[Government is now the major supporting organization for scientific research. The pursuit of science will probably no longer be guided by individual initiatives. Recognizing that the strengthening of our journals led to the formation of peer groups in various subjects, a bold step was taken by the Department of Science and Technology (DST) in the early eighties to involve these peer groups in the identification of major research areas, or 'thrust areas' as they were called. The first attempt at such a formulation was the series of National Seminars organized by DST, which are now known as the 'Baroda Seminars'. These identified the 'thrust areas', which would be nationally supported through Government funding. It was also amply made clear—and later it was also followed in spirit—that any individual idea in the form of a research proposal that had high innovative content would also be considered for support even if it was not listed among the so-called 'thrust areas'. Nevertheless, the tendency of the scientific community has mainly been to follow the trend identified in these Baroda Seminars.

DST had undertaken a very extensive exercise during the later part of the eighties through its Science and Engineering Research Council (SERC) and its Project Advisory Committee (PAC) to identify specific projects in these thrust areas and support competent groups. SERC also considered providing necessary infrastructure and opportunities for young scientists to work in many areas. Now DST is undertaking to review and update these so-called thrust areas and to evaluate objectively the impact of the research support SERC has provided over the last 5–7 years in the identified thrust areas in the broad disciplines of Chemical Sciences, Life Sciences, Physical Sciences and Engineering Sciences. A document called 'Science and Engineering Research Council—Activities during 1980–87 —A report' has been brought out for publicizing these R & D activities supported by DST. The reviews carried out at the National Seminars are being published as part of the report of SERC activities in the past and indicating 'challenging areas for research' that would be supported in the future. The change of nomenclature from 'thrust areas' to 'challenging areas' is to be welcomed.

We have decided to publish these reports in Current Science. This issue of the journal contains the report on Chemical Sciences prepared on the basis of a seminar in Baroda in November 1988. The report brings out a reasonable balance between 'what is ideally good and what is reasonably practical' in suggesting our efforts in fundamental chemical science. Similar reports in other disciplines identified by SERC will follow. We hope that the issues raised in these reports and the recommendations made by the scientific community would open up a debate on this approach to supporting scientific research in the country.

There is of course the larger issue that can be raised: the consensus of the scientists in what they should do in the next five years may be good for the scientific community but is it the best for the country?

S. Ramaseshan
Editor]

CHALLENGING AREAS IN CHEMICAL SCIENCES

PREAMBLE

DURING the Sixth Five-Year Plan, the Department of Science and Technology (DST), under the scheme of the Science and Engineering Research Council (SERC), initiated a new approach to promote research and development activities in different broad areas of science and technology. This exercise was a part of the DST's mandate of promotion of new areas of science and technology.

At the time of defining this approach in 1980, it had been recognized that science and technology in the country was being encouraged and supported through a number of scientific agencies based on existing infrastructure in the Universities, National Laboratories and Institutes. Specific support was also being provided through sponsored projects, which originated mainly through the interest of individual scientists. As a result DST had gathered sufficient experience to learn from the project mode of funding initiated during 1974–75 through the activities of SERC. The period 1975–80 was therefore a period of exploring ways and means of supporting R & D projects actively in the country. This approach had succeeded to the extent that individual scientists had access to additional resources to carry out specific time-bound research projects of their interest. A need was however felt to focus national efforts in some specific areas that were on the frontiers of science and technology and provided a challenge to the scientific community. There was a need for supporting R & D efforts more in the form of building competent groups in specific areas of science and technology that were challenging and to a certain extent could be utilized in the long run for solving problems of national development.

It is with this background that DST organized, during the early eighties the series of National Seminars at Baroda in the form of well-prepared debates in four broad disciplines, viz. Life Sciences, Chemical Sciences, Physical Sciences and Engineering Sciences. There was wide consultation and in-depth discussion on the base document approved by SERC in a particular area, which highlighted the importance of that area and identified the competence available in the country. These series of seminars, now known as the 'Baroda Seminars', also provided guidelines for supporting R & D activities through the mechanism of SERC in its 'Thrust Area Programmes' taken up during 1980–85. Under these programmes, not only were individual projects supported but also 'core groups' around individual scientists were set up. These Thrust Area Programmes of SERC were undertaken during the Sixth and Seventh Five-Year Plan periods not only through intensive research support activities in the form of project funding but also through other promotional mechanisms such as organizing summer/winter schools, publication of technical reports, group monitoring workshops, encouraging young scientists to take up research and development activities, setting up of sophisticated instruments facilities, etc.

