CHEMISTRY ON SOFT MATERIALS IN TURKU, FINLAND

SPECTROELECTRO-CHEMISTRY

ORGANIC DONOR-ACCEPTOR MOLECULES

THIN FILM PRODUCTION AND CHARACTERIZATION

FOREWORD

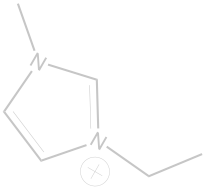
The research group on soft materials is a part of the Laboratory of Materials Chemistry and Chemical Analysis at the University of Turku. The laboratory belongs to the Turku University Centre for Materials and Surfaces, or MatSurf, which is a cluster of materials scientists at the university from different disciplines representing physics, chemistry and biomaterials. The collaboration within MatSurf enlarges the pool of available instrumentation, as does the close cooperation with the research laboratories at Åbo Akademi University.

Since the mid-eighties, the focus of the research group has been on soft materials like conjugated polymers and macromolecules. Today the research is also comprised of materials like fullerenes and graphene-like materials, as well as ionic liquids and polyelectrolytes.

The development of instrumental techniques for studying thin films is an important part of our research, and special effort has been placed on in situ spectroelectrochemical measurement techniques. These characterization techniques enable simultaneous analysis of structural and electronic changes in a material.

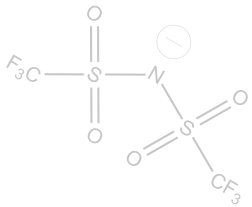
The production of thin films by different techniques such as self-assembly or layer-by-layer deposition, as well as their characterization in combination with surface analysis, is also in our area of expertise. You can learn more about our research by visiting our website www.sci.utu.fi/kemia/en/research/matchem/

In this leaflet, we will provide you with insight into our research topics and techniques in soft materials. We also want to highlight some applications that motivate our daily work as a group focused on relatively fundamental research. Furthermore, a few of our collaboration partners will be presented to give you a broader perspective of materials science in Turku, Finland.



For Industry

We are looking for industrial partners who want to use our know-how, connections and instrumentation for real-life problem solving. An investment in the latest knowledge is a door to profitable technologies and better business.



For Fellow Researchers

We can provide tailored materials and characterization tools for interdisciplinary research projects. This will connect researchers to new people and to a world of fresh ideas.

Fullerenes

In our research of fullerenes, we are focusing on the use and characterization of derivatized fullerenes as acceptor molecules. Derivatization of fullerenes plays an essential role when self-assembly and good complexing properties are sought for relevant applications.

Potential applications of these spherical molecules can be found in *bioimaging* as in *optoelectronics.*

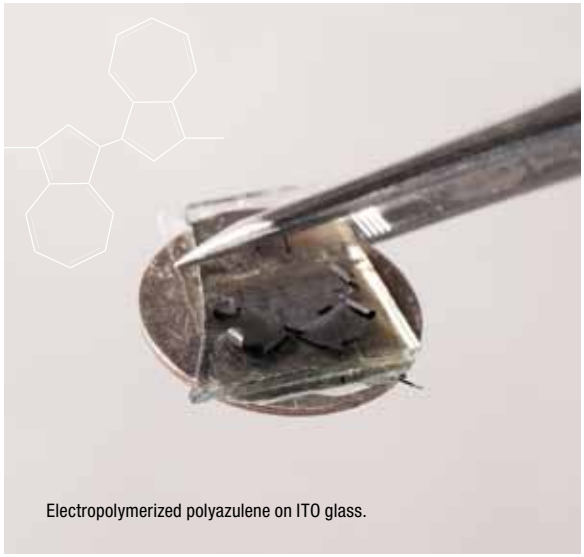
”Donor-acceptor materials for optoelectronics”

Focus is in application of derivatized fullerenes for self-assembly and bioimaging.

