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Report

National Symposium on Biomolecular Electronics—Interfacing Physics and Chemistry with Biology

September 16–17, 1999

Organized by Biomolecular Electronics
and Conducting Polymer Research Group, National Physical Laboratory,
Dr. K. S. Krishnan Road, New Delhi-110012

The National Symposium on Biomolecular Electronics—Interfacing Physics and Chemistry with Biology was held at the National Physical Laboratory (NPL), New Delhi, India, on September 16–17, 1999. This symposium was sponsored by the Council of Scientific and Industrial Research, New Delhi; Department of Science and Technology (DST), New Delhi; Department of Biotechnology, New Delhi; Defence Research and Development Organization, New Delhi; Department of Electronics, New Delhi; Indian National Science Academy, New Delhi; Board of Research in Nuclear Sciences, Mumbai; National Research and Development Corporation, New Delhi; Semiconductor Complex, Mohali, Panjab; Labindia Pvt., New Delhi; and Blue Star, New Delhi. The organizer of this symposium was the Biomolecular Electronics and Conducting Polymer Research Group (BECPRG), NPL, New Delhi. The prime objective of the symposium was to generate vitality to a challenging and promising area of biomolecular electronics by emphasizing its openness to interface actively with chemistry and biology, in order to make it more beneficial to society.

The symposium comprised seven sessions, each dedicated to a specific topic of research and application aspects of biomolecular electronics. About 240 delegates from different parts of the country and 8 delegates from abroad participated in the symposium.

Inauguration

Prof. A. K. Raychaudhuri, Director, NPL, New Delhi, gave the welcome address. He talked about the successful programs in conducting polymers that have given rise to various marketable products. He emphasized his interests in enabling the institute to scale new heights, particularly in the area of biomolecular electronics and biosensors. Prof. V. S. Ramamurthy, Secretary, DST, New Delhi, inaugurated the symposium. Dr. B. D. Malhotra, Scientist-in-Charge, BECPRG, NPL, gave the vote of thanks.

He thanked all the invited speakers from India and abroad. Prof. S. K. Brahmachari, Director, Centre for Biochemical Technology (CBT), Delhi, gave the scintillating keynote address. The topic of his lecture was "Functional Genomes and DNA Chips." He outlined the goals of the Human Genome Project, major achievements in this project, and its significance to the average person. He stated that human genomics is a holistic and true science and, therefore, necessitate participation of researchers from all fields. He opined that India, for many decades, has been relying on predictions and, therefore, is an example for the rest of the world to be prepared ethically to accept the Human Genome Project.

Technical Sessions

There were seven technical sessions, and the main topics deliberated on were as follows:

1. Biomolecular Electronics/Biochip. Chair: Dr. Subhas Chandra, Scientist G, NPL; cochair: Dr. T. Lazar Mathew, Director, Institute of Nuclear Medicine and Allied Sciences (INMAS), Delhi.
2. Biosensors. Chair: Prof. M. N. Gupta; co-chair: Prof. Sneh Anand, Indian Institute of Technology (IIT), New Delhi.
3. Conducting Polymers. Chair: Prof. T. N. Mishra; cochair: Prof. S. P. Tiwari.
4. Biomaterials. Chair: Prof. Ratna S. Phadke; cochair: Prof. S. M. Ashraf.
5. Molecular Recognition. Chair: Prof. E. S. R. Gopal; cochair: Dr. R. Bhattacharya.
6. Immobilization and Characterization of Biomolecules. Chair: Dr. H. H. Weetall; cochair: Prof. A. S. N. Murthy.
7. Panel Discussion on Biomolecular Electronics, Biosensors, and Conducting Polymers. Chair: Prof. A. K. Raychaudhuri, Director, NPL, New Delhi.

Session I: Biomolecular Electronics/Biochip

Dr. M. J. Zarabi of the Semi-conductor Complex Limited, Chandigarh, gave an overview of biomolecular electronics, stressing that it needs to be pursued vigorously in India. Prof. Ratna S. Phadke of Tata Institute of Fundamental Research (TIFR), Mumbai, gave a very lucid picture of the trends in the emergence of the concept of biomolecular electronics and its relationship to various disciplines of science. Dr. K. P. J. Reddy of the Department of Aerospace Engineering, IISc, Bangalore, explored the implications of naturally available protein bactereorhodopsin extracted from the bacteria *Halobacterium halobium* in the development of components such as holographic data storage, Fourier processing, photonic gates and switches, spatial light modulators, and neural networks. Dr. N. Mustan delivered the last talk of this session, which was on the development of an integral quantitative amperometric immunosensor.

