Conference Reports

CHEMRAWN IX

World Conference on the Role of Advanced Materials in Sustainable Development, Seoul, Korea, 1–6 September 1996

The UN Conference on Environment and Development held in Rio de Janeiro in 1992 alerted world-wide attention to the effective and wasteless use of materials and energy, zero emission and zero-waste production, and systematic recycling for sustainable development. These strategies are now having a significant impact on the environmental policies of governments and are bringing about change in industrial and economic structure as well as to international trade.

In Korea, the need for reconsideration of mass production at any price and for sustainable development to preserve the environment has been widely felt. CHEMRAWN IX was organized to offer a chance to examine industrial and economic activities of the present day world and to search for effective ways of achieving zero emission and zero waste production.

The CHEMRAWN IX World Conference was held at the Sheraton Walker Hill Hotel, Seoul, Korea, 1–6 September 1996. The Conference consisted of four sessions: Communication, Transportation, Construction and Energy. Academics, scientists and industrialists came to examine and analyze current production technologies and their impacts on the environment. Recycling methods, development of ecologically friendly materials, improving production processes, exchanging information and policy making were all discussed.

Organizing Committee Chairman Dr Min Che Chon gave the opening address, which was followed by congratulatory speeches by Dr A. Hayes, Chairman of the IUPAC CHEMRAWN Committee, and Prof. Saburo Nagakura, President of the Kanagawa Academy of Science & Technology, welcoming remarks by Prof. Sang Chul Shim, President of the Korean Chemical Society, and a Future Actions Committee report by Prof. Young Bok Chae, Chairman of the CHEMRAWN IX Future Actions Committee.

Among the distinguished lecturers were Sir John Meurig Thomas of the Royal Institute of Great Britain and Peterhouse, University of Cambridge, UK, who lectured on 'The Crucial Role of Catalysis in Sustainable Development'; President Jun-ichi Nishizawa of Tohoku University, Japan, who lectured on 'Needs and Seeds for Revolutionary Technology Towards Sustainable Society; the former IUPAC President Prof. C.N.R. Rao of the Advanced Scientific Research & Indian Institute of Science, who lectured on 'The Impact of New Emerging Areas of Solid State Science on the Development of Advanced Materials: Three Case Studies'; and President Charles O. Holliday of DuPont Asia Pacific, who talked about 'Policy and Practical Issues in Sustainable Development: an Industrial Perspective on Opportunities and Responsibilities'.

Among speakers from Korea, President Chung Wook Suh of Korea Mobile Telecommunication talked about 'Wireless Telecommunications in Korea'; Vice-President Sang Bok Hong of Pohang Steel Corporation spoke about 'The Korean Steel Industry and Development'; Dr Han Jung Kim, Director of the Research Institute, Korea Electricity Corporation, talked about 'Issues in Materials Research for Electric Power Generation and Distribution—Perspective of Korea Electric Power Research Institute'; Vice-President Chong Gil Lee of Samsung Electronics talked about 'The Present and Future of the Korean Semiconductor Industry'; and Dr Dae Un Lee, Director of the Research Institute, Hyundai Automobile Corporation, spoke about 'The Automobile Industry of Korea and Sustainable Development'.

Perspectives and Recommendations, a report produced by the Future Actions Committee (FAC) in conjunction with all CHEMRAWN conferences, is distributed to all leaders and policy makers in world politics, economics, science and industry, for their use and reference. The CHEMRAWN IX Perspectives and Recommendations, now available from the IUPAC Secretariat at Oxford, identifies seven key findings and makes six recommendations for future actions, as outlined on page 128.

The CHEMRAWN Committee

Seven key findings

1 There is a need for increased understanding and use of life-cycle assessments in making decisions on materials and technologies supporting the objectives of sustainable development.

2 Ways to recycle complex manufactured goods containing advanced materials need to be developed. Designing such goods for recycling may be a top priority.

3 The importance of conservation of and development of adequate water supplies for agriculture and human consumption cannot be underestimated. Shortages will be the source of major conflicts in the future.

4 There are opportunities in the upgrading of locally available materials with small amounts of other materials or processing technologies from outside the region.

5 The opportunities to improve many traditional materials (steel, cement...) are consistent with the goals of sustainable development.

6 A number of advances in energy production can contribute to sustainable development.

7 Catalysis research offers the potential for routes to sustainable production techniques.

Six key recommendations for future action

The Future Actions Committee (FAC) made the following six key recommendations for future action:

1 We should create a 'materials for sustainable development' research and development agenda to guide national funding agencies.

Action: A team from the FAC will develop a special message and background details from the President of IUPAC to National Adhering Organizations urging that the local organizations approach funding agencies with these priorities. The FAC team will also seek other ways to communicate this message (for example, develop a research agenda to take to a funding agency; develop a research partnership between organizations in developed and developing countries; discuss with the Carter Center, Atlanta, Georgia, UNESCO, UNIDO, UNDP and the International Center for Evaluation of Technology. FAC team 1: C.N.R. Rao, P.M. Norling, J. Nishizawa, S.J. Park, A. Hayes, Y.B. Chae and F. Kuznetsov.

2 The FAC supports the need to contribute to the ready transfer of environmental technologies across industries, across nations and across public/private sectors; to increase the focus from control and remediation technologies to avoidance and resource conservation.

Action: To include urging from the IUPAC President as in Recommendation 1. FAC team 1.

3 We urge the protection of Intellectual Property Rights in a way that acts as an important driver for the introduction of advanced material and process technologies that can further sustainable development rather than as a hindrance to increased collaboration for sustainable development.

Action: FAC Team 1 will include this issue in the letter to be developed under Recommendation 1.

4 We plan to develop a programme of technical education related to sustainable development that can be included in future CHEMRAWN conferences.

Action: Follow up in CHEMRAWN X and propose supporting educational efforts of material societies, UNESCO and UNIDO. FAC team 2: The CHEMRAWN X Organizing Committee and selected members of the CHEMRAWN Committee: R. Pariser, P. Moyna and R. Hamelin.

