Nature,* could provide new ways of making solution-processed photovoltaic cells with unprecedented power conversion efficiencies and stability that's equal to or even greater than those of today's best thin-film photovoltaic devices.

Hybrid perovskites are a class of compound in the family of calcium titanium oxide mineral species that have attracted attention as light-harvesting materials for mesoscopic solar cells because of their unique structures of alternately stacking sheets of organic and inorganic components on the molecular scale. Until now, the perovskite pigment CH_3NH_3 PbX_3 has been deposited in a single step onto mesoporous metal oxide films using a mixture of PbX_2 and CH_3NH_3X in a common solvent. The precipitation is uncontrolled in this case though and produces large variations in morphology. This results in a wide range of photovoltaic performance and hampers the prospects for practical applications.



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Directed by Michael Grätzel, ISIC researchers Julian Burschka, Norman Pellet—who holds a joint appointment at ISIC and the Max Planck Institute for Solid-State Research in Stuttgart—Soo-Jin Moon, Robin Humphry-Baker, Peng Gao and Mohammad K. Nazeeruddin developed a sequential deposition method that allows the formation of the perovskite pigment within the porous metal oxide film. Lead iodide is first introduced from solution into a nanoporous titanium dioxide film and subsequently transformed into the perovskite by exposing it to a solution of CH_3NH_3I. The conversion within the nanoporous host occurred as soon as the two components came into contact: this allowed much improved control over the morphology.

"THE TECHNIQUE COULD PROVIDE NEW WAYS OF MAKING SOLUTION-PROCESSED PHOTOVOLTAIC CELLS WITH UNPRECEDENTED POWER CONVERSION EFFICIENCIES."

Using this new technique for the fabrication of solid-state mesoscopic solar cells not only increased the reproducibility of their performance significantly, it also allowed the researchers to achieve a power conversion efficiency of about 15% with the best device. This is among the highest for solution-processed photovoltaics and sets a new record for organic or hybrid inorganic–organic solar cells in general. The best commercial amorphous silicon-based photovoltaics currently boast power conversion efficiencies of about 13%.

The innovative method opens new routes for making perovskite-based photovoltaic devices: other preformed metal halide mesostructures could be converted into the desired perovskite using the same insertion reaction. The researchers say the new class of mesoscopic solar cells is likely to be widely used and lead to devices that rival conventional silicon-based photovoltaics.

The paper comes during a remarkable period for Grätzel: his original paper on DSSCs has been cited more than 10,000 times and his body of papers more than 100,000 times. With an h-index greater than 150, he is currently the third most cited chemist in the world.

MicroRNAs Critical to Red Blood Cell Production Identified in *Science* Paper

Adult bone marrow generates about one hundred billion new red blood cells every day. It's a complicated, multi-step process that sees stem cells transform into the fully developed erythrocytes that deliver oxygen throughout the body.

A better understanding of how the process works could help identify the causes of disorders such as anemia and lead to the production of blood replacement products in the lab; scientists are investigating the mechanisms behind the process intensively. A paper published in the April 19 issue of *Science* has made a significant contribution by identifying a group of genes playing a critical role in an essential step of the process.

"WHEN COMPARED WITH CONFIRMED TARGETS IN THE FRUIT FLY AND HUMAN, THEIR ALGORITHM SHOWED SIGNIFICANT IMPROVEMENT IN PRECISION, WHILE ALSO REDUCING THE COMPUTATIONAL COST."

The essential phase in question is mitophagy, a process that involves the elimination of mitochondria from the stem cells. The mechanism behind the step, which maximizes the cell's ability to carry hemoglobin, has been a mystery. A collaboration between EPFL researchers from Didier Trono's Laboratory of Virology and Genetics and Jiri Vanicek's Laboratory of Theoretical Physical Chemistry identified proteins and microRNAs essential to the process.