It was recognized that the wider approach to supporting R & D activities through the Thrust Area Programmes of SERC was increasingly appreciated by the scientific community and also brought about an improved level of scientific activity in the country. This effort also resulted in some major national programmes being generated in the fields of biotechnology, plasma physics and immunology.

During 1987–88, SERC decided to review the impact of its Thrust Area Programmes undertaken during the earlier part of the eighties. This exercise of reviewing its Thrust Area Programmes was called 'Baroda Revisited' and once again a series of national seminars were chalked out in the above disciplines. The Baroda Revisited series of seminars in the areas of Life Sciences, Chemical Sciences, Physical Sciences and Engineering Sciences have already been held. The scientific community has given very useful feedback to DST to evaluate its approach to support for science and technology so far and has helped in proposing its future plans for the forthcoming Eighth Five-Year Plan period.

At these seminars, apart from reviewing the national status in a particular field in the context of the international scene, contributions made by Indian scientists in a particular area were also discussed. Broad questions of reviewing the thrust area programmes, updating them and evolving new mechanisms for supporting scientific research in the country are being debated. One of the major questions that emerged during these national seminars was that of defining and identifying relevant thrust areas. The new approach supporting S & T activities in the country through the programmes of 'Technology Missions', projects being implemented in 'mission mode' and nationally co-ordinated projects (e.g. superconductivity, new fibres and composites, etc.) had to be taken note of before defining the research priorities for the Eighth Five-Year Plan. It was felt that the thrust area programmes should not be viewed as programmes for achieving some time-bound targets or for delivering specific products, goods and services, but that the concept of 'thrust' should be examined from the point of view of creating an impact on the scientific research scene in India and abroad. It was also felt that since mechanisms like technology missions, projects in mission mode, nationally co-ordinated projects, etc were available, the efforts of SERC should be more in the form of ensuring that areas that would provide challenges for creating new knowledge and understanding be given the thrust. The emphasis should be on the first objective enunciated in the Scientific Policy Resolution of 1958, i.e. to foster, promote and sustain, by all appropriate means, the cultivation of science and scientific research in all its aspects—pure, applied and educational. The scientific community in the country should be encouraged to take up carefully selected and challenging areas of science and technology. Through such efforts of providing opportunities and encouraging research and development in challenging areas, India would be in a position to build competence and expertise in different disciplines of science and technology. On the one hand, such an approach would give opportunities to Indian scientists to work at the frontiers of science and technology, and on the other, their expertise could be made use of in solving some national development problems by giving them specific tasks under the mission approach.

It is with this understanding that DST is attempting to identify several broad areas for scientific research that would interest and encourage the scientific community in India to come together and work in many of these areas individually and collectively. The Baroda Revisited exercise, therefore, is now concentrating on the question of identifying 'challenging areas' in various disciplines that would be pursued by the scientific community through the support of DST. Other funding agencies may also find these areas to be of direct relevance in their own specialized goal-oriented activities. The challenging areas are being widely publicized to encourage the scientific community to participate in this promotional programme being co-ordinated by DST. It is hoped that the exercise would also give opportunities for younger scientists to take up challenging research careers for themselves.

This report is the result of one such exercise in the area of Chemical Sciences. It is based on the discussions at a National Workshop held at Baroda to review and update the Thrust Area Programmes promoted by DST so far.

INTRODUCTION

Chemistry is a central science and provides the necessary basic understanding for dealing with a large variety of needs of society. Whether it is feeding and clothing our population, tapping new energy sources, improving health and fighting disease, or finding new substitutes for dwindling natural resources, chemistry plays a crucial role. Fundamental research in chemistry will be of great help to future generations in coping with new and unexpected problems and in finding appropriate solutions to these problems. Chemistry has been continually developing interfaces with other sciences such as physics and biology at a phenomenal pace and the scope and structure of the subject keep changing constantly. It is therefore important to be on constant vigil not to miss opportunities to contribute to new directions in chemical sciences and to apply chemical knowledge to answer newer challenges and obtain better solutions to problems facing society.