5 We should urge experts to define (in writing) the needs and opportunities in advanced materials to build a better awareness amongst the public of the contributions of chemistry and advanced materials to our society and to sustainable development.

Action: An FAC team will explore a series of IUPAC monographs 'Chemistry in the 21st Century' using materials from papers presented at CHEMRAWN IX. There is also the possibility of a column or articles in selected magazines or periodicals. FAC team 3: Y.B. Chae, Y.S. Sohn, J.M. Thomas, F.A. Kuznetsov and M.C. Chon.

6 We will urge that where awards are given, special recognition be given to advances in developing materials that contribute to sustainable development.

Action: The FAC will develop a plan to: (i) approach existing award groups and make nominations; (ii) propose that organizations establish such awards; (iii) raise awareness within IUPAC (and other groups) of the existence of such awards. FAC team 4: K. Taylor, J. Economy and A. Tcheknavorian-Asenbauer.

Min Che Chon
Chairman of the Organizing Committee
IUPAC CHEMRAWN IX

Dr Min Che Chon

Copies of the CHEMRAWN IX: Technical Proceedings may be ordered from the Korean Chemical Society, 703 Korea Science & Technology Center, 635-4 Yeogsam-Dong, Kangnam-Gu, Seoul 135-703, Korea.

ACS/IUPAC/CMA/EPA Collaborative Symposium, San Francisco, California, USA

The 213th National Meeting of the American Chemical Society (ACS) held in San Francisco included a collaborative symposium between the ACS, IUPAC, the US Chemical Manufacturers Association (CMA), and the US Environmental Protection Agency. It was held at the San Francisco Hilton and Towers Hotel on 14–15 April 1997 and entitled *Green Chemistry/Environmental Sustainable Manufacture as a Competitive Advantage.*

San Francisco is a fine city on the Western seaboard of the USA. In American standards, it is petite, only 7 miles in length. This city, by the Pacific Ocean Bay, is a town bursting at the seams. Within its watery boundaries lie many neighbourhoods, all with their own charms, peculiarities and even weather conditions.

The Hilton Hotel, the base for this symposium, is at the geographic 'Grand Zero' in the heart of the city's luxury shopping and hotel district.

The symposium was attended by about 150 delegates. It took the form of a number of high-level addresses which were followed by six sessions. These sessions were opened by moderators, and were followed by a panel discussion from three or more internationally respected experts which concluded with an audience, question-and-answer period.

Purpose

The purpose of the symposium was to ensure society of a standard of living acceptable to an increasingly industrial world without danger to the environment or risk to worker health and society. It focused on manufacturing activity and not agricultural activity, except for agriculture as a consumer.

The principal objectives included:

- Encouragement and suggestions for development of environmentally sustainable processes;
- Proposals for competing in the domestic and global market place; and
- Recommendations to government, international and professional agencies, on ensuring safety and environmental protection.

Overview

With the rapid development of new and changing technologies, industrial products and practices inevitably generate materials potentially hazardous to public health and the environment.

Regulation is designed to balance the progress of the chemical and allied industries with the life-sustaining needs of the environment. This concept of sustainable manufacture has become one of the most important challenges for the chemical process industry and has offered the potential for some of the greatest rewards in an increasingly competitive market.

The chemical process industry has often perceived environmental and health regulation as a barrier to productive research and development (R&D). The symposium discussed the relevant issues and recommended methods by which regulations may serve as an aid to competition. Regulation can be viewed as both an incentive and disincentive world-wide.

The symposium was based on six moderated sessions:

- Product development in the chemical industry;
- Risk-based decision-making;
- Business needs in environmentally sustainable manufacture;

San Fransisco hosted the 213th National Meeting of the American Chemical Society

- Human health and environmental health issues;
- Governmental incentives and disincentives; and;
- Implementation in industry.

Keynote lecture

This was delivered by Profs Frank Sherwood Rowland and Mario Molina, 1995 Nobel Prize recipients. They described Atmospheric Chemistry with particular reference to chlorofluorocarbons (CFCs), which were formerly used as a replacement for ammonia and sulfur dioxide in domestic (and other) refrigerators. One part in 10^{12} can cause ozone layer depletion.

The basic chemistry involved is:

$$CCl_3F + UV\ (light) \rightarrow Cl + CCl_2F$$
$$CCl_2F + UV1\ (light) \rightarrow Cl + CClF$$
$$Cl + O_3 \rightarrow ClO + O_2$$
$$ClO + O \rightarrow Cl + O_2$$

Summing $$O + O_3 \rightarrow O_2 + O_2$$

Ozone deficiency was first observed in the Antarctic in the early 1980s.

In the early 1990s the Montreal Protocol was adapted by a number of Governments but was much too weak and has now been strengthened.

There are considerable problems with developing countries; where the situation has been assisted greatly by the UN Agencies by careful use of multilateral funds. The UN also provides the much needed technical assistance, especially in the least developed countries which have recently introduced domestic refrigerators.

Prof. Molina concluded by saying that unless we make far better use of the limited resources we shall need a planet of three times the size of the Earth.

Prof. Frank Sherwood Rowland gave a very rapid outline of the chemistry involved stressing the importance of the Dobson Spectrometry. He stressed that ozone depletion was first observed in October 1984. The Antarctic vortex has on many occasions now stretched as far as South America, and this is most likely to cause DNA absorption of UVB. This leads to thiamine coding errors due to the formation of cyclobutane pyridine dimers. In countries such as Hawaii, direct sunlight exposure should now only be four minutes instead of the previous twelve minutes.

Prof. Mario Molina

The revised Montreal Protocol is now offering effective solutions but the effects from CFCs will be present until at least the end of the 21st century. This will lead to effects on all biological species.

For the future, Governments and the UN agencies will need to react far more quickly to give higher priority to such early warning of adverse effects having the magnitude of ozone depletion.

