A Conduit for Emerging Technologies

The Role of the ECS New Technology Subcommittee

by Walter van Schalkwijk

In the nearly one hundred years since its founding, The Electrochemical Society has been the dominant forum for those who control and observe electron movement in chemical and solid-state systems. Its membership and divisional structure has moved with agility as new technologies have emerged. This agility has been tested over the past few decades with the advent of many competing professional societies with their associated publications and meetings all trying to compete for ideas, time, and money. In part, ECS has met this challenge through the New Technology Subcommittee (NTS) of the Technical Affairs Committee. In a way, the NTS is the guardian for ECS in matters of emerging technology.

The role of the NTS in the Society's success cannot be understated: every so often something new comes along and we must be in position to recognize it, introduce it to the Society, and give its investigators a forum and resources that can be home to the technology.

Prior to 1968, the New Technology Subcommittee existed as an ad hoc committee of those interested in bringing emerging technological advances to the Society. The first records of the ad hoc committee date to 1968 at the fall meeting of the Society in Montréal. The meeting was largely devoted to organizational matters and to a discussion of the responsibilities of the "New Technology Committee" as it was then called. The ad hoc NTC became a standing committee in 1968 with future Society president N. Bruce Hannay as its first chairman. It was agreed that the committee was responsible for: (1) the identification of the technical areas the Society might become interested in, and that are not being covered adequately in current Divisional activities; and (2) the stimulation and (temporary) supervision of new activities by the Society in areas of this kind that are so identified. Today, the mission of the NTS is essentially the same. NTS looks at new technology areas and their impact on society and on The Society. The ebb and flow of technology has caused the Society's divisional arrangement to change over the years; as a conduit for emerging technologies, the NTS plays a vital role in this process.

The three technical oversight committees of 1970 were the Electrode Processes Technical Committee, the Solid State Technical Committee, and the New Technology Committee. By 1975, the first two committees were combined to form the Technical Affairs Committee with New Technology as a standing subcommittee.

The records of the NTC (and then NTS) for the early 70s couldn't be found but it appears that the committee's activities picked up steam in the mid 70s under the care of Alvin Salkind and Forrest Trumbore. The NTS sponsored or co-sponsored several symposia during that time including: Energy Storage, 1975; Corrosion in Molten Salts, 1975; Photochromics and Electrochemics, 1975; International Symposium on Molten Salts, 1976; Inorganic Dielectric Materials for Display and Storage Devices, 1976; Reactions on Semiconducting Electrodes and Thin Films, 1977; and Materials and Processes for Conventional and Electric Vehicles, 1977.

We look at these topics today and take them for granted: what's so "new" about them? Molten salts (or ionic liquids as they are now sometimes referred to) have become part of the lexicon of synthetic chemistry and physical electrochemistry, yet just a short time ago they were a new hot topic. The Luminescence and Display Materials Division (LDM) can include a 1976 NTS symposium in its roots. These early symposia played a part in the birth of the Energy Technology Group (and then Division). The ETG was formed in 1976.

During its history, the NTS has not been hesitant about sponsoring symposia on unusual topics. Some of the proposals or actual symposia included, for example: *Earth-*

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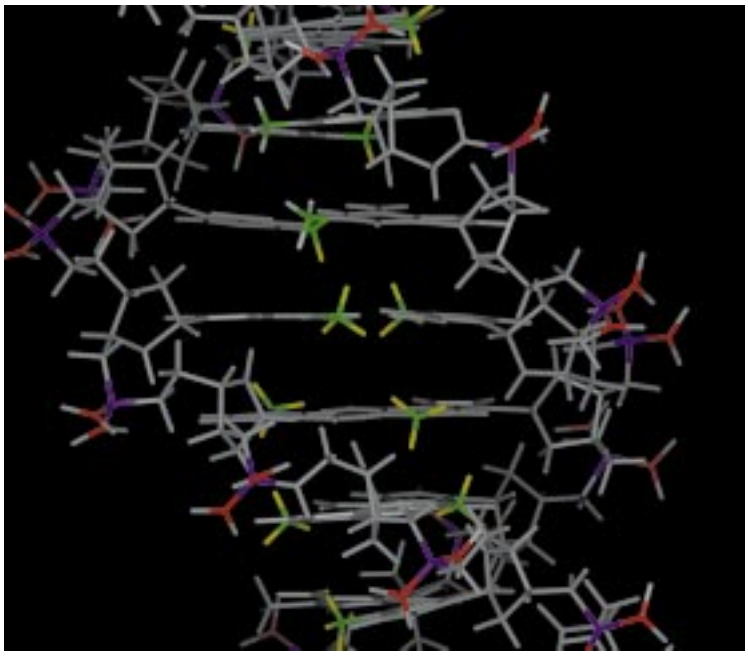
Past Chairs of New Technology