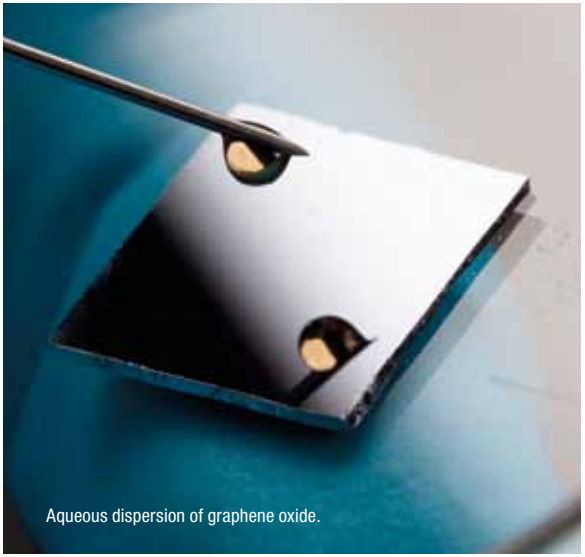
Conducting polymers

We can synthesize conducting polymers on various substrates. Thin films can be synthesized electrochemically in a controlled way or cast from chemically synthesized, soluble polymers. The optoelectronic and vibrational changes taking place during doping of the polymers are studied by spectroelectrochemistry. We also have considerable experience with the in situ conductance measurements of conducting polymers.

Electrosynthesis is a powerful tool that can be applied to the mass production of small and precise organic electronic devices, like *hybrid solar cells, transistors, LEDs* and *memory devices.*



Electropolymerized polyazulene on ITO glass.



Aqueous dispersion of graphene oxide.

Graphene

Our research efforts on this sheet-like carbon structure consist mostly of covalent and non-covalent modification of graphene and its subsequent spectroscopic and electrochemical characterization.

We are proudly applying our knowledge in joint projects with other groups focused on graphene oxide-based (GO) *optoelectronics* and *sensors*. Another field of interest for GO is its use in *bioimaging* with transmission electron microscopy. GO's qualities, such as high transparency under an electron beam and an affinity for certain biomolecules, makes it an ideal candidate for a substrate material.

Nanostructuring of graphite with Ionic liquid produces IL-decorated sheets of graphene.

Ionic liquids

The high ionic conductivity and wide potential window of ionic liquids are some of the properties that make it such an interesting media from an electrochemical point of view.

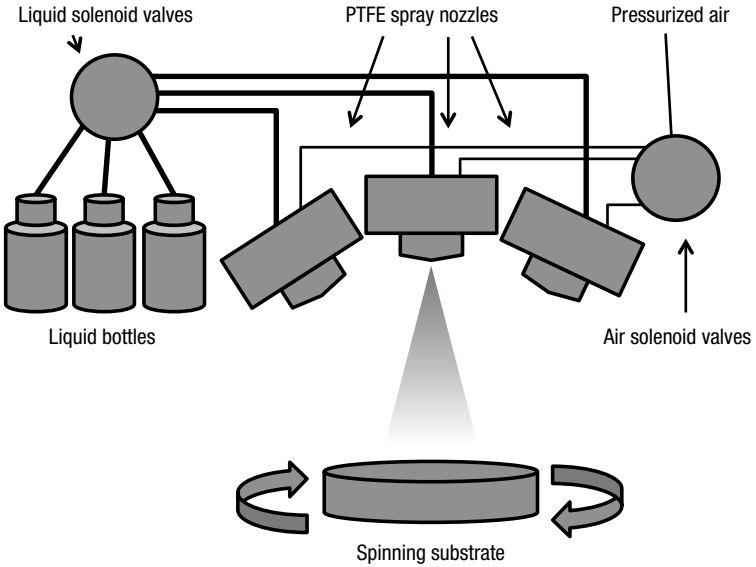
The research today is also focused on the use of ionic liquids for the functionalization of graphene-like materials. This modification would further provide for the charge needed for self-assembly and open up a route for the creation of ordered interfaces.

Layer by layer assembly for **thin films and coatings**

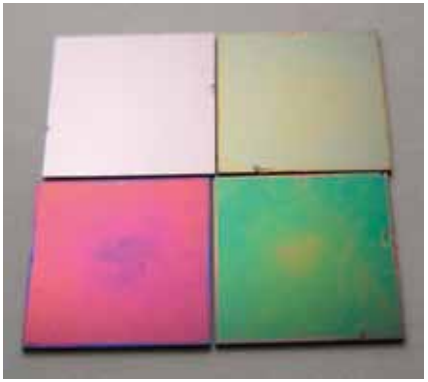
Layer-by-layer assembly is an inexpensive way to fabricate either nanoblended coatings or multilayered structures on various substrates. This technically simple procedure gives us control on a nanometer-scale and the combination of LbL assembly with spin and spray techniques facilitates even more controlled film formation.