Keynote industrial address

The first item of the Industry Forum Breakfast attended by the moderators, panelists and invited guests was the keynote address delivered by Victoria Haynes, Chief Technical Officer of BF Goodrich.

She stressed the need for 20-20 vision and that both sustainability and the need to invest heavily in research and developments were assets for the chemical industry and that these were major corporate matters.

Excellent customer and supplier relations were essential. Sustainability leads to increased productivity and to enhance economic values.

Green Chemistry is a market issue as it leads to, amongst other issues, low waste generation; the chemical industry, including that in the developing countries, cannot be involved in another issue such as Love Canal.

Companies need to comply with the Responsible Care Programmes initiated by the CMA and CEFIC, Montreal Protocols, etc. Developing countries also need to take advantage of the assistance available from the UN Agencies, in particular UNIDO.

Victoria Haynes continued by stressing the importance of the real status of endocrine disrupters and the need for a well balanced report by a well-recognized international body.

There are major technical challenges to be won, including those in chemical science, manufacturing and engineering.

Major products, even in 1997, are manufactured largely by classical methods. There should now be sustainable processes and products using new synthetic procedures, e.g. catalysis, biotechnology, etc. Novel synthesis involving biology and physics were essential.

She highlighted the need for partnerships between academia and industry and to make more with less; and to know more about manufacturing processes and hence to undertake complex syntheses with far fewer synthetic stages.

Allan M. Ford

There was a requirement in processing chemistry to have improvement in engineering and real time control.

The need for recycling and re-use was paramount and the chemical industry needed to seek far more discriminating activities. Such sustainability activities would increase shareholder returns, especially via good and meaningful Intellectual Property Protection and thus achieve competitive advantages.

The opening remarks were given by:

- **Allan M. Ford**, ACS Division of Environmental Chemistry, in formally opening the conference and who thanked both the organizer Mr Scott Stoogenke and the contributors, stressing that it was very much an IUPAC event.
- **Edward Callahan**, representing the Committee on Chemistry and Industry, gave high regards to the current President of IUPAC, Prof. Albert Fischli, and stressed the importance of the conference organized by the American Chemical Society, IUPAC, CMA and the EPA.

This was the third such conference, the first being held in Basle, Switzerland in 1990 [*Chem. Intl.* 1991, **13**(2), 50]. The second in Japan in 1993 [*Chem. Intl.* 1994, **16**(2), 41]; a fourth would be organized in a Pacific Rim country probably in two years time.

Edward Callahan

Mr Callahan stressed growing importance of biochemistry and sustainability. There were many problems in sustainable development with a considerable number of problems to solve, one of which was the chemical description of the oceans in terms of environmental chemistry.

The chemical community needed to be able to tackle environmental chemical problems when they were initially observed and to ensure that potential input would be achieved much sooner than, for example, the influence of CFCs on atmospheric chemistry. This was a challenge for academia, Governments, chemical manufacturers, the UN Agencies, and not least the professional chemical societies and IUPAC.

The IUPAC address was presented by Prof. Albert Fischli, President of IUPAC

Prof. Fischli delivered a masterful and concise account of the history of IUPAC. In the area of environmental chemistry and sustainability he stressed the importance of the recent collaboration between UNESCO and IUPAC. IUPAC was the only International Union with a Committee on Chemistry and Industry, and hence there was a direct route for academia to collaborate with industrial chemists.

He gave due acknowledgment to IUPAC collaboration with various UN Agencies, including UNESCO, International Programme on Chemical Safety (IPCS) and not least the UN Industrial Development Organization (UNIDO). Due emphasis was given to the sterling work being undertaken by Division VI—Chemistry and the Environment Division.

There was a growing requirement for globalization for a greater activity in industrial rather than pure chemistry within IUPAC. This was achievable with collaboration with UNIDO.

Great emphasis was given to the overwhelming response that had been received from the 'White Book on Chlorine' [*Pure Appl. Chem.* 1996, **68**(9), 1683–1824]. As a future topic of growing public concern, Prof. Fischli indicated that endocrine disrupters would be the subject of a forthcoming 'white book'.

Within developing/industrializing countries, there was an immediate need for training and this should be achievable by IUPAC's ongoing collaboration with UNESCO and UNIDO.

Session A—Product development in the chemical industry

Moderator: Joseph Coates (Coates and Jarratt Inc.). This symposium explored the broad trends influencing the future of chemistry as a science and its reduction to practical applications. Speakers dealt with individual aspects of the future of the chemical industry in terms of sectorial developments, industrial developments and some product developments as well as market changes over the next decades. Special attention was given to the very important role of environmental considerations in shaping the future of the industry.

The moderator and three panelists, in developing these topics, stressed the need for the merging of chemical disciplines, e.g. inorganic with organic chemistry and with other natural sciences, in particular biology and physics.

In the future they foresaw major developments being gained from genetics, computer imaging, catalysis, especially the use of enzymes developed from extremeophiles, gas hydrates and hydrogen, as a prime power source, intelligent materials, especially in composites, lubricants and polymers, new fertilizers with micro delivery systems, and the use of nanotechnology.

In outlining Project 2025 they considered that information technology, material technology, genetics, energy technology and environmentalism to be areas for development. There had to be a drive by science and technology to decrease the usage of toxic chemicals.

A competitive advantage was achievable by the use of ISO 14000. There was an increasing public demand in the environment and the non-specialist should be able to gain information via information technology, e.g. the Internet.

The public has a right-to-know in material accounting and its effect on air and water and this was achievable through the chemical industry with IUPAC assistance via libraries and schools.

In this way, increasing accountability in sustainable development was achievable to give competitive advantages.

Session B—Risk-based decision making (co-sponsored by CMA)

Moderator: David Sigman (Exxon Chemical)
This covered:

1 Need for risk and benefit-cost legislation
2 Wise application of judicial review of regulation
3 Improving risk-based data bases
4 Enhancing federal risk guidance
5 Development of comparative risk methodology
6 Development of risk principles
7 Interpretation and application of the precautionary principle

The points stressed by the moderator and three panelists included the priority being given by the CMA in law and policy and the importance of risk assessment and risk management. In view of the growing number of chemicals being synthesized, greater use had to be given to priority setting.