N. Bruce Hannay, 1970-72
Alvin J. Salkind, 1972-76
Forrest A. Trumbore, 1976-77
J. Paul Pemsler, 1977-80
Adam Heller, 1980-81
Ernest Littauer, 1981-85
Jerry Smith, 1985-87
Edward Nicollian, 1987-90
Frank McLarnon, 1990-93
Patrick Ng, 1993-97
Mark Verbrugge, 1997-98
Krishnan Rajeshwar, 1998-99
Walter A. van Schalkwijk, 1999-Present



Adam Heller to Deliver Keynote Lecture to NTS Fall Symposium

At the ECS meeting this October, the NTS is sponsoring the Symposium, "Electrochemistry and Solid-State Science and Technology in the Service of Medicine." Prof. Adam Heller, of the University of Texas, Austin, will deliver the keynote lecture, "Carrier Transport in DNA and the Hypothesis of Cathodic Protection of Genes." Carrier transport in DNA has been the subject of both experimental and theoretical work over the past 37 years. However, over and beyond the issue of the conduction of electrons (or holes) along the long axes of double-stranded (ds) DNA and oligonucleotide helices, Dr. Heller discusses the intriguing notion that the organization of ds-DNA in aligned, polarizable arrays may prove to be a central evolutionary strategy for preserving genetic information.

Dissolved DNA duplexes transport holes via phenomena that are reasonably well studied at the molecular level. However, when solid DNA duplexes are aligned with their long axes parallel to the applied electric field, their conductivity increases well above corresponding levels in solution. On the other hand, the diffusivity of electrons in unaligned and unstretched calf thymus DNA is negligible. The high unidirectional polarizablity and dielectric constant of the aligned array are attributed to the rapid and concerted shift of protons between neighboring base pairs of the stack.

The G-nucleotide is the most reducing of the four nucleotides of DNA, and chromosomal domains in which the mole fraction of G is well above 0.25 are expected to be reducing with respect to the genes, where their mole fraction is ca. 0.25. If the DNA is an electronic conductor, then G-rich domains are proposed to cathodically protect domains that are less rich in G against oxidative damage. This protection model is analogous to the cathodic protection tactic well known to the corrosion community. Thus the steel hull of a ship is protected by a zinc rod in electronic contact with the hull.

If the hypothesis of cathodic protection is valid, then Dr. Heller raises the possibility that aging and genomic instability of cells may reflect the loss of protection of genes against oxidative damage. He claims that the extent of protection provided by a G-rich region also has implications in mutation and sensitivity to radiation damage. Prof. Heller's lecture will be given on Monday morning, October 23, at the ECS fall meeting. ■

The figure shown above is a detail of the image on this issue's cover. It depicts the stick model of an aligned DNA duplex in the solid phase, showing the possible channels through which protons may move concertedly in an electric field paralleling the main axis. The primary amine groups of the C, G, and A bases are shown as protonated sp^3 hybrids. Color code: violet = phosphorus; red = anionic and partially anionic phosphorus-bound oxygen; green = primary amine-ammonium nitrogen; yellow = primary amine-ammonium nitrogen bound hydrogen/proton.

Image courtesy of Dr. Jonathan Heller, Exelixis Pharmaceuticals, San Francisco.

quake Prediction or more generally, *Prediction of Natural Phenomena; Zero Gravity Phenomena;* and *Electrochemical Aspects of Weather and Space Phenomena*. Several symposia sponsored by NTS addressing the status and future of electrochemistry education have been held over the past two decades. Returning to this topic may be timely since computer animation, virtual reality, and simulation of instrument/equipment operation can be combined on a web-based system to provide state-of-the-art electrochemical education in all topical areas. Web-based education is a hot topic in almost every discipline and ECS can play a leadership role in this inevitable transformation of education.