Chemical science has grown explosively in the last few years. Chemists have, as of today, synthesized over 8 million compounds. The doubling time for newly discovered chemical compounds is now hardly 10 years, compared to 40 years in the 1940s, thanks to new diagnostic tools as well as better unifying theoretical models.

PRESENT-DAY CHEMISTRY—A BIRD'S-EYE VIEW

The practice and perception of chemical sciences have undergone major changes in the past two decades and it has emerged as a more vibrant and interactive discipline. New frontiers have emerged. Several parallel developments have made this possible. Foremost among them is the spectacular advance and sophistication in chemical instrumentation. For example: events in the nanosecond and picosecond range, like electron transfer processes in photosynthesis and transient species in fast reactions, can now be readily monitored; high-field, multinuclear NMR makes it possible to map three-dimensional structures from biopolymers to zeolites; liquid chromatographs can routinely detect and separate the minutest amounts of natural products or environmental pollutants and mass spectrometers can now determine molecular composition to five decimal places. On the preparative side, there has been an explosive growth of new reactions, reagents and methods to design new materials, exotic organic molecules, drugs, catalysts, enzyme mimics and chemical sensors, among others. Heat, light, sound, pressure, plasmas, microwaves and lasers are being employed along with new chemical reagents in synthesis. Organometallics in particular have come to the forefront. Lastly, the advent of fast computers, new computational techniques and molecular graphics has enabled accurate predictions of reactivity, and electronic and molecular structure. Molecular interactions, conformations and even transition states can now be seen in action and simulation studies dealing with drug, catalyst and polymer design have made major impact.

The foregoing examples are only representative and are not meant to delineate emerging frontiers in chemical sciences. They are meant to indicate that *nouveau chimique* lies at the interfaces with other disciplines and its creative potential is strongly dependent on instrumentation support and bench-level logistics. Being a 'central science' chemistry must remain conscious of its societal obligations and chemists must gaze at horizons beyond research grants and publications.

THE INDIAN SCENE AND SERC INITIATIVES

Research in chemical sciences in India has been pursued from the beginning of this century at several centres. While the number of scientists engaged in chemical research has been steadily increasing in the past few decades, peaks of excellence have been very few and far between and of short duration. An example is the research in the area of natural products which flourished from the mid-fifties to the mid-sixties but withered away in the seventies. In fact, in the seventies, when the global research scene in chemical sciences changed rapidly, our efforts in India remained largely static and tradition-bound. This was the result of a combination of several factors. First, the new developments in chemical sciences required modern instrumentation facilities, which were either non-existent or very scarce. One can cite many instances of this but let us look at the case of NMR spectrometers, a basic bread-and-butter instrument for chemists. Until 1975 we did not have more than a dozen NMR spectrometers in the entire country and perhaps none working in the FT mode. Secondly, the large number of practising chemists in India either did not perceive the changing scenario or, even if they did, perhaps could not find funding and infrastructure to support them. All this added up to a general loss of direction. Clearly, the remedy lay in better appreciation of new trends in chemical sciences, access to sophisticated instrumentation, substantially augmented funding for bench-level support (chemicals, manpower, etc.) and interaction among active chemists.

To improve the none-too-healthy state of chemical sciences research in India in the late seventies, SERC embarked on several initiatives in tandem. To begin with, SERC followed the well-established dictum of scientific research that 'people perform best when they are allowed to do what excites them most' and funded a number of individual research projects after scrutiny through the peer review system. For the first time, the quantum of funding and instrumentation support on many of these projects was at such a level that investigators could be on their own in pursuit of their objectives. Thus NMR spectrometers, UV–IR–CD-nanosecond spectrometers, GLC–HPLC units, electrochemical systems, ESR instruments, X-ray generators and computers were sanctioned as part of individual projects. In many cases, it was through these projects that some of these essential instruments made their entry into university chemistry departments. Individual research projects were funded in many diverse areas of chemical sciences like chemical kinetics, solid state chemistry, catalysis, polymer chemistry, photochemistry, organic synthesis, natural products, transition metal chemistry, organometallics and theoretical chemistry. While some of these projects were clearly front line efforts of topical interest, there were others that were down-to-earth but indicated an endeavour to 'catch on'. A few projects were mainly concerned with some regional problems and requirements were also supported.

