CONDUCTION POLYMERIC MATERIALS - EUPOC 2015

Søren Hvilsted[1], Maria Omastova[2]
Danish Polymer Centre
Department of Chemical and Biochemical Engineering
Technical University of Denmark, Lyngby
sh@kt.dtu.dk
[2]Polymer Institute
Slovak Academy of Sciences, Bratislava
Maria.Omastova@savba.sk

The European Polymer Conference 2015 (EUPOC 2015) that focused on conducting polymeric materials took place 24-28 May in Palazzo Feltrinelli, Gargnano, Lago di Garda. The overall objective of the conference was to provide the most recent developments within the various areas of conducting polymeric materials. This goal was attempted to be achieved through invited lecture presentations by 11 leading and eminent scientists from 4 continents. EUPOC 2015 also featured 28 short oral presentations and 27 posters. Throughout the conference there was lively and stimulating discussions among the participants both after the oral presentations, during the poster presentations as well as during the refreshment breaks and the social arrangements for which the venue is especially well suited lying directly on Lago di Garda. In total EUPOC 2015 had 72 participants mainly from academia coming from 27 countries with all continents represented.

The conductivity of polymeric materials is caused by electrically charged particles, ions, protons and electrons. Materials in which electrons are the charge transfer elements are intrinsically conducting polymers, where the electrical conductivity is a result of delocalized electrons along the polymer backbone, with polyaniline, polypyrrole, and PEDOT as prominent examples. Already in 2000 Alan Heeger, Alan MacDiarmid, and Hideki Shirakawa were awarded the Nobel Prize in chemistry “for the discovery and development of conductive polymers”.

The proton conducting polymers are extensively exploited in low temperature fuel cells. Fuel cell stacks and systems are presently commercialized and in operation e.g. in hydrogen driven cars. Extensive research activities are seeking next generation polymer electrolyte membranes to replace the present market leader Nafion®, a perfluorated polyether with sulfonic acid side groups. Instant recharge methanol based micro fuel cells are challenging batteries in hearing aids. Conducting polymeric composites based on an insulating polymer matrix, e.g. a PDMS elastomer, with embedded conducting fillers, find applications as actuator materials in artificial muscles or (wave) energy harvesting devices. Ionic conductivity provided by ions typically provided by salts dissolved in a soft but solid polymer matrix find many applications in e.g. flexible electronics or in Li^+ ion batteries.

The program of EUPOC was organized thematically and initiated with two plenary lectures (PL) under the heading conducting polymeric materials for bionics. In the first PL Professor Gordon G. Wallace, University of Wollongong, Australia, discussed *surfaces, interfaces and organic bionics*. In that context examples on devices for real clinical applications in order to implant conduits for nerve and muscle regeneration and implanted bionic devices for epilepsy detection and control were provided. The second PL by Professor Edwin W. H. Jager, University of

Linköking, Sweden, described *electroactive fabrics for tissue engineering and soft robotics*. In the framework of electroactive polymer (EAP) scaffolding fabrics for cardiac tissue engineering a new type of soft actuators: electroactive textiles was introduced. This new EAP based fibres or yarn was based on a metal-free combined chemical-electrochemical synthetic route.

The following part on conducting polymer materials with nanofillers featured a PL by Dr. Mohamed M. Chemini, Sorbonne Paris Cité, France, on *conductive polymer hybrids: the role of coupling agents and surfactants.* Emphasis was especially paid to the paramount role of coupling agents like silanes and aryl diazonium salts as adherent coatings on inorganic and flexible organic substrates like PET and PEN, intercalated and exfoliated clay-polypyrrole and core-shell carbon nanocomposites, as well as fillers for thermoplastics and thermosets. That was succeeded with the PL of Professor Anne L. Skov, Technical University of Denmark, who spoke on *conductive PDMS elastomers: how to obtain an efficient distribution of fillers.* The direct processing of multi walled carbon nanotubes (MWCNT) together with PDMS prepolymers by mechanical mixing, sonification, speedmixing or roll milling were discussed. In addition the advantages of modification of the MWCNT by atom transfer radical polymerization (ATRP) using compatibilizing monomers was presented.