A recurring theme for NTS sponsored symposia has been electrochemistry and solid-state science and the environment. In addition to creating a certain amount of waste intrinsic to electrochemical processing, the use of electrochemical methods for cleaning up the environment have been examined by NTS symposia over the years. Technology developed for fuel processors or "reformers" for fuel cells, electrolytic chemical manufacture, and coatings technology are just a few of the technology areas that can contribute to remediation of the environment. Topics such as: Electrochemical Aspects of Ocean Resource Utilization, Electrochemical Methods in Wastewater Treatment, Reduction at Source, Recycling, and New Processes, Symposium on Waste Treatment: Processes and Materials, Upper Atmosphere Chemistry, and Water Purification by Photocatalytic, Photoelectrochemical, and Electrochemical Processes Recycling and Recovery have appeared over the 30 years of the NTS (either sponsored or co-sponsored by NTS). In the near future, the NTS plans a return to environmental electrochemistry in a more comprehensive manner to include remedial and analytical techniques, and recycling, as well as policy matters.

One timely example is the treatment of Chemical Mechanical Polishing (CMP) waste. CMP has emerged as a preferred technology for planarization of interval dielectrics and metal interconnects in the fabrication of advanced integrated circuits. Acidic, silica based slurries are used in CMP of metal films. It has been estimated that 30-50 liters of slurry waste are generated for each level of planarization of a 200 mm wafer. Researchers at the University of Arizona recently reported the results of electrophoretic methods (electrocoagulation and electrodecantation) for cleaning the slurry wastes.[1,2]

The biggest success of the NTS has been the introduction of fullerenes to the Society and the formation of the Fullerenes Group. Electrochemical investigators have long experience in the use of carbon materials and when C_{60} materials were first discovered in the mid-1980s, ECS was quick to capitalize on the discovery. The NTS helped with the co-sponsoring of several symposia, usually with the High Temperature Materials Division (HTM). HTM wanted Fullerenes to be incorporated into their Division, but it was recommended by the NTS to the Technical Affairs Committee and ultimately to the ECS Board of Directors that Fullerenes stand as a separate group. In hindsight (which is almost always 20-20), this was correct because of the proliferation of fullerene materials, and now applications, that are emerging. NTS could have and perhaps should have remained in play with the Fullerenes Group longer to encourage and initiate joint symposia with other Divisions. Fullerenes were such new materials that many of their properties were (and still are) being investigated; applications are just coming into their own and with it the interest in joint symposia with other ECS Divisions.

The most abundant empty fullerene, C_{60}, can be purchased for about $US30/gram, whereas it cost about $US1,000/gram a decade ago. Endohedral metallofullerenes have low production yields (10^2-10^3 times lower than for empty fullerenes) and are correspondingly more expensive. It is reasonable to expect that advances in purification techniques and chemical derivatization techniques will bring their costs down as well. In the meantime medical research can tolerate the small amounts of available material and the higher cost. This will no doubt lead to new collaborations in electrochemistry and medicine.

This fall, at the 198th meeting of The Electrochemical Society in Phoenix, Arizona, the NTS will host a symposium entitled "Electrochemistry and Solid-State Science and Technology in the Service of Medicine." There are many areas in medical research where electrochemistry and solid-state science and technology can play roles in facilitating breakthroughs. This symposium is designed to explore such opportunities and to identify common grounds and synergisms between medical research and the two ECS communities. This symposium is an outreach, in that papers will be solicited from outside the Society, mostly from the clinical research community. There will certainly be some papers from within ECS, particularly from the Organic & Biological Electrochemistry (OBE), Sensor, and Battery Divisions, and the Fullerenes Group.

Some clinical researchers are using electrochemical or solid-state sciences, perhaps without knowing that ECS exists as a great resource to assist their efforts by interaction with the physical scientists and engineers who have developed most of the techniques used in their laboratories. The cross fertilization of ideas will most certainly further the science. By going outside the Society in search of papers, ECS hopes to generate interest that will not only increase membership, but also widen the scope of science and technology reached by ECS. When the symposium was announced at the Symposium Subcommittee meeting at the Boston meeting (fall 1998), virtually every Division wanted to co-sponsor. Society by-laws prohibit more than four co-sponsoring Divisions or Groups, so the NTS decided to go it alone rather than leave out any one Division. Most of the Divisions have given input to the NTS to help move the symposium forward.