Simultaneously, a bold and imaginative move was made by DST at 'pump priming' certain emerging areas in chemical sciences. The Baroda seminar formulated a Thrust Area Programme in chemical sciences and this was widely publicized. The programme was broadly defined under five headings:

(i) Molecular structure and dynamics
(ii) Solids, surfaces and catalysis
(iii) Frontiers in organic chemistry
(iv) New interfaces of chemical sciences with biology
(v) Co-ordination and organometallic chemistry.

To give practical shape to the programme and monitor its progress, five programme advisory committees (PAC) dealing with the above areas were constituted. The initial response to the thrust area programme from investigators was cautious and somewhat limited. However, through a programmed series of updates, seminars and discussions with present and prospective investigators by PACs more and more proposals are being received and the response now is very encouraging. Through the PAC mechanism, major front line projects in photochemistry, solid state chemistry, natural products synthesis, asymmetric synthesis, marine natural product chemistry, organometallic chemistry, bioorganic and inorganic chemistry, transition metal chemistry involving novel redox and electron transfer processes, laser and flash photolysis studies, biomembranes, theoretical chemistry, etc. have been supported. The PAC exercise has proved very effective in identifying, clarifying and sharpening the focus of many projects.

Another major initiative of SERC in chemical sciences has been through the Intensification of Research in High Priority Areas (IRHPA) programme. Under this programme, two units on solid state and surface chemistry, and chemical dynamics and picosecond spectroscopy have been established at IISc, Bangalore, and TIFR, Bombay. The Bangalore unit has made notable contributions that are widely recognized. The state-of-the-art facility at TIFR offers challenging opportunities to investigators who wish to plan experiments around it. Furthermore, as part of efforts to create national research facilities, a 500 MHz NMR facility at TIFR and a 300 MHz solid state NMR facility at IISc have been commissioned for wide-ranging studies in chemistry, physics and biology.

While funding in chemical sciences represents a relatively small fraction of the SERC budget, it is still substantial and calls for a performance audit and evaluation of its impact. It is not easy to assess the scientific impact in a discipline across this country and it is still harder to quantify it. One can only look for certain trends and logically extrapolate them. The most widely accepted norm for evaluating scientific activity and accomplishments is through the quality and quantity of research publications. In this regard a significant change has been witnessed in the past five years, and contributions from India in the world's leading journals in chemical sciences have increased significantly. A quick survey reveals that in some of the top journals there has been a three- to five-fold increase in contributions from India. This is truly remarkable. One is at least entitled to draw the conclusion that many groups are working and striving for excellence. One can legitimately ask if this change is due to SERC funding alone. There is no simple answer but the fact that most of the chemists who publish in leading journals are also SERC grant holders cannot be mere coincidence. Together with this spike in quality publications, several Indian chemists have acquired international visibility. There are clear indications that more Indian chemists are being invited to deliver lectures at international symposia, discussion meetings, Gordon conferences, etc. There has also been a definite improvement in the quality of the projects being received for funding by SERC and this is particularly true of projects under the thrust area programme in Chemical Sciences. This is again an indication that a process of change is on.

There is another positive outcome, perhaps a less visible one, from SERC funding to the university system. Induction of modern instruments and bench-level facilities, although through individual projects. has had a very healthy influence as many students and teachers have gained exposure to them. It also helps to create an awareness that if there are ideas, they could be pursued and funds obtained.

To sum it up, the research scene in chemical sciences has brightened considerably in the past few years. There is a spurt in research activity and an urge to look at the new and emerging frontiers in chemical sciences is discernible. There is still a lot of lost ground to be covered. But we seem to have turned the corner and SERC and DST have played a substantial role in it.