“We can automate LbL method for various substrates”

A more fundamental approach of our research with LbL thin films is in the study of their buildup mechanisms. We possess a long history of mathematical modeling, data interpretation and instrument design in this area of research with a promising future. Our present know-how enables our collaboration partners to work with powerful tools, like fully automated LbL-apparatus of the spin-spray and flow-cell types. Our combination of know-how and instrumentation can be applied to *anti-corrosive* and *-reflective coatings, biomaterials, energy conversion,* and *flexible electronics*.

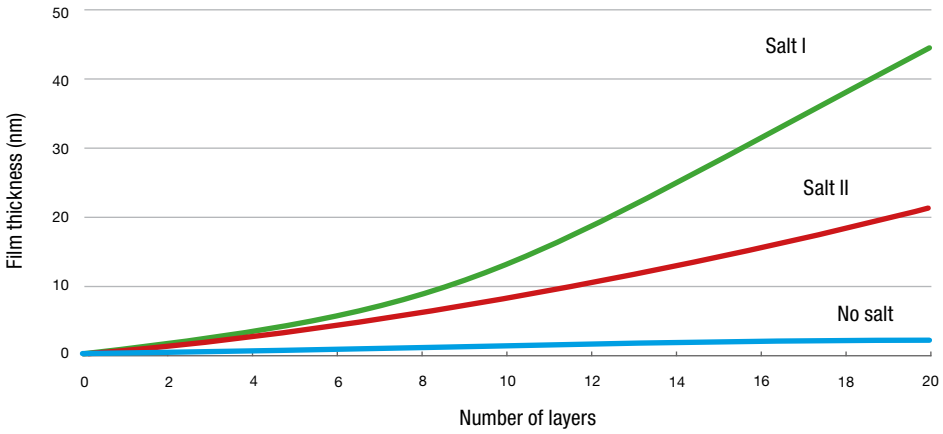


LbL method combined with the spin-spray technique is a powerful tool for fabrication of multilayer thin films.



Composite films on silicon substrates. Untreated silicon (↖), 15 bilayers (↗), 20 bilayers (↙) and 25 bilayers (↘).

"Control at nanometer scale"



Effect of salt on film thickness of a general polyelectrolyte.

