ADVANCED MATERIALS

# Synthetic Metals—Coming of Age But Still Controversial

The "International Conference on Science and Technology of Synthetic Metals" (ICSM '88) was held from 26 June to 2 July 1988 in Santa Fe, New Mexico, USA. It was attended by more than 550 physicists, chemists and materials scientists, more than half of whom came from Europe and Japan. There were over 700 contributions—lectures and posters—in four parallel sessions. The conference, organized by *M. Aldissi* from the Los Alamos National Laboratory, was primarily concerned with experimental and theoretical aspects of low dimensional conductors. Since the discovery of the first conducting polymer, more than ten years ago, there has been a growing interest in organic conducting materials. The main purpose of these investigations is the synthesis and study of new materials which combine the electrical properties of semiconductors or metals with the mechanical properties of polymers or other compounds. These have, in addition, the advantage that their properties can be tuned through molecular engineering, leading to well defined chemical structures.

The program of the conference covered the following areas: conducting crystals, conducting polymers, organic and high-$T_c$ superconductors, organic ferromagnets, and materials with nonlinear optical properties. In contrast to the latest three ISCM meetings in Les Arcs (1982), Abano Terme (1984) and Kyoto (1986), the interest was focused on applications of conducting polymers. More than fifty presentations dealt with applications and many participants came from industry; however, only one or two products have been introduced to the market.

The meeting started with three plenary lectures: *V. J. Emery* (Brookheaven National Lab., Upton, USA) talked about the relationship between organic and high-$T_c$ superconductors, and made a critical comparison of the mechanisms of superconductivity in both materials. It was hoped that the knowledge gained recently in the high-$T_c$ ceramics field would help to improve organic superconductors as well. *K. Bechgaard* (Copenhagen, Denmark) reported on new molecular metals based on various heterocyclic donors. *H. Shirakawa* (Univ. of Tsukuba, Japan) chose as his topic polyacetylene with high conductivity (up to 22000 S $cm^{-1}$), high density and good mechanical strength. He stressed the importance of synthesizing polyacetylene films with very long conjugated segments and highly oriented polymer chains free of chemical defects. This can be achieved by a special treatment of the catalyst such as ageing and solvent evaporation prior to the polymerization process. Unfortunately, the chemical stability toward autoxidation could not be improved.

Three different types of polymers dominated the conducting polymers sessions: polyacetylene, polyaniline and substituted conducting polymers, especially substituted polyheterocycles (polypyrroles and polythiophenes) and poly-*p*-phenylenevinylenes. Substituents improve the solubility and processability of these materials. Nevertheless, a more accurate characterization of the polymers with respect to structural details, molecular weights etc. was not achieved.

Of particular interest in this area were talks dealing with composites or blends of conducting polymers and insulating matrix polymers. Such materials combine the intrinsic conductivity of the polyconjugated system and the mechanical properties of the matrix polymer.

*M. F. Rubner* (MIT, Cambridge, USA), *S. Tripathy* (Lowell Univ., USA) and *T. A. Skotheim* (Brookhaven National Lab., Upton, USA) presented results on conducting thin films of substituted polypyrroles and polythiophenes, which were made using the Langmuir-Blodgett technique. Such conducting thin films are of interest for developing molecular electronics.

Another polymer which received particular attention was polyaniline. Despite the fact that the conduction mechanism and the exact structure of this polymer are still a matter of controversy, as a large number of contributions proved, the first example of a commercial application of a conducting polymer in energy storage was reported by *T. Nakayima* (Bridgestone Corp., Tokyo, Japan). He described a rechargeable battery, developed in a joint project by Bridgestone and Seiko, which consisted of a polyaniline cathode and a lithium/aluminium alloy anode. Such a battery is used as a back-up power source for integrated circuit memories, or as an energy store for clocks with solar cells. That conducting polymers are promising materials for energy storage was also demonstrated in the subsequent talks by *M. Mizumoto* (Hitachi Ltd, Hitachi-she, Japan), *E. M. Genies* (Centre d'etudes Nucleaires, Grenoble, France) and *L. W. Shacklette* (Allied Signal Inc., Morristown, USA).

Polyacetylene again attracted a lot of interest, particularly because its conductivity has been improved significantly; the value of about $10^5$ S $cm^{-1}$ that has recently been reported by *Naarmann* et al. (BASF, Ludwigshafen, FRG) is almost equal to that of copper. Several other authors reported conductivity values of more than $10^4$ S $cm^{-1}$ in oxidized and highly oriented samples of polyacetylene [*T. Schimmel* (Univ. of Bayreuth, FRG), *M. Galtier* (Univ. of Montpellier, France); *Y. W. Park* (Seoul National Univ., Korea) and *J. Chiang* (UC Santa Barbara, USA)]. The improvement in the conductivity is achieved by a further development of the Shirakawa technique of acetylene polymerization using different solvent and polymerization conditions. This procedure probably leads to a more uniform catalyst with a smaller number of different

reactive species. Nevertheless, a complete understanding of the structural parameters and nature of the charge carriers and their mobility is still lacking.