CHEMISTRY AND INDUSTRY

Most of modern industry has a strong chemical base and the progress of advanced countries has been mainly through their chemical industries. Progress in chemical research generally goes hand in hand with progress of chemical industry. The situation is not altogether encouraging in India.

The Indian chemical industry is hardly 30 years old and is now poised for major growth. It is estimated that investment in this industry during the next 15 years may reach Rs. 70,000 crores or more (excluding downstream processing industries for elastomers, fibres, plastics, etc.). Efforts are being made to determine our priorities in areas such as fertilizers, petrochemicals, agrochemicals, bulk drugs, polymers, speciality chemicals and biotechnology, taking into account our renewable and non-renewable resource pattern. But industries have not identified long-term research problems that need to be tackled and have not provided support for them in the academic sector. Scientists in academia have to seriously take greater interest in industrial problems. Unless chemical research has industrial backing, the subject will suffer in the long run.

MANPOWER IN CHEMISTRY

Although we are producing large numbers of MSc's and PhD's in chemistry, we are crucially short of well-trained chemists with expertise in many aspects of modern chemistry. Fewer bright students are taking up chemistry as a profession.

The acute shortage of chemical talent, badly required in educational, research and industrial R & D organizations, has to be remedied. Our strategy in funding chemical research has to take into account the need to selectively train such chemical manpower.

NEW CHALLENGING AREAS

Thrust areas in chemical science have been identified in the past by SERC. This was based on the status of chemical science in the late seventies. However, science has changed in its scope and emphasis in the last decade. Newer areas have emerged in traditional disciplines of chemistry. At the same time, certain new directions in science have affected the way chemistry itself is developing; for example the advent of modern biology and biotechnology is making considerable impact on chemistry. Similarly, the recognition of materials science as an important endeavour has also been recognized by chemists, particularly after the discovery of high-temperature superconductivity. Today it is recognized even in the advanced countries that chemistry of materials and chemistry of life processes are integral parts of chemistry. We have tried to reflect these features in identifying challenging areas in this document. At the same time, we have also paid due attention to the changing face of the traditional aspects of chemistry and included all those areas that are vital to the progress of chemical sciences in this country. Typical of these new directions are molecular sensors, metal clusters, supramolecular chemistry and new ways of looking at the structures of chemical systems at micro- and ultramicro-levels with greater resolution and involving a sophistication in instrumentation never before witnessed in chemistry. Today the practice of chemistry, no matter what branch, requires the combined use of theories and experiments involving considerable instrumentation. Although intuition is the most important attribute of a good chemist, it is becoming increasingly important for theoreticians to be abreast of experimental findings and for experimentalists to know sufficient theory to be able to decide on meaningful experiments. When we look at the present status and possible future of chemistry in the world at large, they look mind-boggling; at the same time if one examines the current scenario in the country, one cannot help getting a little frustrated. An attempt has been made to bring a reasonable balance between what is ideally good and what is reasonably practical under our circumstances in identifying the challenging areas listed below, being fully conscious that many of the areas listed have no practitioners yet. One can only hope that things will get better.

Organic Chemistry

Organic synthesis

Total synthesis: Design of novel and challenging organic molecules utilizing new and innovative synthetic schemes and techniques and in particular asymmetric synthesis of complex bioactive compounds and synthesis of theoretically and topographically interesting organic molecules.

Development of protocols involving multiple C–C bond formation, multicomponent single-pot reactions, utilization of natures chiral pool for asymmetric synthesis; new methodologies of synthesis based on thermal, photochemical, electrochemical and radical reactions; computer-aided synthetic design, automation and robotics in organic synthesis; new strategies for the development of processes for the production of biologically active and other commercially important products.

Newer organic reactions and reagents: Discovery of new reagents for carrying out regio-, stereo- and enantioselective operations; chemico-enzymatic methods in synthesis; design of chiral auxiliaries and catalysts for asymmetric synthesis; organic reactions in organized and semi-organized media (solid, liquid, crystalline and aqueous); applications of ultrasound, microwaves, high pressure, lasers and plasmas in organic synthesis.