Building on preliminary microRNA expression data obtained in Trono's laboratory, Jiri Vanicek and PhD student Ray Marin contributed to the project with a theoretical prediction about which candidate genes were mostly likely to be repressed by these microRNAs. These predictions, which included genes mediating mitophagy, were then confirmed experimentally by colleagues from Trono's group including postdoctoral researcher Isabelle Barde.

MicroRNAs are small single-stranded RNAs of about 22 nucleotides that bind to mRNA transcripts and usually down-regulate the expression of a given protein. Because of their important roles in cell differentiation and development, cancer and other biological processes in species ranging from viruses to humans, identifying microRNA targets is essential.

Though indirect experimental approaches towards identifying targets in large genomes exist, they are both resource- and time-intensive. Experiments are then better guided by accurate computational methods for predicting functional microRNA-target pairs. While target identification or prediction is relatively straightforward in plants because the whole miRNA and the messenger RNA sequences need to be almost perfectly complementary, it's much more complicated in animals because only partial complementarity is needed.

Different methods for predicting targets have led to successful experiments, but the theoretical approaches are still unreliable. Vanicek and colleagues looked to get around current limitations by using a novel approach, published as a featured article in *Nucleic Acids Research* in 2011. While currently available algorithms taking into account RNA secondary structure rank predictions according to the hybridization energy or the sum of the opening and hybridization energies, Marin and Vanicek argued that this is not an efficient approach to ranking. They instead employed an algorithm that uses the RNA secondary structure only to filter out the inaccessible binding sites, and then ranks the predictions among the remaining, accessible binding sites according to over-representation of the binding sequence compared with a background sequence.

When compared with confirmed targets in the fruit fly and human, their algorithm showed significant improvement in precision, while also reducing the computational cost compared with other free energy-based methods. In the human genome, their algorithm is at least twice as precise as other methods with their default parameters. In the fruit fly, they found five times more validated targets among the top 500 predictions than other methods, again with default parameters. Since the original algorithm, Vanicek and colleagues have developed several other algorithms for predicting conserved microRNA targets as well as recently discovered target sites within coding regions of genes.

Predictions by Marin and Vanicek were used by colleagues at the Laboratory of Virology and Genetics to show that mitophagy is regulated in part by so-called KRAB zinc finger proteins and a cofactor called KAP1. The researchers found that KRAB zinc finger proteins together with KAP1 suppressed the microRNAs predicted and confirmed to target transcripts encoding mitophagy factors. As a result, mice modified to lack KAP1 could not produce red blood cells and became anemic. Stem cell differentiation stopped during mitophagy in these mice and knocking out KAP1 had a similar effect in human cells.

The researchers showed that the KRAB/KAP1 system works by repressing microRNAs that in turn repress mitophagy. This suggests that mutations in the system could play a role in blood disorders such as anemia and certain types of leukemia, suggesting future targets for medicines.

THIERRY MEYER'S NEW BOOK EXAMINES RISK FROM A FRESH PERSPECTIVE

Thierry Meyer, head of ISIC's Group of Chemical and Physical Safety, has been managing risk and developing new approaches to it so successfully that he was asked to write a book about it.

"Engineering Risk Management," written with Genserik Reniers of the University of Antwerp, was published earlier this year and will be used as a textbook for classes given to both undergraduates as well as to experienced managers coming to EPFL for continuing education. Because of other commitments, Meyer initially resisted the idea of writing the book when approached by the publisher De Gruyter, but was convinced by the need for a textbook tailored to the interests of specific readers. Though the book is aimed at anyone facing risk and safety issues—*e.g.*, engineers, scientists, professionals, sociologists and psychologists—it looks at risk management specifically from an engineer's perspective.

"ENGINEERS LOOK AT RISK MANAGEMENT DIFFERENTLY. WHEN WE FAIL, WE DON'T LOSE VIRTUAL MONEY WITH A DROP IN THE VALUE OF SHARES OR THINGS LIKE THAT. WE LOSE REAL ASSETS."