An increasing number of contributions—compared with the Kyoto meeting two years ago—dealt with the possibility of using polymers with conjugated backbones in semiconductor devices [*F. Garnier* (Lab. Photochimie Solaire, Thiais, France), *R. H. Friend* (Cavendish Laboratory, Cambridge, UK) and *H. Koezuda* (Mitsubishi Electric Corp., Japan)]. The idea of an all-plastic electronic device constructed from semiconducting polymers is challenging. In these presentations it was shown that such devices work in principle, but up to now either the charge carrier mobility and/or the long term stability of the device is not sufficient compared to conventional inorganic semiconductors.

Next to polymers, the synthesis, structure and theory of superconducting low molecular weight crystals were covered in many contributions. The most promising candidates as organic superconductors are various BEDT-TTF radical salts; the onset of superconductivity has been measured at about 10 K at ambient pressure! Although this temperature is not very high compared to the values of the new high-$T_c$ ceramics, the steady increase in the transition temperature and the more detailed knowledge of the structure encourage further investigations of these new organic materials.

A variety of social events such as receptions and excursions to places of interest near Santa Fe provided a relaxing diversion from the intense scientific program (up to 13 hours per day). The large number of lectures and poster presentations made it difficult to attend contributions in different fields. The shortness of the lectures (15 or 25 minutes plus five minutes for discussion) led to the situation that in some cases the results of one research project were reported in different lectures and poster presentations. It would be better to restrict the number of oral contributions in order to keep track of the progress made in the different fields. For reasons of clarity a combination of longer plenary lectures and short communications would be preferred.

The contributions to the ICSM '88 will be published in "Synthetic Metals" before the end of this year. The next ICSM meeting will be held in 1990 in Tübingen (FRG) and will be organized by *M. Hanack* (Univ. Tübingen, FRG) and *S. Roth* (Max Planck Institute for Solid State Research, Stuttgart, FRG).

*Jürgen Rühe* and *Tiberio A. Ezquerra*
Max-Planck-Institut für Polymerforschung
Mainz (FRG)

# Surface and Colloid Science

The 6th International Conference on Surface and Colloid Science (6-ICSCS) was held on June 5-10, 1988 in Hakone, Japan, organized by the Division of Colloid and Surface Chemistry of the Chemical Society of Japan. Surface and colloid science has made rapid progress in recent years, due to the development of completely new experimental techniques and the industrial needs arising from the introduction of advanced technologies. Studies of amphiphilic substances are being pursued alongside research on organized molecular assemblies in solutions and at interfaces. Rapid progress is being made in investigating solid surfaces using the experimental techniques of high-vacuum physics, leading to many new results related to catalysis and chemical and photochemical reactions at surfaces. Biosurfaces and biocolloids are important research topics in the context of the recent upsurge in biological science. The preparation of fine particles and of concentrated dispersions are important topics in relation both to new industrial applications and to pure research, e.g. the direct measurement of interparticle forces.

Nearly 800 participants from 25 countries throughout the world came together for the 6-ICSCS, and 530 papers and poster presentations made up the five sessions: 1) Organized Molecular Assemblies in Solution, 2) Organized Molecular Assemblies at Interfaces, 3) Solid Surfaces and Catalysis, 4) Biomembranes and Biocolloids, and 5) Fine particles and Dispersed Systems. In addition to exchanging information on fundamental aspects of surface and colloid science and their applications to advanced materials, participants were able to enjoy the beautiful scenery of Mt. Fuji.

Six plenary lectures were presented on the mornings of Monday and Wednesday. In the first of these, *E. Matijević* (Potsdam, NY, USA) discussed "Colloidal Science of Ceramic Powders", pointing out that the properties and processing of ceramic materials are strongly influenced by the nature of the powders from which they are made. With the help of many beautiful electron micrographs he showed that a large number of dispersions can now be obtained with uniform particles, ranging in size from several μm to several nm, in a variety of shapes including spheres, rods, ellipsoids, cubes, platelets, discs, etc.

*K. Shinoda* (Yokohama, Japan) lectured on "Conceptual Advances in Organized Solutions: a Milestone in the Physical Chemistry of Biological Organization", and described the ideal organized solution.