Natural products

Isolation and structural elucidation of bioactive principles, especially from marine, terrestrial insect and other unexplored sources; study of biosynthesis and biogenetic-type synthesis of novel compounds; studies in chemical ecology related to pheromones, allelopathic agents, etc.; microbiological transformation of complex natural products.

Physical organic chemistry

Studies directed towards newer understanding of bond-making and bond-breaking processes with emphasis on electron transfer reactions and reactive intermediates; investigation of structure, dynamics, reactivity and unusual properties of organic molecules by modern physical and theoretical methods.

Inorganic Chemistry

Synthesis and structure of novel inorganic compounds

Synthesis of compounds containing new or modified macrocyclic or polydentate ligands as well as main group cage and ring compounds, other structurally novel inorganic compounds of the main group and transition metals and their structural characterization.

Homogeneous catalysis and activation of small molecules

Activation of small molecules such as O_2, CO, NO, SO_2, CO_2, etc. through co-ordination to metal centre; C1 chemistry; homogeneous catalytic processes. (See under Physical Chemistry.)

Bioinorganic chemistry

Biomimetic chemistry; models of metal sulphur compounds, copper enzymes and hemoproteins; studies directed towards understanding biological pumps such as Na^+, K^+, Ca^{++}, Mo, Zn, etc. (see also under Interface of Chemistry with Biology.)

Mechanistic inorganic chemistry

Mechanistic studies of electron transfer reactions; reactivity of co-ordinated ligands; fluxional processes and reactions in non-aqueous media.

Organometallic and Cluster Chemistry

Organometallic chemistry

Catalytic enantioselective hydrogenation and epoxidation of prochiral molecules through use of organometallic catalysts; design and evaluation of newer organometallic reagents and catalysts for better regio-, stereo- and enantioselectivity in organic transformations. Chemistry of compounds with metal–carbon bonds. (See also under Inorganic Chemistry.)

Metal clusters

Synthesis, characterization and reactivity studies of clusters and compounds with multiple metal–metal bonds.

Physical Chemistry

Spectroscopy and molecular structure

High-resolution rotational vibrational spectroscopy using diode laser; spectroscopy of transient species, weakly bound states and exotic molecules; spectroscopy at low temperature and high pressure; multiphoton ionization spectroscopy and study of Rydberg states; nonlinear and electronic Raman spectroscopy; band structure studies using electron spectroscopy and cognate techniques; studies of jet-cooled molecular exciplexes; geometry and co-ordination studies by EXAFS and XANES; study of excited states, molecular clusters and spin cross-overs by Mössbauer spectroscopy; multiple pulsed magnetic resonance; studies in solid state by CPMAS, multidimensional NMR; pulsed ESR and NQR; NMR and ESR imaging; *in vivo* ESR and NMR; spin echo; multiple resonance techniques using CW and pulsed modes (ENDOR, ELDOR, ESEEM); multifrequency ESR (S, L, X, Q, etc.) spectroscopy; new developments in mass spectrometry.

Chemical dynamics

Preparation of neutral as well as ionic species in specific electronic, vibrational and rotational states; chemical events leading to selected states of product molecules; inter- and intramolecular energy transfer in molecular systems; the dynamics of weakly bound systems and clusters of different types; study of transient species in picosecond and femtosecond time domains; gaseous plasmas; study of ion–molecule reactions at low temperatures; effect of magnetic field on chemical reactions; very-low-pressure pyrolysis; transport phenomena, chemical reactions and electron transfer in condensed media.

Surfaces and interfaces

Characterization of surfaces by modern techniques like EXAFS, XANES, etc.; study of adsorbed species on single-crystal and polycrystalline solid surfaces and liquid interfaces using spectroscopic techniques like UPS, XPS, EELS, infrared spectroscopy, second harmonic generation, etc.

Surface-enhanced Raman scattering; beam–surface interaction; photodesorption and surface-assisted photochemistry.

Use of micelles, micro-emulsions, hydrotropes, cyclodextrins and phase transfer catalysts for enhancement of rates of heterogeneous reactions.