In risk management greater input was required from the informed public. This in turn required improvements in risk communications.

There was a need for basic research, especially the mechanisms by which chemicals react with the environment and interaction with human health.

One of the topics of current concern was endocrine disrupters and the CMA was funding research over the next two years. During the discussion period, the concern for these was highlighted, especially that the chemicals elicited to exhibit endocrine disrupters should be considered very carefully and their criteria specified. There was a very urgent need for the development of a reliable chemical or biochemical test procedure.

The panelists stressed the need for ecological assessment research, especially to support the risk reduction strategies identified within Chapter 19 of Agenda 21.

Session C—Business needs in environmentally sustainable manufacture

Moderators: Balasubramanyan Sugavanam and Ralph (Skip) Luken (UNIDO)
This covered:

1 Definition of Environmentally Sustainable Manufacture
2 Importance of chemicals vs. impact on environment
3 Source reduction vs. end of pipe treatment (Cleaner production)
4 Self regulation vs. enforcement
5 Environmental justice and its relevance
6 Tools used for environmentally sustainable manufacture:
(a) Responsible care
(b) Control of substances hazardous to health and environment (COSHHE)
(c) Life cycle analysis
7 Monitoring:
(a) Eco-labeling
(b) Ecotoxicity
(c) ISO 14000

Balasubramanyan Sugavanam

8 Accountability:
(a) Corporate responsibility
(b) Government responsibility
(c) Responsibility of international organizations
(d) Responsibility of non-governmental organizations
(e) Public role

9 Recommendations

The points stressed by the moderators and three panelists included environmental sustainability, its management and difficulties, especially in the least developed countries. Greater emphasis was needed in upstream environmental sustainable manufacture. Regrettably the concern for the environment, particularly in a number of developing countries, had progressed from bad to worse.

A video demonstrated very clearly the considerable successes that UNIDO had achieved in sustainability in a number of developing countries, emphasizing the achievements in economy, environment and employment.

Major equity concerns need to be addressed, especially as poverty induced poor environmental conditions. With the support of experts having wide international experience, UNIDO was working actively and with an excellent success rate in environmental impact assessment, the use of new technologies and techniques, leading to successful environmental and integrated management procedures.

This was being achieved through life cycle studies, vision, action and eco-efficiency, in turn resulting in an impressive reduction in illness rates and increases in process and product safety.

Session D—Human health and environmental health issues

Moderator: Fred Hoerger (formerly Dow Chemical)
This covered:

1 New Priorities:
(A) Global
(i) Climate change
(ii) Restoration of fisheries
(iii) Biodiversity
(a) Loss of rain forests
(b) Loss of habitat
(B) National
(i) All inclusive health and environmental benefits
(ii) Equitable opportunity for achieving economic environmental, and social well being
(iii) Use, conserve, protect, and restore natural resources
(C) Local (regional, community)
(i) Stop the loss of prime farmland
(ii) Redevelop 'brown' urban areas
(iii) Protect, enhance habitats and biodiversity
(D) Conflicts
(i) Agreement on priorities and allocation of resources between sectors and within sectors
(ii) Reliance on trade-offs and comparative risks and benefits instead of absolute risk and benefit in decision making

2 New Framework for Action:
(A) Research
(i) New priorities and international agenda setting
(a) Long-term approaches
(b) Emerging global problems
(c) Relation between human and natural systems
(d) R&D to improve risk assessment and cost-benefit analysis
(ii) Trends and status of the environment
(iii) Interdisciplinary, international collaboration
(B) Regulatory
(i) Performance-based standards
(ii) Stewardship
(iii) Market-based incentives
(iv) Enhanced product responsibility programmes
(C) Education
(i) Health, environmental content of curriculum
(ii) Accessibility of information
(iii) Lifelong learning
(D) Cooperative, open planning and action at the community level
(E) Information collection, management, distribution
(i) What is needed?
(ii) What is the nature of the system?
(iii) Who funds and manages the system?

3 There is Momentum to Solve the Issues

4 Issues Related to Implementation:
(A) What type of information is needed about important air contaminants?
(B) How do we establish what are the important contaminants in drinking water and ground water and their sources?
(C) Within the framework of NAFTA, what are the important trans-boundary human health problems that need to be addressed?
(D) On a societal basis, how does one balance the priorities for clean air and clean water with the priorities which relate more to ecosystem health (e.g. comparing the priority for decreasing ambient air contaminants to preserving wildlife habitat)?
(E) Can comparative risk studies provide insight for the regulatory/legislative arena, or is the trade-off strictly political?
(F) How can health related agencies and professionals interact with and coordinate their efforts with ecologically oriented agencies and professionals?

The moderators and five panelists reviewed a number of topics of current concern including test methodologies for estrogen mimics, risk assessment methodology and needs for benefit–risk appraisals.

One conclusion was that we were slowly evolving towards a new environmental paradigm—but an evolution which is hampered by existing institutions and counter political and social priorities. Current activities are still hampered by the laws, regulations and mentality of the past two decades and only a small overlap with the vision of sustainable development. The current focus needs included protecting humans from the environment and equally the environment and the ecosystems from humans. There was a need to gain expertise in how to ask the right questions to provide meaningful answers. Increased attention was needed in pragmatic and attainable environmental legislation with an input from the public. This was now achievable through the activities of the International Forum on Chemical Safety (IFCS), the current presidency being held by Canada.

There was a need to achieve sustainability by interaction between environment and societal activities.

One of the panelists reported on a serious area of lack of sustainability, namely warfare in the environment. Whilst the media accentuated human suffering, the dramatic and often irreversible effects to the environment were neglected by the media, mediators and politicians. UNIDO had been active and successful in assisting Croatia by sending an international expert during the conflict to observe, report and recommend remedial action.