"Engineers look at risk management differently," Meyer said. "When we fail, we don't lose virtual money with a drop in the value of shares or things like that. We lose real assets—we lose lives, production capacity and resources, we harm Mother Nature."

Meyer says that because it is not always obvious whether an action is good or bad, right or wrong—it may be good for one person, but bad for another—making the right decisions time and time again requires risks to be "engineered," that is, they should be managed with engineering principles. In the book, the authors introduce the concept of risk and then discuss risk management principles, how to diagnose, analyze and treat them. They cover event analysis, crisis management, economic issues and risk governance and also give examples of practical application in chemistry, physics and emerging technologies such as nanoscience. Meyer and Reniers also look at well-known major industrial accidents, aiming to show how we can learn from them.

Meyer's first exposure to risk came from working at Ciba-Geigy SA, first as a development chemist, then as head of development ad interim and finally as production manager for high performance pigments. Ciba-Geigy, like other businesses in the chemical industry, was subject to intense public scrutiny and placed a huge emphasis on avoiding accidents. Transferring what he learned over his years there to academia has been the critical element to managing risk successfully at EPFL, Meyer said.

"There was limited structured safety management before, everyone was doing what he thought was best with little coordination," he said. "That's the way academics have traditionally worked."

Meyer and colleagues in the newly formed group set up a four-level management program called MICE—"Management Information Control and Emergency"—that involved all elements of organizing a coordinated approach to safety: training people, hazard mapping, spreading information, safety audits, helping people to do their daily work safely and dealing with emergency response.

"In this case, that doesn't mean firemen and first aid, but rather helping people repair damage when accidents happen, and not just leaving them to deal with the fall out," Meyer said.

Meyer says he's continuing to learn about risk management, a necessary evolution because associated problems are getting ever more complex. That's because various processes have themselves become more complex, with more interrelations and interactions. When one step is changed slightly, it can still have a significant impact on other elements of the process. This requires different thinking, and means engineers need to master a much broader system, he said. Risk management is a never-ending process being more iterative than ever with the increasingly fast evolution of emerging technologies.

This doesn't necessarily mean that the solutions are mathematically more complex, but managers need to address the question of how such systems can be broken down and then brought back together again. This is the real work of the engineer and "what they're made for," Meyer said.

"They're educated to take apart complex systems and build them again and that's their great strength compared with analysts," he said. "Engineering thinking is based on a systemic approach, something similar to the well-known Russian dolls. The analytical approach is completely the opposite, going from the infinitely small to the large. This doesn't suit risk management because you lose the overview—engineering is the right discipline for risk."

ISIC'S YOUNG PROFESSORS CONTINUE TO WIN ERC STARTING GRANTS

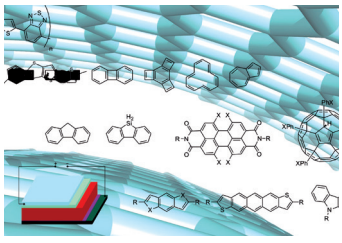
Corminboeuf Awarded ERC Grant to Design Molecular Organic Electronics

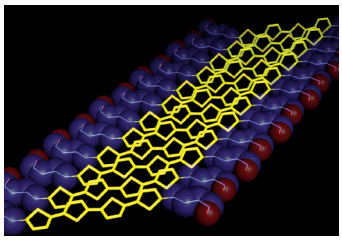
Organic electronics—a carbon-based class of materials—have emerged as promising alternatives to inorganic semiconductors. Resulting in devices that feature new properties such as mechanical flexibility, transparency, low-cost processing or resistance to impact, their development may lead to many advantages.

Although thin films of small-molecule organics and polymers have demonstrated promising results, their electrical performance is still low compared with that of silicon and related inorganic chemicals for many potential applications such as organic transistors and solar cells. Improving and controlling this quality rests on optimizing molecular-level organization, overall morphology and electronic structure. Clémence Corminboeuf, head of ISIC's Laboratory for Computational Molecular Design, has been awarded an ERC Starting Grant of EUR1.5 million to develop computational approaches to doing just that.