Participants of EUPOC 2015

The third theme on conducting polymeric materials was devoted to ionically conducting polymers and initiated by the PL of Professor Patric Jannasch, Lund University, Sweden, who detailed *synthetic strategies towards anion and proton exchange membranes with enhanced morphological control and conductivity.* Extensive research on the proton conducting effect of variations of number and position of the sulfonic acids groups in polysulfones in order to challenge the market leader Nafion were presented. Likewise the significantly enhanced OH^- conductivity of poly(phenylene oxide) equipped with quarternary ammonium groups was shown. The PL by Dr. Jan H. Hales, Danish Technological Institute, addressed an ongoing industrial development expected to reach the market within 3 years with *towards commercialization of micro fuel cells.* The necessary miniaturization of a methanol fuelled hearing aid in order to meet the increasing energy demands as well as the successful efforts to produce nanocrystalline Pt for the fuel cell electrodes in high quantities were presented.

A forth theme was devoted conducting polymeric materials oriented towards applications with the PL by Professor Hidenori Okuzaki, University of Yamanashi, Japan, on *hierarchical structure and electrical properties of PEDOT/PSS and applications to organic devices.* Significant improvements of electrical conductivity (several orders of magnitude) were obtained in the presence of secondary dopant such as ethylene glycol or dimethyl sulfoxide. In addition the applications of highly conductive PEDOT/PSS to organic devices such as capacitors, touch panels, flexible speakers and compliant electrodes for soft actuators were shown.

A fifth theme was the conducting polymer materials on batteries and applications initiated with the PL by Professor Steven Holdcroft, Simon Fraser University, Canada, who provided thorough fundamentals *towards solar fuels from conjugated polymer photoelectrodes.* One take home message was a warning that although multilayer devices based on advanced, multistep organic syntheses of conjugated polymers provide fundamental insights and slowly improve the solar energy conversion efficiencies these approaches are only of academic value and will never reach a commercially viable and attractive level. This was followed by the PL of Professor Manfred Stamm, Leibniz Institute of Polymer Research Dresden, Germany, who presented an overview of *use of polymers for high-energy-density batteries*. The urgent need to replace the fossil energy sources by renewable non-polluting sources (solar, wind, and biomass) and not least the need for efficient energy storage devices (like the LiS battery) were convincingly argued.

The seventh theme was devoted to electrolytes with a PL by Professor John R. Varcoe, University of Surrey, UK, on *radiation grafted anion-exchange polymer electrolytes for electrochemical applications.* These electrolyte materials (anion-exchange membranes (AIM)) with various morphologies and chemistries are intended for clean energy technologies such as alkaline polymer electrolyte fuel cells and reverse electrodialysis cells. The efforts to develop the production procedures from small-scale experiments to large scale batches (square-metre-sized batches of AEM) were presented.

In the final part on conducting polymeric composites the PL by Dr. Jürgen Pionteck, Leibniz Institute of Polymer Research Dresden, Germany, was simply entitled *conducting polymeric composites.* The presentation provided an overview of different fillers for antistatic and conductive modification of conventional polymers, the effect of filler geometry on the electrical percolation concentration, and factors influencing the dispersion and distribution of conductive fillers in the polymer matrix.

Conference organizers from the left: Daniele Caretti, Giancarlo Galli, Maria Graziella Viola, Michele Laus, Maria Omastova, and Soren Hvilsted

A long range of oral contributions and posters were dispersed through the program relating to all the subjects described above. Many new and interesting findings and discoveries too numerous to mention were presented and revealed.

In summary, the EUPOC 2015 was very successful and more than fulfilled the expectations of the organizers since many new networks, collaborations and friendships were generated. Hopefully this is also the feeling and impression of the participants not least the Ph. D. students and the junior scientists that are the next generation of researchers in the conducting polymeric materials scenario.

EUPOC 2015 was organized by Dr. Maria Omastova, Polymer Institute, Slovak Academy of Sciences, Bratislava, and Professor Søren Hvilsted, Technical University of Denmark, assisted by Professor Giancarlo Galli, University of Pisa, Professor Michele Laus, University of East Piemonte, Alessandria, and Professor Daniele Caretti, University of Bologna. An instrumental key person was the EUPOC 2015 secretary Ms. Maria Viola, University of Pisa.

Feedback

Professor Steven Holdcroft, Department of Chemistry, Simon Fraser University, Canada.

EUPOC 2015 was memorable for both the breadth of topics covered, which was remarkably large given the specificity of the symposium topic, and the location, which provided a relaxing backdrop for extended scientific discussion. Participating in active debate on topics ranging from biological prosthetics to solar fuels to microfuel cells, all under the auspices of conducting polymers was refreshing and stimulating.