Considerable discussion was held on the need for meaningful environmental monitoring, especially in the least developed countries or in areas depredated by warfare. It was recognized that generic testing, such as the use of *Vibrio fisheri* (the Microtox test) had much to offer. Of greater importance was the need for developing/industrializing countries and in particular countries in transition to ensure that their environmental legislation was pragmatic in such a manner as to ensure it was geared to both the country's capabilities in environmental monitoring (and hence the use of generic techniques) and the capability and training of scientists to be able to undertake risk assessments, risk management, leading to risk reduction, and hence chemical safety.

UNIDO had been very active and successful in such areas. One notable example being the establishment of a regional ecotoxicology laboratory in Islamabad, Pakistan, serving the requirements for South-East Asia.

UNIDO also had the foresight to engage the services of a high-level scientist in 1995 to travel to a number of Central and Eastern European countries and selected Arab Stages to report and provide recommendations on Environmental Monitoring of Industrial and Domestic Pollutants and Chemical Safety.

This major assignment led to the implementation of a number of projects on sustainable manufacture with competitive advantages. Funding of these projects was of concern and the meeting was asked to invite tax payers in every country to assist the UN Agencies and, in particular UNIDO, to build on these firm foundations to persuade their Governments to support the sterling work of these Agencies, which over 150 Governments ratified at the Rio Summit (UNCED) in June 1992. This commitment has to be supported to the fullest.

With such provision, real strides forward can be taken to the maximization of risk reduction procedures and sustainability as we enter the 21st century.

Session E—Governmental incentives and disincentives

Moderator: Jean-Jacques Salzmann (Novartis)
This covered:

1 Introduction:

(A) Goal of business and government is a sustainable economy

(i) Balance between growth, competitiveness, employment, and the limited carrying capacity of the environment

(ii) Balance requires shared responsibility between producer, consumer, and legislator

(B) Questions

(i) Is industry willing to improve its environmental performance in the direction of sustainable development?

(ii) Are the financial markers, which press business to maximize shareholder value, open to consider sustainable criteria?

(iii) Are the legislators capable of introducing rules and incentives adapted to the purpose of sustainability?

(iv) Are the consumers willing to change their attitude and behaviour to the needed level of environmental responsibility?

2 Thesis 1:

(A) As long as the environment is still considered as a free and common good, legislation will be necessary.

(B) As long as industry is striving for 'compliance only', new incentives to go beyond and towards sustainability are necessary.

(C) Recommendations

(i) Industry and legislators should enter into a pro-active dialogue.

(ii) They should become partners for solutions towards sustainable regulations and incentives.

(iii) Industry should break down and allocate the environmental costs to their products (Cost-allocation would lead to an internal regulatory instrument).

(iv) Environmental regulations should always be based on a scientific risk assessment and the cost-benefit relation should be demonstrated beforehand.

(v) The 'precautionary principle' should not be misused to prescribe techniques or to ban/phase out products.

3 Thesis 2:

(A) There is a strong discrepancy between the global environmental problems and the political decisions on the local level.

(B) Local environmental protection decisions too often ask for large investments for business with a marginal effect on improving the quality of the environment.

(C) Recommendations

(i) Environmental regulations should be harmonized on an international or at least on a regional level.

(ii) 'Joint implementation' procedures should be enhanced, whereas efforts and investments should be made in these (geographical) areas, where the environmental yield per dollar can be maximized.

4 Thesis 3:

(A) Command and control legislations have only limited effectiveness.

(B) In setting not only the environmental objectives, but also in prescribing the means to reach the objectives, these legislations are hindering innovations and are often unsustainable.

(C) Innovation is for business the main driving force to improve its environmental performance.

(D) Recommendations

(i) The use of a 'policy mix' should be advocated.

(ii) Besides command and control regulations, market oriented instruments and enforceable (negotiated) agreements, which allow a sustainable use of scarce resources and production factors should be used.

(iii) Environmental quality objectives should be set.

(iv) The corresponding regulatory instruments should not only be focused on specific industrial sectors but they should encompass all potential pollution sources.

The moderator and three panelists referred to whether regulations were of assistance or hindrance to the manufacturing industry. It was vital to receive cooperation and not enter into confrontation.

Eco-efficiency was now an achievable goal through training on emissions or discerning use of taxation.

The achievement of wealth and value creation through environmental sustainability was stressed, but it was pointed out that the financial market works against environmental sustainability and investors on the whole do not appreciate environmental issues. Hence, there was a need to convince accountants of the importance and monetary benefits to be attained from environmental sustainable development.

There were requirements for joint projects.

Governments must think globally, especially when dealing with environmental issues, as pollutants do not recognize national boundaries.

There was a need to have far less command and control from government. There was a considerable opportunity for cooperation between industry and regulators with major inputs from bodies such as the CMA, IUPAC and the UN Agencies, leading to trust and cooperation through negotiated agreements, products at the right price, exhibiting eco-efficiency, thus providing shareholders with demonstrable value.

Session F—Implementation in industry

Moderator: Earl Beaver (Monsanto)

The moderator and four panelists reviewed many of the key points from the previous five sessions.

There were needs to be imposed upon the chemical industry from an historic viewpoint; the vision 2020 projects and industrial needs, leading to an objective path forward.

Cost and product quality were key factors for the 21st century.

Competition was of increasing importance, but at the same time, much greater attention had to be given to processes involving toxic and hazardous substances.

Many chemical companies had been very successful in achieving considerable reduction in waste and this was likely to continue in the future.

By 2020 the chemical industry would be a world leader.

Particular aspects of success could be in the enhancement of health, safety and the environment and modeling, especially eco-efficiency models, product development cycles, leading to greater value added products and integration of data bases which was currently not feasible.