"We are seeking model systems that can serve as a platform to better understand the relationships between supramolecular structure and charge transport, as well as the limiting factors for device performance," Corminboeuf said. "This may lead to next generation materials that can be inexpensively processed and suited to different types of applications. We are not engineers though—our work is done on the computer and interaction with experimentalists will be crucial."

Getting the best performance out of the polymers and oligomers that might eventually be used in organic electronics requires fine-tuning the morphology and relative orientation/position of these π-conjugated molecules. In Corminboeuf's lab, this is done using computational schemes that fine-tune the structural, electronic, and charge transfer properties of novel precursor molecules. The aim of the work is to design molecules that have specific, controllable features such as charge carrier generation and charge transport by adjusting their aggregation and nanoscopic confinement as well as their quantum properties.





One of the first steps of the project is identifying and systematically screening hybrid macromolecules that can π-stack as close as possible. The targeted assembled oligomers can be very large from a computational perspective: one of the biggest tasks the researchers face is figuring out how to sample the possible conformations at the nanoscale and give reliable descriptions of the electronic properties.

"FINDING THE PROPER BALANCE BETWEEN ACCURACY AND COST-EFFICIENCY IS A BIG CHALLENGE IN ITSELF."

"The latter depends on the electrons, so we need to rely on quantum chemistry, but this is not achievable beyond a few hundred of atoms," Corminboeuf said. "Finding the proper balance between accuracy and cost-efficiency is a big challenge in itself."

Recent work in Corminboeuf's lab includes addressing both the shortcomings of density functional theory approximations and other related schemes that might be used to get electronic information as well as the lingering difficulties in describing the properties of π-conjugated systems. In collaboration with experimentalists, Corminboeuf's lab has also characterized the internal structure of self-assembled organic nanowires that show highly promising macroscopic properties typical of organic semiconductors. Such research is essential to the project.

The team, which includes ten graduate students and post-docs, will address the challenges with multi-scale analysis that ranges from molecular mechanics simulations to quantum chemical computations that rely on both new approaches and existing methods.

The ultimate, long-term goal of the project is to test computer-designed molecules experimentally. To this end, Corminboeuf plans to work with the group of Holger Frauenrath at the Laboratory of Macromolecular and Organic Materials as well as with various ISIC research groups studying different approaches to discovering molecular organic electronics.

"It's not yet very common to have what comes out of the computer end up in the wet lab," Corminboeuf said. "It is our holy grail even though it could take a long time."

The project has been funded for five years until the end of November, 2017.

Sivula Gets ERC Grant to Develop Solution Processed Organic Semiconductors

Kevin Sivula, head of the Laboratory for Molecular Engineering of Optoelectronic Nanomaterials, received a EUR1.5 million European Research grant to develop techniques for controlling the crystal packing, crystalline domain size and mixing ability of molecular organic semiconductors (MOSs) in thin-film devices. The project, called CEMOS (Crystal Engineering for Molecular Organic Semiconductors), will run for five years.

The work is meant to further develop solution-processed organic semiconductors, tools that could themselves ease the development of inexpensive, ubiquitous solar energy conversion. Such semiconductors can be made less expensively than traditional semiconductors, but improving their performance to acceptable levels is a fundamental challenge.

"Currently in the field of solution-processed organic electronics there is rapid and exciting development employing small molecules," Sivula said. "Compared to polymer semiconductors, they have the advantage of easier structural tunability and purification, but their strong tendency to crystallize causes difficulties in fabricating thin films."

"THE ABILITY TO PRODUCE SEMICONDUCTOR DEVICES AT RADICALLY LOWER COSTS WILL ENABLE TECHNOLOGIES LIKE RECYCLABLE, SINGLE-USE SENSORS FOR MEDICAL DIAGNOSTICS, 'SMART' FABRICS WITH INTEGRATED FUNCTIONALITY, AND ENERGY CONVERSION DEVICES."