Session II: Biosensors

Session II was aimed at the developments and applications of biosensors. This session comprised six lectures. Dr. H. H. Weetall of the National Institute of Standards and Technology, Gaithersburg, MD, delivered the first lecture, "Optical Tweezers–Based Immunosensor Detects Femtomolar Concentrations of Antigens and Nucleic Acid Targets." This lecture was followed by a talk on thermal biosensors given by Prof. B. Danielsson of the Chemical Centre, University of Lund, Sweden. He projected the use of thermal biosensors in personal meters such as glucose biosensors. He stated that his group was making efforts to prepare hybrid biosensors combining different sensing techniques, such as thermal and electrochemical detection for extending sensor performance. Dr. M. S. Thakur of Central Food Technological Research Institute (CFTRI), Mysore, thoroughly explained the varied applications of biosensors in food and dairy industries. He highlighted that the use of biosensors could render good-quality and pure food products. The contributory talk of Dr. Rita Kumar of CBT was based on the biochemical oxygen demand (BOD) biosensors. She described these biosensors as a reliable and rapid device for *in situ* measurements for the strength of wastewaters. These devices will aid the accurate and rapid sensing of the organic materials in wastewaters. Finally, Dr. Shridhara Alva, of Abbott Laboratories, MediSense Products, described the importance of the electrochemical glucose biosensors and their growing market.

Session III: Conducting Polymers

Session III highlighted the present and future prospects of conducting polymers. The session began with a talk on artificial muscles using chemomechanical deformation of conducting polymers by Prof. K. Kaneto, Kyushu Institute of Technology, Japan. He showed a video on the movements of artificial muscles. Dr. B. D. Malhotra, BECPRG, the convener of the symposium, explicitly explained the use of conducting polymers for biomolecular electronics. Dr. S. Ghosh explained his work on poly(3,4 ethylene-dioxythiophene) complexed with polystyrene sulfonate and its applications as hydrogel for sensors. Dr. Reghu Menon, IISc, Bangalore, explained the charge transport in doped conducting polymers. Finally, Prof. A. K. Bakhshi, Delhi University, emphasized that the molecular designing of low-band-gap polymers is one of the fundamental challenges in the field of electrically conducting polymers.

Session IV: Biomaterials

Session IV was on the applications of biomaterials. Dr. N. Kumar of Defence Research Laboratory, Jodhpur, delivered the first lecture on conducting polymers for biomedical applications. He gave a brief overview of functionalization of some important conducting polymeric systems with special organic and biologic molecules and their various biologic applica-

tions including biosensors, tissue engineering, and medicine. Prof. A. S. N. Murthy of Tate Energy Research Institute (TERI), New Delhi, spoke on the use of self-assembled monolayers as biosensors for amperometric determination of glucose.

Prof. S. Slomkowski, of the Polish Academy of Sciences, Poland, discussed the use of microspheres with controlled surface properties as materials for biosensors. He said that the polymer microspheres with properly designed and controlled chemical composition and morphology of surface layers were used as carriers of proteins and oligonucleotides appropriate for applications in medical and veterinary diagnostics, particularly in the construction of biosensors. Prof. A. Q. Contractor of IIT Mumbai attempted to describe its recent studies on the development of sensors with polyaniline, and the development and sensor arrays for electronic tongue. Finally, Dr. R. Saraswathi of the Department of Materials Science, Madurai Kamraj University, Tamil Nadu, explained the electrochemical quartz crystal microbalance techniques for the quantitative analysis doping and undoping of polycarbazole in 5 *M* $HClO_4$.

Session V: Molecular Recognition

Prof. H. M. Chawla of IIT, New Delhi, focused on the use of new calixarene-based sensor materials for bioamines. Dr. K. A. Suresh of Raman Research Institute, Bangalore, discussed the relevant issues related to liquid crystal molecules that are made by depositing monolayers of suitable materials by the Langmuir-Blodgett method and their applications in molecular electronics. Dr. Sushil Chandra of the Institute of Nuclear Medicine and Allied Sciences, New Delhi, gave an overview of the wide biomedical applications of molecular electronics, specifically as biosensors, microgas analyzers, and active catheters. Prof. B. Jayaram of the Indian Institute of Technology, New Delhi, explained the importance of computer simulation studies on biomolecular recognition. Dr. S. Annapoorni of the University of Delhi discussed work on the efficient coating of nanoparticles with conducting polymers that charges their electrical, magnetic, optical, and other physical properties thereby rendering them useful in quantum electronics devices. Finally, Dr. K. L. Yadav of NPL spoke on the direct-current conductivity studies on poly(3-methyl thiophene).