Heterogeneous catalysis

Zeolite synthesis, characterization and catalysis; shape-selective catalysis.

Promotion and inhibition of catalytic activity and selectivity; doping of catalyst surface and modification of activity and selectivity through interaction between the support and the active catalytic component.

Catalysis in organic synthesis; application of zeolites to liquid-phase reactions; catalysis by pillared clays; preparation and characterization of novel catalysts and development of new strategies for stereoselective and enantioselective catalysis.

Chemistry of Materials

Ceramics

High T_c superconductors; superhard plastic solids; structural ceramics like silicon carbide, silicon nitride, stabilized zirconia, ZTA, etc.; organometallic and inorganic polymers as precursors to ceramic fibres (preceramics).

Novel glasses

Optical, solid electrolyte, glass ceramic and laser applications.

Mixed conductors

Battery applications.

Ferroics and coupled-property materials

Magnetic materials

Magnetic materials with controlled/tailored magnetic properties (inorganic/organic).

Organic polymers

New methods of polymer synthesis; design and characterization of newer polymers; precision synthesis of macromolecules with well-defined architecture; synthesis of polymers capable of withstanding extreme conditions of temperature and pressure; functionalized polymers as reaction matrix and enzyme mimics; structure–property relationship in polymers.

Combined organic materials

Polymer blends/alloys; composites with organic and inorganic fibres; chemistry of interfaces.

Organic solid state

Design, synthesis, characterization and processing of organic solids capable of exhibiting phenomena such as electrical conductivity, superconductivity, ferromagnetism, nonlinear optical properties, energy conversion, etc.; interaction of radiation (light, laser, electron beam, X-ray) with organic solids; structural transformulation physical properties; application of organic solid state network structures in electronics, information, storage and transmission, and memory devices.

Liquid crystals and mesophases

Synthesis and study of novel organic compounds capable of exhibiting various liquid-crystalline and plastic-crystalline phases.

Novel transitions such as incommensurate transitions, soft mode driven transitions, glass transition, etc.

Photochemistry and Laser Chemistry

Photochemical reactions of organic and inorganic substrates and novel photochemical routes to synthesis.

Temporal and spectral studies of transients using time-resolved absorption, fluorescence and resonance Raman spectroscopy.

Photochemistry on semiconductor colloids, photoelectrochemistry and problems related to solar energy conversion.

Photochemistry in organized assemblies such as micelles, liquid crystals, clays, silica, cyclodextrins, zeolites, Langmuir–Blodget films, etc.

Use of photons in microelectronics, photolithography, charge separation, etc.

Use of infrared laser for novel selective reactions.

Electron transfer reactions and problems related to biology.

Chemical Theory

Chemistry

Electronic structure and properties (including reactivity) of atoms, molecules, solids and surfaces; atomic, molecular and gas-surface scattering.

Statistical mechanics

Structure and dynamics of liquids; electron-transfer and other reactions in condensed media; structure and properties of amorphous solids.

Dynamics

Theories of chemical reactions; classical and quantal dynamical calculations relating to state-to-state process; nonlinear dynamics including solitons and chaos.

New mathematical approaches

Applications of topology, catastrophe theory, graph theory, fractals, etc. to enhance chemical insights, e.g. fractals as models for non-regular structures.

Computers in chemistry

Software for use in the above areas; interactive graphics; computer simulation of structures and reactions; use of artificial intelligence parallel processing, etc. in chemistry.

Interface of Chemistry with Biology

Enzyme models and inhibitors; molecular design of biologically active models and drugs; synthetic models for ion and molecular transport.

Supramolecular designer chemistry; creation of molecular assemblies and networks for recognition, regulation and transport with possible applications in biology and electronics.

Metal ion interactions with biomolecules; metalloproteins; molecular fixation and transport; trace elements in biology.

Chemistry of biopolymers and their constituents including new synthetic strategies; chemical and photochemical modification of lipids, proteins and nucleic acids.

Enzymes as catalysts in organic chemistry.

Micellar chemistry, e.g. structure, catalysis, membrane models.