Much greater emphasis would need to be given to identification of priority, research, funding, leading to technological transfers. These aspects would take into account full cognizance of environmental, social and financial impacts. This would be achievable through increased interaction between inter-industrial sectors, industry and academia, industry and government, taking into account inputs from the UN Agencies and other active role players, such as IUPAC.

As is now the case in Japan, there needs to be an appreciation of integration of the environment and business.

In countries in transition pragmatic implementation of environmental legislation was a problem requiring expert input. This was achievable as industry in such countries adopted the principle of Responsible Care, the needs for improvements in cost accounting and many of the other aspects of Green Chemistry discussed during this symposium.

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Fate and effects of contaminants in soils as influenced by natural organic material

This article summarizes the essentials of a symposium held at the Fraunhofer-Institute for Environmental Chemistry and Ecotoxicology 16–18 September 1996 under the auspices of IUPAC, the Commission on Water and Soil Chemistry and the Gesellschaft Deutscher Chemiker, Fachgruppe für Umweltchemie und Ökotoxikologie.

In recent years processes of interactions between contaminants and physical as well as chemical soil parameters have been intensively studied to achieve advances in the hazard and risk assessment of contaminants in soils. As regards soil organic matter major research areas have been sorption and binding processes. A more recent area includes the influences of natural organic matter (NOM) and the dissolved part (DOM) on mobility, bioavailability and toxic effects of heavy metals and organic contaminants.

The role of dissolved natural organic compounds in the field has been identified to be a major one both with respect to the analytical facet of the problem as well as regards modifications in fate and effects of contaminants.

Formation and characterization of soil organic matter

Depending on the use of the soils (e.g. forest, pasture, agriculture) the amount, composition and properties of the litter and plant residues (roots and leaves) are the dominant factors for humification in the terrestrial environment. Since soil organisms, especially the microbial biomass (the micro-organisms themselves and their excreta) play an important part in the carbon cycle, they are also involved in the humification processes.

From a physical chemical point of view, the formation of soil organic matter proceeds as:

- the formation of particulate organic matter originating from larger sized parts of the litter resulting in stabilized organic matter particles of high binding capacities like lignite but with a slow migration of pollutants into their inner pore system;
- humification of natural high and low molecular substances and coating of soil mineral particles by this organic material; and
- formation of dissolved organic matter in the soil solution.

The soil organic matter in layers below the A-horizon should be taken into consideration especially concerning the behaviour of organic contaminants in soil. The long-term behaviour of soil organic matter is another important topic. In this context only information on the classical differentiation of soil organic matter into fulvic and humic acids and insoluble humins is routinely available. More information is needed for the classification of organic matter with respect to its stability and binding and mobilization processes of pollutants.

New concepts and their modelling require the distinction of soil organic matter in its functions within the carbon-cycle in soil. Upon the decay processes the plant residues will lead to structure carbon, metabolic carbon, active carbon, slow degradative soil carbon and passive soil carbon. From a scientific point of view the characterization of solid soil organic matter also includes the differentiation of the soil particle sizes since it influences OM quantity and quality.

Separation of agricultural top soils according to their particle sizes resulted in more than 40% of the organic matter in the clay fraction demonstrating that soil particles are coated during the formation of the insoluble organic matter. The particulate and dissolved humic substances are refractory due to the structure of the organic matter and due to the building of organic-mineral complexes.

For the classification and characterization of organic matter different highly sophisticated methods are available or under development. One recently often used technique is NMR spectroscopy to elucidate the chemical composition of humic substances with respect to carboxylic carbon, aromatic carbon, o-alkyl carbon and alkyl carbon. Pyrolysis-GC/MS and pyrolysis-GC/AED are methods aiming for the analysis of building blocks of isolated organic matter, enabling polymers of natural and anthropogenic origin to be distinguished. The information content on building blocks and their binding state in the organic matter backbone can be enhanced by thermally-assisted hydrolysis and methylation. FTIR and ^{1}H-NMR spectroscopy are used for recognizing origin, building blocks and degree of humification of organic matter.

The splitting-off of functional groups and the breakdown of the polymer network upon organic matter degradation can be traced effectively by TG-MS and TG-FTIR. The pyrolysis-MS studies performed with organic matter at both atmospheric pressure and high vacuum (insource mode) indicate a high proportion of pyrolysis residues (about 40 wt%) upon heating to 750 °C. The released pyrolysis products include mainly nonspecific, low molecular-weight compounds which are at present of limited value for characterizing the polymeric network. The TG-FTIR coupling turned out to be only useful in recognizing low molecular compounds such as H_2O, CO_2, CO, H_2S, COS, CH_4 and NH_3 which show distinctive absorbance patterns. The use of these techniques for OM characterization thus is still open.

Regarding residue analysis in soils, soil organic matter has not only an important influence on amount and quality of non-extractable residues in soils but also on the kind and amount of clean-up procedures required prior to analysis. The recovery of contaminants depends on the quantity and quality of the solid soil organic matter and on the quantity and quality of the dissolved organic matter in soil solution. An influence of the soil pH is also given. If the co-extracted organic matter is not carefully removed it will interfere with proper separation and quantification of pollutants. On the other hand these clean up steps may lead to a substantial loss of the pollutants. Especially the content of dissolved organic matter should be taken into consideration when interpreting analytical results of environmental samples.

Interactions of contaminants with SOM

Affinity capillary electrophoresis (ACE) has been used to investigate the binding processes between s-triazines and soil as well as water extracted fulvic and humic acids (FA and HA). The distribution coefficients of the s-triazines between the dissolved humic substances and the water phase were found to be a function of the degree of ionisation of both s-triazines and ligands, indicating both ionic and hydrogen bonding types of interactions. Furthermore, micellar electrokinetic chromatography (MEKC) experiments showed that the interactions of the s-triazines with HA could be described as a partitioning of the s-triazines between water and the dissolved organic humic phase. Similar to surfactants, humic acids behaved like ionic micelles in the aqueous buffer at concentrations higher than a defined 'humic critical micellar concentration' (HCMC). The low molecular weight acidic fulvic acids (FA) behaved the same way but showing higher HCMC. These results confirm the micellar properties of HS and the hydrophobic type of interaction of the s-triazines with hydrophobic sites of humic and fulvic ionic micelles.