Session VI: Immobilization and Characterization of Biomolecules

Session VI began with an interesting talk by Dr. S. F. D'Souza of TIFR, Mumbai, on the immobilization and stabilization of biomass for biosensors and allied applications of proteins for biomolecular devices.

Dr. T. N. Misra of Indian Association for the Cultivation of Science (IACS), Calcutta, discussed the application of ultrathin Langmuir-Blodgett films in biotechnology. He talked about an alcohol biosensor developed by his group using the Langmuir-Blodgett technique for enzyme immobilization that could detect the presence of alcohol in a solution. Dr. A. M. Kayastha of B.H.U., Varanasi, discussed his work on the purification and

immobilization of urease from seeds of *Cajanas cajan* spp. and its potential analytical applications. He said that his studies on immobilization had a potential role in hemodialysis machines in maintaining the urea level in kidney patients and in the construction of a portable artificial kidney. Finally, Dr. K. Ramanathan of Lund University, Sweden, gave an overview of the contemporary advances made in the field of biomolecular electronics with special reference to the development of new biomaterials for bioelectronics, applications of biomaterials to electrical/optical devices, and possible improvement in "addressing" biomolecules on various "platforms."

Poster Session

Twenty-one posters were presented at the poster session held on September 17, 2000. The posters were based on different aspects of the conducting polymers, biosensors, application of conducting polymers to biosensors, and other materials for biomolecular electronics.

Session VII: Panel Discussion

The symposium concluded with Session VII. The discussion panelists were Prof. K. Kaneto, Prof. B. Danielsson, Dr. V. K. Misra, Dr. M. J. Zarabi, and Dr. Y. N. Rao. They expressed their general comments about the state of the art in biomolecular electronics, biosensors, and conducting polymers as well as the future prospects in these fields in different countries. The chairman, Prof. A. K. Raychaudhuri, opined that extensive work should be done toward the exploitation of the capability of biomolecular electronics to interface with physics and chemistry. He expressed his deep concern in this area and his interest in making successful programs in this field in order to render marketable products. He gave a brief overview to show how nature can be imitated in order to make biomolecular materials that can incorporate the beneficial aspects of electronics and natural self-assembly abilities. Prof. B. Danielsson briefly summarized the objectives of all the sessions, emphasizing the need for greater attention and increased finances for research and development (R&D) in the field of biomolecular electronics. Dr. V. K. Misra, Advisor, DST, expressed his opinion that although scientists talk about the applications of biomolecular electronics, they, however, lack a strategy to make the research more industrially applicable, so that it will result in actual products that can be sold in the market for use by anyone. He said that the scientists from various disciplines should join hand in hand and plan for higher projects/missions. A country like India needs clear-cut objectives so that R&D programs can be focused on commercializable products. He stressed the need to identify and bridge technologic gaps. He also said that India should focus more on the increased clinical and environmental applications of biosensors and collaborate with people of different countries working on the same aspect.

Dr. M. J. Zarabi strongly recommended that researchers need to convert their intuitions into convictions that can lead to successful research

and its lead in the market. Dr. Kaneto, who talked about the current status of research in biomolecular electronics in his country, said that the only reason for successful R&D in Japan was perhaps the extrapolation of advancement of chips even 10 yr prior to the chips actually being produced and sold in the marketplace. He also said that Japan strongly believes in long-term plans and involves more and more people to work on the same area so that the probability of breakthroughs in a particular field is increased. Dr. Y. N. Rao of the Ministry of Health emphasized that more efforts should be made to make biosensors for marketable products used in clinical diagnostics.

The following areas were identified as highly exciting, emerging fields of research having decisive implications in the advent of biomolecular electronics:

1. Biosensors: medical, food processing, pollution detection devices, and so on.
2. Immobilization and characterization of biomolecules.
3. Three-dimensional memories: proteins, other small molecules.
4. Films of functional organic molecules with well-designed molecular architecture.
5. Molecular recognition.
6. Biochips and DNA chips.

The panel strongly recommended that funding be increased by government agencies in the very near future for R&D in the area of biomolecular electronics, biosensors, and conducting polymers.

Dr. B. D. Malhotra