Sivula's work will approach the problem with innovative methods of "bottom-up" crystal engineering for organic semiconductors. His group will use specifically tailored molecules designed to take advantage of both thermodynamic and kinetic aspects of molecular organic semiconductor systems to direct and control crystalline arrangement, promote crystallite nucleation, make disparate phases compatible, and plasticize inelastic materials.

The group aims to show that their new classes of materials can allow tuning of charge carrier transport and morphology in MOS thin films, and will evaluate their performance in actual thin-film transistor (TFT) and organic photovoltaic (OPV) devices. The interdisciplinary approach, which combines material synthesis and device fabrication/evaluation, aims to improve the performance and stability of OPVs and TFTs, but also shed light into how crystalline packing affects optoelectronic properties, independently from molecular structure.

The group hopes that the materials developed will serve as ground-breaking new concepts in solution processable organic semiconductors. Success would rapidly advance the performance of MOS devices, and should lead to their more widespread use. This will enable reproducible and comparable performance in a wide variety of semiconductor devices compared with traditional semiconductors but at much lower processing costs.

"The ability to produce semiconductor devices at radically lower costs will enable technologies like recyclable, single-use sensors for medical diagnostics, 'smart' fabrics with integrated functionality, and energy conversion devices that economically harness renewable sources," Sivula said. "The CEMOS project will be a step toward these goals."

Molecular engineering | Semiconductor inks | Solution processing | High performance electronic devices

Waser Wins Starting Grant for New Hypervalent Iodine Reagents

Jérôme Waser, head of the Laboratory of Catalysis and Organic Synthesis, won an ERC starting grant to design new hypervalent iodine reagents that combine the high reactivity of metals with the reduced toxicity and cost of main group elements. The new reagents will also open new horizons for the synthesis of organic molecules.

Though transition metal chemistry has completely changed the field of synthesis over the last century, it is nonetheless often based on rare and toxic metals. Traditional organic chemistry, on the other hand, makes use of cheap and innocuous organic molecules, though this comes at the cost of more limited reactivity.

Waser's lab hopes to address this dilemma by accelerating research and developing a toolbox, an "iKit," for medicinal chemists. The optimal outcome of the research would be a "magic iodine bullet" that can be used to install a chemical functional group on a given organic molecule.

"The dream for a medicinal chemist is to be able to install the functional group he or she wants on the desired position selectively using a technically easy and fast reaction," Waser said. "In this project, we will try to come closer to this dream."

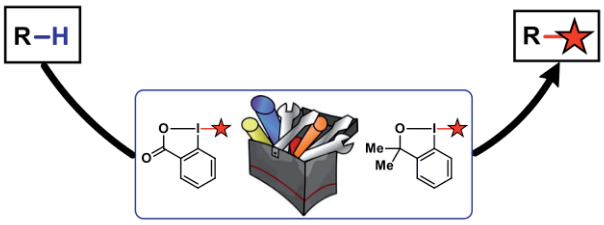
"THE DREAM FOR A MEDICINAL CHEMIST IS TO BE ABLE TO INSTALL THE FUNCTIONAL GROUP HE OR SHE WANTS ON THE DESIRED POSITION SELECTIVELY USING A TECHNICALLY EASY AND FAST REACTION."

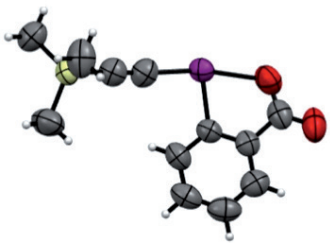
The project will also lead to a greater understanding of the reactivity of hypervalent iodine reagents and their interplay with metal catalysts, which could in turn lead to applications we can only begin to imagine. This understanding could, for example, lead to the development of reactions catalytic in iodine—this could be useful not only for research, but also for the larger scale chemical production.