The symposium will feature a series of tutorials by invited speakers on selected topics to summarize state-of-the-art technologies and to highlight key research topics. A panel discussion is also planned. In conjunction with this symposium, a pre-conference short course is planned that will provide common grounding for medical and electrochemical and solid-state researchers. A number of other speakers will be invited, representing a wide spectrum of clinical areas. The call for papers was wide open, "trolling for anyone pushing electrons in a clinical environment." Specific areas of interest include: (1) neuro-stimulation; cardiac pacemaker/defribulator power sources; (2) electrochemical cancer therapy; (3) bioactive and biocompatible implant materials; (4) glucose and nitric oxide sensors; (5) analytical chemistry (including voltammetry, electrophoresis, and chromatography) in medical research; (6) electrical interactions in bone remodeling; (7) neural networks and nerve signal transmission/transduction; and (8) bioelectrics and medical instrumentation. By the time this goes to press, the papers will have been submitted and it is probable that papers on topics like those may be submitted, but papers on another dozen unforeseen topics will also be submitted.

The plenary speaker for the Phoenix meeting will also be on topic for electrochemistry and solid-state science in medicine: Dr. Carl Djerassi of Stanford University will be speaking and signing copies of his book *NO—NO* having a chemical connotation and not an emphatic negative response. Dr. Djerassi is well known as the "father of the Pill" and for developing synthetic pathways for other steroids. Dr. Djerassi is also known for stirring the pot when he delivers a speech: he once gave a commencement address entitled "In Praise of Polygamy," which in advance of his address raised a lot of ire, but his message was about "intellectual polygamy" and the value of cross fertilization of ideas. Dr. Djerassi has recently written a play with Roald Hoffman entitled *OXYGEN*. In part, it is the story of the debate over the discovery of oxygen, but it is set in the context of a debate over the awarding of the first "retro-Nobel Prize." The play is in the workshop stage. It has been requested for performance in Swedish translation at the Nobel ceremony this fall.

At The Electrochemical Society Meeting in Toronto in May, 2000, there were a number of papers presented on the application of non-functionalized fullerenes, metallofullerenes, and carbon nanotubes in medicine for such diverse uses as drug delivery, magnetic resonance imaging (MRI) contrast agent precursors and is being considered for radiotracers and radiopharmaceuticals. To be medically useful, C_{60} and metallofullerenes must be derivatized with hydrophylic substituents.[3] Once solubilized, the fullerene can be used to produce (with some synthetic difficulty) fullerene-based drugs that can target specific tissue. Research into the biological effects of fullerenes is in its early stage and the toxicity of fullerenes and their derivatives is being determined. There is relatively little toxicity information available on metallofullerenes and there is little reason to suspect different toxicities than for empty fullerenes.

The NTS is already thinking beyond the Phoenix meeting. A strong effort will be made to keep momentum on the medicine topic and several more joint symposia are planned. The first will be a symposium on DNA sensors, joint with the Sensor Division to be held at the Washington, DC meeting in the spring of 2001. Beyond that, there are some other joint symposia planned at future meetings. A second symposium on the Phoenix medical topic may be planned soon.

In the future, the NTS will return to environmental aspects of electrochemistry. Water resources are becoming critical in some areas of the world and combined with new electrochemical technologies for producing ultra pure process water for semiconductor manufacture, will lend itself to improvements in treatment of wastewater and potable water. Maybe we just like to feel "green" once in a while and revisiting environmental chemistry makes us feel good.

A symposium is planned on the topic of electric utilities deregulation and its implications and opportunities for ECS. This will be pertinent to several Division activities. It is expected to be a one- or two-shot deal with symposia/tutorials at one or two meetings with invited speakers from the utilities, the Electric Power Research Institute (EPRI) and the government (perhaps including the National Renewable Energy Laboratory (NREL)) to inform ECS members of the nuts and bolts of deregulation.

The New Technology Subcommittee stands ready to address any and all interesting new technologies and topics that are of interest to its members. A budget is in place to assist with introducing these topics to the membership. At present, the committee has eight members, so not all of the Divisions are represented. The chairman must rely on unsolicited input from Divisions that are not represented. Any suggestions for new technologies that might be of interest to the Society should be addressed to the author at waltvans@aol.com. ■

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