The use of solid phase microextraction (SPME) in combination with headspace-GC/MS or GC/AED techniques was applied to investigate the sorption process of polycyclic aromatic hydrocarbons (PAH), polychlorinated biphenyls (PCB), chlorinated pesticides and tin organic compounds to humic organic matter (HOM). These techniques were used to investigate the sorption kinetics and to determine partition coefficients (K_{OC}). The results showed that hydrophobic, nonpolar interactions dominate the sorption process of PAH, PCB and chlorinated pesticides to HOM. However further experiments have to elucidate whether HOM coats the fibres to an extent that will change the sorption properties and kinetics.

Stationary and time-resolved laser-induced fluorescence (LIF) and fluorescence quenching studies were used for the investigation of humic substances (HS) and their interactions with polycyclic aromatic compounds (PAC). Aqueous solutions of HS of different origin (e.g. aquatic, soil or peat HS) were investigated with these techniques both with and without the presence of PAC. The fluorescence quenching efficiencies, expressed by the Stern-Volmer constants (K_{SV}), depend on the fluorophor (PAC) as well as on the HS. From the temperature and pH dependencies of the K_{SV}-values, information on structural variations of HS and on the thermodynamics of PAC/HS interactions was obtained. The suitability of these sophisticated techniques was demonstrated in soil column experiments, but has to be further improved.

Desorption kinetics vary considerably dependent on the experimental procedure used, e.g. column experiments may lead to different results compared to flask-shaking experiments. Time-resolved column leaching procedures provide information useful for the understanding of the organic matter to pollutant interaction. They allow to distinguish between spontaneous desorption and a subsequent diffusion controlled steady-state. The extent of both processes is closely related with each other. The desorption kinetics and amounts are significantly dependent on the composition of the eluent. In general, the stronger eluents (e.g. $Na_2H_2PO_4$) provoke distinct desorption peaks, indicating a strong alteration of the organic phase by the eluent, while the elution profile of weak eluents (e.g. $CaCl_2$) are quasi-constant and appear, thus, to be governed by slow diffusion processes from inner spheres of the particulate matter towards the surface.

However, column studies have the disadvantage that they are difficult to standardise with respect to flow rate, desorption solution and homogeneity of the soils (homogeneous water flow through the soil column is essential).

The dependence of the association between a sparingly soluble organic contaminant and DOM can also be shown by batch techniques. Results confirm that the sorption of contaminants strongly depends on:

- the origin and composition of the organic matter;
- the physico-chemical characteristics of the pollutants; and
- the solute chemistry (e.g. pH-value, salt content and composition (ionic strength).

The origin of humic matter and its sorption properties also influence the sorption of organic substances to sewage sludges. It was shown that the sorption capacity as related to the organic carbon content of the sewage sludges is comparable to that of agricultural top soils. This example demonstrates that appropriate and simple methods are needed which can be routinely used for a characterization of the dissolved and particulate organic matter with respect to their sorption potential.

Enhancement of mobility by dissolved organic matter

Measurements of PAH-concentrations in different soil horizons show the migration of the hardly soluble PAHs from the topsoils of a high organic matter content to subsoils. This migration can only be explained by a co-transport with DOM. Model experiments with DOM fractions from composts show that the binding capacity of high molecular DOM fractions is significantly higher than those of low molecular fractions. Nevertheless DOM fractions of a molecular size below 1000 D showed also interactions with PAHs. For the DOM fractions two types of interactions can be postulated. Sorption of hydrophobic substances on hydrophobic regions within the macromolecules and interactions of the substances with hydrophobic sites and amphoteric low molecular weight DOM molecules. The solubilizing effect is correlated with the hydrophobicity of the substances, with the sorption to the soil matrix and it also depends on the composition and origin of the DOM and the overall chemical composition of the solution. As regards the importance of the origin of DOM it could be shown that fungal metabolic products significantly enhance the solubility of hydrophobic organic chemicals.

For an assessment of ground water pollution which may be caused by a mobilization of hardly soluble toxic substances sorption and desorption processes in the three phase system soil–DOM–water, the properties of the DOM and its sorption to soils need to be considered. Mathematical models are under development to simulate these processes. First results show that:

- a three-phase model provides satisfying simulation results.
- an *a priori* prediction of HOC mobility based on the three-phase partition models is possible.
- the identification of relevant processes is impossible with 'classical' experimental designs.
- inverse modeling might result in misinterpretation of experimental data sets.
- nonlinearity is an important fact in HOC sorption.

Numerical simulations confirm the observations, that DOM influenced mobility of HOC in porous media is

- increased due to co-transport.
- reduced due to co-sorption and/or cumulative sorption, and;
- controlled by site-specific physicochemical properties.

Effects of natural organic matter on the fate of substances

Binding of xenobiotics to humic matter influences their degradation in soil. Führ *et al.* investigated the effect of straw amendment on the formation and translocation of residues of ^{14}C-methabenzthiazuron with laboratory and lysimeter experiments. The lysimeter experiments performed with an orthic luvisol (pH 7.2; 1.2% OC; 6.4% sand; 78.2% silt; 15.4% clay) showed that the amendment of straw to the plough layer according to agricultural practice resulted in a significant increase of the degradation and mineralization of methabenzthiazuron but also in the formation of bound residues. In the fraction of bound residues larger amounts of radiocarbon were found in fulvic and humic acids compared to the radioactivity in humines. The enhancement of microbial activity, mineralization and degradation rate were comparable to laboratory experiments. Increasing amendment with straw material resulted in an even more rapid formation of bound residues. Additionally, the amount of methabenzthiazuron in the leachate was affected. Although the amount of leachate was the same in the lysimeters with and without straw amendment, the total amount of transferred methabenzthiazuron was considerably lower in the lysimeter with straw amendment.