The success of the project will eventually make unlimited numbers of organic transformations possible. Applications may go beyond synthetic chemistry with the development of other well-defined reagents tailored to meet the needs of scientists in chemical biology and materials science.

iTools4MC

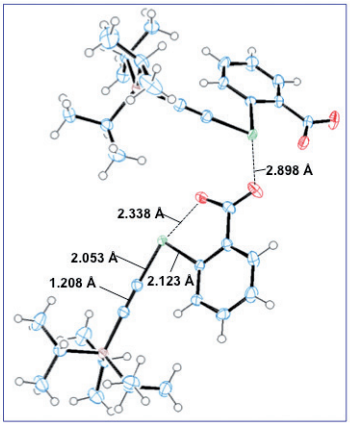
Hypervalent Iodine Reagents: a Tool Kit for Accessing Molecular Complexity





EthynylBenziodoXolones (EBX):

Exceptional Reagents



for more information, see http://lcso.epfl.ch

CREATING THE BUILDING BLOCKS FOR TOMORROW'S CHEMINFORMATICS INFRASTRUCTURE

Luc Patiny, head of ISIC's Chemical Information Service, is preparing for a revolution. Not the political or social kind, but rather one that will see computers revert to simple terminals whose only feature is a web browser. He anticipates that this fundamental change will take place within the next ten years.

His prediction is mainly based on the increased trend towards cloud computing. The concept, which generally refers to distributed computing over a network, enables us to run programs on many connected computers at the same time and to store data on remote servers. Services like Google Docs and Apple's iCloud are examples of how the concept is already being used in practice.

"Five years ago you had nothing in the cloud, but now a lot of people are using such applications," Patiny said. "You don't really know where your data are, but you get used to it. More and more people are using the cloud without ever thinking about it. We need to prepare for this revolution in the field of chemistry too."

The challenge then, for Patiny and his team, is to develop dedicated applications that are both specialized to specific tasks and able to interact with each other to complete complex tasks. The team has already developed two such tools that are freely accessible on the Internet and being used by thousands of chemists every day.

"The first step is always to store the information correctly, the second step is to create tools that allow us to process this information and the third step is to visualize the result and get some knowledge from it," Patiny said. "It's this third point that we're mostly working on now."

The newest is an application called ChemCalc.[1] The tool can be used for molecular weight calculation, to get information about peptide fragmentation and isotopic distribution, and for determining molecular formula from monoisotopic mass. Another of his established successes is the NMR Predictor. The tool allows researchers to draw a chemical compound and generate the predicted NMR spectrum, allowing them to compare data with experimental results.

> "MORE AND MORE PEOPLE ARE USING THE CLOUD WITHOUT EVER THINKING ABOUT IT. WE NEED TO PREPARE FOR THIS REVOLUTION IN THE FIELD OF CHEMISTRY TOO."