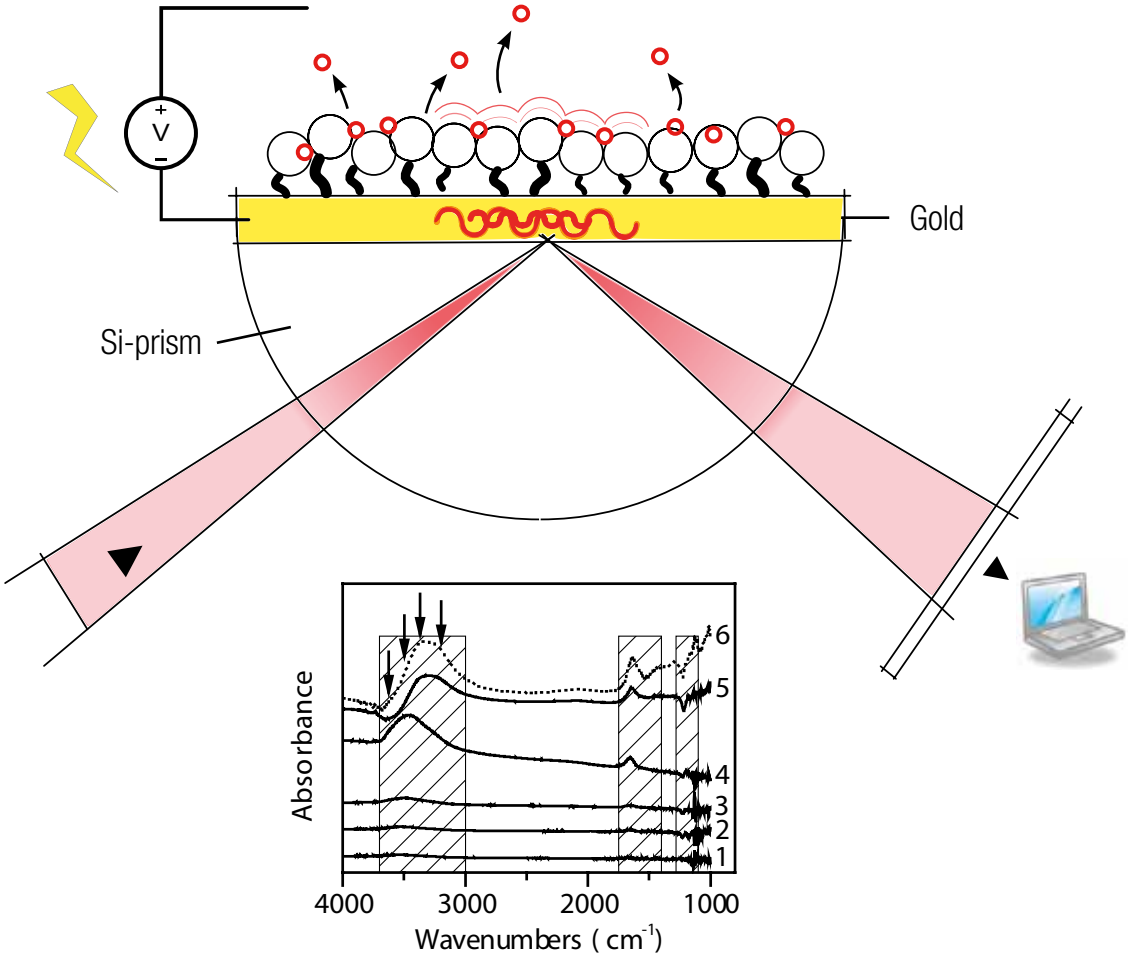
In situ **spectroelectrochemistry**

With in situ spectroelectrochemistry, we are able to observe a gradual change in matter and this enables us to understand the very essence of its chemistry. We have invaluable tools for partners interested in optimizing chemical or electrochemical processes involving thin biofilms, organic coatings and their interfaces. Our instrumentation covers a wide spectrum of electromagnetic radiation, including IR, NIR, VIS and UV excitation sources. We would also like to emphasize the possibility of in situ imaging ellipsometry in our laboratory.

“Spectroelectrochemistry for biocompatible thin films”

FTIR and RAMAN: Enhanced by a surface

The combination of RAMAN and FTIR spectroscopy with the phenomena called surface enhancement, focuses our spectroelectrochemical know-how on the interface of the electrolyte and the solid matter. This allows for the study of certain processes on polymer surfaces and the detection of small and specific changes in the structure of self-assembled monolayers and biomembranes.



An example of electrochemical surface enhanced in situ infrared measurement. The gold film on a silicon prism acts as the working electrode for electrochemical deoxygenation of graphene oxide monolayer. At same time, this nanostructured gold surface creates a strong enhancement of the IR signal at the interface of the gold and the electrolyte solution. The appearance of new bands in the infrared spectrum of thin graphene oxide film during the electrochemical experiment indicate gradual reduction of the layer.

INSTRUMENTATION

Our laboratory's instrumentation covers a wide spectrum of characterization tools. To mention a few, we have a high quality Imaging Ellipsometer located in a 100-Class clean room. With a new Atomic Force Microscope sitting next to it, we have a good combination of resolving power to focus on morphologies of thin films and surfaces.

A complete list of our instruments can be found at www.matsurf.utu.fi.

The fact is, in Turku we are surrounded by multiple interconnecting networks of instrumentation. This means we have an excellent environment for interdisciplinary research and active knowledge transfer.

- **The Instrument Centre** is a facility specialized in NMR and Mass Spectroscopy, financed by the two Universities of Turku.
- **MatSurf** connects the facilities of research groups working on material and surface science in the University of Turku.
- **Turku BioImaging** is a broad-based, interdisciplinary science and infrastructure umbrella that aims to unite bioimaging expertise in Turku and elsewhere in Finland.

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- Freiburg Materials Research Center, University of Freiburg, Germany
- Nokia Research Center, Cambridge, UK
- School of Materials Science and Engineering, Nanyang Technological University, Singapore.
- Royal Institute of Technology, Division of Surface and Corrosion Science, Stockholm, Sweden
- Institute of Problems of Chemical Physics, Russian Academy of Sciences, Chernogolovka, Moscow Region, Russia

Expertise in materials suitable for optoelectronic devices, energy conversion and sensors.

Electronic and spectral characterization of conducting polymers and carbon materials.

Layer by layer assembly of structured thin films: Buildup mechanims and automated instrumentation.

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