Upon addition of wheat straw, lucerne leaves and farmyard manure in experiments with ^{14}C-labelled isoproturon different ratios between dissolved organic carbon and dissolved radioactive material as well as different metabolite patterns in percolates of small-scale column experiments were observed. The amount of bound residues increased with time and differed dependent on soil treatment. Generally, the quality and not the quantity of the added organic matter was decisive for the results in these experiments.

The binding behaviour and the nature of binding of the fungicide anilazine and the herbicide amitrole to dissolved organic matter was investigated by Spiteller *et al.* Using ^{13}C-NMR-spectroscopy one type of linkage of anilazine to humic matter was characterized as a covalent ether-bonding in soil, compost and lake water. This was underlined by experimental breaking the bond using TMSCl and the identification of the corresponding trimethylsilylether-derivate. A postulated covalent linkage of amitrole to humic matter was also investigated and confirmed by ^{15}N-NMR-spectroscopy. However, besides covalent binding also hydrogen-bonding and/or charge-transfer complexes have to be considered. In the case of amitrole an inhibitory effect on plant growth was observed due to remobilized amitrole, identified in DMF/TMSCl-extracts of the incubated plants.

Bioavailability and ecotoxicity

The ecotoxicological potential of a soil is determined by investigation of soil organisms (terrestrial ecotox-tests) or as a substitute with limited evidence by the use of aquatic ecotox-tests for example with daphnids, algae, luminescent bacteria using soil extracts.

To achieve realistic interpretation of each ecotox-test its limitations have to be taken into account. Tests with soil organisms give information about the habitat function of a soil. With aquatic ecotox-tests toxic bioavailable contaminants are determined. Contaminants are detected which can be eluted from the soil. Therefore information on the retention function of the soil and on possible contamination of groundwater are obtained. There is general agreement that for an intensive assessment of a soil the different exposure paths of the investigated organisms have to be considered.

Soil organisms—The results of several studies with earthworms indicate that soil organic matter content has an important influence on the accumulation and toxicity of a range of chemicals (metals and non-polar compounds). However, the availability and hence the effects of these two groups of chemicals are additionally modified by other co-variable factors. For metals, e.g. soil pH plays a major role for free metal ion concentrations in the soil pore water, while for non-polar compounds the lipophilicity of the compound is the most important co-determining factor. As organic matter reduces the uptake and the toxic effects of a range of pollutants by organisms it can be concluded that the maintenance of high levels of organic material in contaminated soils is important.

The uptake and transfer of plant available heavy metals from soil into plants furthermore depends on plant specific factors based on genetic differences with respect to the properties of the root system, selectivity against different metals, inner plant translocation mechanisms, transpiration rate etc. Last but not least the general growing conditions (climatic conditions, nutrient supply, duration of the vegetation period) also influence the heavy metal transfer from soil into plants. The evaluation of several experiments elucidates that generally SOM has a relatively low influence on the uptake of heavy metals by plants. The direction of this influence is still controversially discussed. May be that a further differentiation of SOM as shown for example by Kögel-Knabner *et al.* is necessary to show any clear dependency of parts of the SOM on the transfer of heavy metals from soil into plants. Even if relationships between parts (fractions) of the SOM and the uptake of heavy metals by plants will be elaborated it will be difficult to put this knowledge into administrative rules. For practical purpose the use of neutral salt extractions is the best solution because the different influences of soil specific parameters can be sufficiently considered. Furthermore NOM seems to influence the biomass weight

Problems with Ecotoxicological Tests / Outdoor/Field Investigations

Test System	Advantage	Potential Disadvantages/Problems
acute aquatic tests	• quantification of the toxicity via dilution series	• preparation of eluates • correction of pH-value? • at least partially low sensitivity (only high concentrations can be detected) • coloring of the extract • Interference of the test systems/organisms with micro-organisms, which had been extracted • fairly soluble substances cannot be detected
chronic aquatic tests (algae test)	• quantification of the toxicity via dilution series	• see acute aquatic tests • nutritional problems
terrestrial tests (added organisms)	• (in)direct statements/conclusions in regard of habitat functions • different exposure pathways can be determined to a certain extent	• uncontaminated control often not available, consequently dilution series cannot be carried out • ⇒ only severe impacts are detectable (plant test) • due to the chemical-physical and pedologic conditions the habitat may not be optimal for the test organisms
terrestrial investigations (soil endogenous organisms)	• direct statement in regard of habitat functions • determination of different exposure pathways	• uncontaminated control often not available, consequently dilution series cannot be carried out • ⇒ only severe impacts are detectable • abundances/activities for important organisms must be determined depending on soil substrates and land use (so far very few data are available)

of roots and shoots. Both inhibition and stimulation have been observed, presumably depending on plant species.

Tests with aquatic organisms—When using aquatic tests with soil extracts a precise measurement of the dissolved contaminants or exclusion of particles is necessary. Design of the tests and the chemical exposure analyses should provide for the definite distinction between aquatic and particulate exposure, in order to avoid totally misleading results with soil extracts.

Specific and conclusive experiments investigating the influence of DOM on toxicity of chemicals have been so far mainly performed with aquatic organisms. Depending on experimental design not only enhancement of toxicity (phototoxicity) but also masking of toxicity were observed. In one experiment, e.g. the daphnia, toxicity of lindane and pendimethalin could be reduced to ‘not measurable’ upon addition of natural DOM.

Conclusion

Available evidence clearly shows a significant influence of dissolved organic matter in soils and waters on the fate and effects of chemicals. This role of natural organic carbon in environmental compartments is in addition and partly directly contrary to the conventional role which has been thoroughly investigated and considered in legislation. In order to quantify and elucidate the significance of dissolved organic matter in the real environment with respect to risk assessment of contaminants, systematic, well-targeted investigations are needed.

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Dedicated to Prof. Werner Klein on the occasion of his 60th birthday