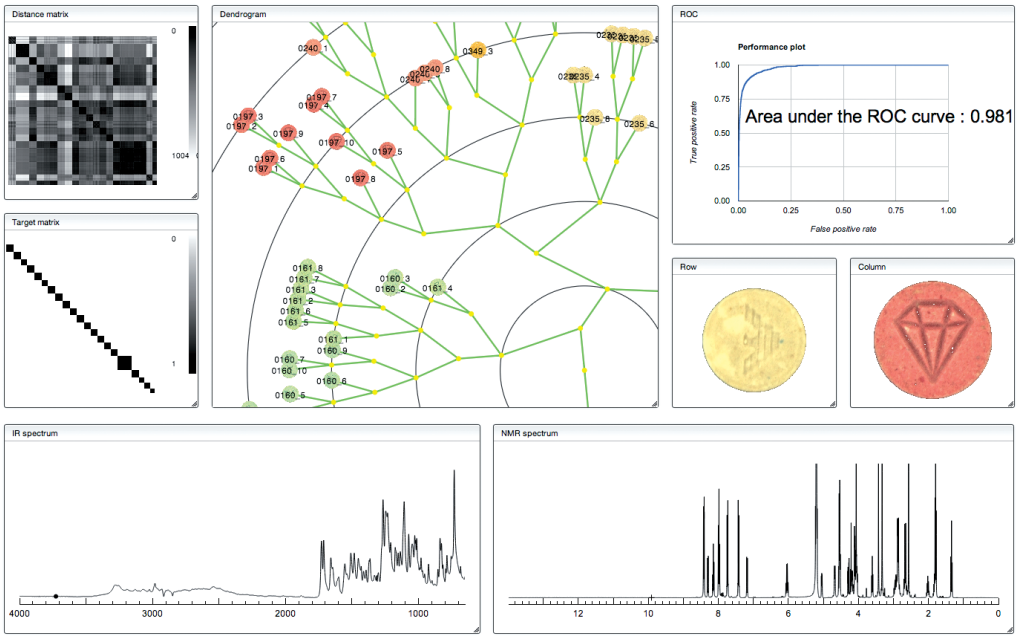
Another novel tool is being developed in cooperation with forensic police who monitor the traffic of illicit drugs such as Ecstasy. The approach involves analysing the tablets based on their visual characteristics and building up a profile based on appearance. Visual features are used to develop similarity measures, which in turn form the basis for a pill monitoring strategy that can both infer whether two pills come from the same seizure and model groups of pills that share similar visual characteristics.[2]

Although this application is the most advanced, the same approach can also be applied to chemical molecules and analytical results such as spectra or chromatograms. This can be used not only to classify molecules based on their similarity of their NMR spectra, for example, but also for automatic quality control in production or parallel synthesis.

"What we're really trying to do is convert information into knowledge," Patiny said. "All of these tools are doing just that."

1 Patiny L, Borel A. ChemCalc: A Building Block for Tomorrow's Chemical Infrastructure. *J. Chem. Inf. Model. 2013,* 53 (5): 1223-1228.

2 Camargo J, Esseiva P, Gonzalez F, Wist J, Patiny L. Monitoring of Illicit Pill Distribution Networks Using an Image Collection Exploration Framework. *Forensic Science International.* 223 (1): 298-305.



ETH BOARD APPOINTS FOUR NEW PROFESSORS TO THE SCHOOL OF BASIC SCIENCES

ISIC will gain from the experience and expertise of four new professors after the nominations of Anders Hagfeldt, Ardemis Boghossian, Jeremy Luterbacher and Berend Smit.

Hagfeldt, currently full professor at Uppsala University, Sweden, has been named full professor of Physical Chemistry. Regarded as one of the world's leading researchers in dye-sensitised solar cells, Hagfeldt uses various methods and new nanostructured materials to improve the efficiency of these third-generation solar cells. Hagfeldt has been appointed as of September 1st, 2014.

Boghossian, currently post-doctoral researcher at the California Institute of Technology, USA, has been named tenure track assistant professor of Chemical Engineering. Boghossian focuses on topics including electrochemical systems and biosensors, contributing to new strategies for bioengineering nanomaterials for energy technology and biomedical applications. At EPFL, Boghossian plans to help develop new biological and biochemical methods for producing durable hybrid nanomaterials. Boghossian has been appointed as of September 1st, 2014.

Luterbacher, a former EPFL student and currently post-doctoral researcher at the University of Wisconsin-Madison, USA, has been named tenure track assistant professor of Chemical Process Engineering. Luterbacher focuses on topics including biomass depolymerization to sugars and heterogeneous catalysis routes for the production of biomass-derived hydrocarbons and platform chemicals. His work also looks at simulation methods that allow the modeling and evaluation of technologies for biomass conversion. Luterbacher has been appointed as of August 1st, 2014.

Smit has been nominated full professor of Chemical Engineering. Smit, a chemical engineer who focuses on molecular modeling, has in recent years been head of the Berkeley-based Energy Frontier Research Center, a program that develops innovative technologies for the separation, binding and storage of carbon dioxide from gas mixtures. Smit has been appointed as of July 1st, 2014.

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