GENERAL RECOMMENDATIONS

Many new innovations will have to be introduced in promoting chemical research in the coming years if major contributions of the highest standard have to emerge from our laboratories. These innovations are required not only in the manner of funding outstanding scientists and establishing facilities, but also in finding ways to encourage young talented scientists. A few general recommendations are being made to Government agencies. These would be helpful in promoting research within the country and also in disseminating information about the challenging areas of research identified by SERC through the National Workshop in Chemical Sciences.

(i) X-ray crystallography has become an essential structural tool in organic and inorganic chemistry and is routinely used by chemists. It is therefore recommended that at least two centres be established in the country to cater to this demand of chemists.

(ii) Programme advisory committees/expert panels should identify certain individuals or groups to take up some of the projects in selected challenging areas and establish units/core groups around them for long-term support.

(iii) In well-identified areas of chemical sciences, summer/winter schools and group discussion meetings involving young scientists and scholars may be organized. If needed, a few world authorities may also be invited to give lectures.

(iv) To give a major thrust to a particular area, a co-ordinated programme involving scientists from different laboratories working in that area should be supported.

(v) A large number of medium-sized grants should be made available to promote chemical research on a massive scale, especially to smaller universities, departments and colleges.

(vi) Scientists should not face administrative difficulties in implementing a programme, e.g. in procuring special chemicals, reagents, installation of equipment, etc.

(vii) A new scheme may be initiated to provide research opportunities to outstanding undergraduate and postgraduate students to work in leading University Centres and National Laboratories on a short-term basis, particularly during summer vacations.

(viii) Brainstorming sessions/workshops involving selected scientists along with programme advisory committees may be organized to identify the newer areas emerging on the horizon, especially those where India can achieve a unique place for itself.

(ix) Visiting lecturerships should be instituted to encourage specialists in challenging areas to deliver lectures to students and research scholars in colleges and universities.

(x) A major emphasis be given to chemical instrumentation. Development of instruments requires a completely different mode of funding. Government agencies should find ways of supporting programmes which involve design and fabrication mostly from indigenous resources. There should be extensive training programmes for technicians.

(xi) Ways of providing standard instruments for chemical education in large numbers to the educational community have to be explored by DST.

(xii) Projects dealing with parallel computing for chemical research (particularly in theoretical chemistry) have to be supported to develop software. If planned well, these projects would have an export market.

(xiii) Whatever be the policy for funding research in chemical sciences, an outstanding programme should be fully supported, whether this strictly falls under 'challenging area' or not.

NEWS

"COSMOS-2000" IN POLAR ORBIT

On February 10, this year, the USSR launched with a Soyuz booster the 'Cosmos-2000' satellite carrying scientific equipment for continuation of the exploration of the Earth's natural resources. The flight programme also provides for space photography of the central part of Antarctica for the mapping of inaccessible areas of the continent.

Making one orbit of the Earth in every 88.8 minutes, the satellite also carries a radio system for precision measurement of orbit elements and a radiotelemetric system to transmit back to Earth the data on the operation of instruments and scientific equipment.

This is the first time that the USSR has orbited a remote-sensing satellite in Polar orbit. It may be recalled that the Indian Remote Sensing Satellite (IRS-1A) was placed in a sun-synchronous Polar orbit also by a Soviet booster rocket on March 17 last year.

The orbit of the 'Cosmos-2000' satellite is chosen in such a way as to enable it to take pictures of the central region of Antarctica.

Space photography of Antarctica, covering an area of 14 million square kilometres, will be approximately 98.8% cheaper than conventional areal photography.

Unique data on the ice cover, on the outcrops of rocks, the formation of glaciers and icebergs will be also gleaned. New data will be possibly obtained on the process of the formation of the "ozone hole" over the area.

Besides surveying the ice continent, the satellite's flight programme comprises the study of natural resources, the ecological situation, seismically dangerous zones, and photography for the mapping of various regions of the Soviet · Union. (*Soviet Features*, Science and Technology, Vol. XXVIII, No. 27, February 20, 1989; Published by the Information Department, USSR Embassy in India, P.B. 241, 25 Barakhamba Road, New Delhi 110 001.)