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CHEMISTRY AND SUSTAINABLE DEVELOPMENT —
Towards a Clean Environment,
Zero Waste and Highest Energy Efficiency
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PERSPECTIVES AND RECOMMENDATIONS

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Perspectives and Recommendations of the CHEMRAWN—VIII Conference

I. Introduction

The CHEMRAWN(*) series of conferences is devoted to many problems which are mentioned among programme areas of the Agenda-21 (Agenda for 21st century) that is approved by the United Nations Conference on Environment and Development (UNCED, 3—14 June 1992, Rio de Janeiro, Brazil) [1].

The list of the previous conferences includes:

CHEMRAWN—I. World Conference on Future Sources of Organic Raw Materials (1978, Toronto, Canada).

CHEMRAWN—II. International Conference on Chemistry and World Food Supplies — The New Frontiers (1982, Manila, Philippines).

CHEMRAWN—III. World Conference on Resource Material Conversion to Meet Future Needs (1984, the Hague, the Netherlands).

CHEMRAWN—IV. Modern Chemistry and Chemical Technology Applied to the Ocean and its Resources (1987, Woods Hole, Massachusetts, USA).

(*) An abbreviation of the words "CHEMical Research Applied to World Needs"

CHEMRAWN—V. Current and Future Contributions of Chemistry to Health — the New Frontiers (1986, Heidelberg, FRG).

CHEMRAWN—VI. World Conference on Advanced Materials for Innovations in Energy, Transportation and Communications (1987, Tokyo, Japan).

CHEMRAWN—VII. World Conference on the Chemistry of the Atmosphere — Its Impact on Global Change (December 2—16, 1991, Baltimore, Maryland, USA).

The CHEMRAWN—VIII Conference "Chemistry and Sustainable Development" was related to some current and future problems of chemical science and industry and organized as a follow-up action to the UNCED. In connection with this, the Agenda-21 [1] and statements of some foregoing conferences [2—5, 18] should serve as a base for the general recommendations described below.

II. What does "Sustainable Development" Mean in the Area of Industry?

a. Definition of Sustainable Development

A general meaning of the words "conception of sustainable development" is given in the report of the World Commission on Environment and Development (Chairman — Mrs. Gro Harlem Brundtland, Prime Minister of Norway), that is well known under the title "Our Common Future" [6].

"The message conveyed by "Our Common Future" is very powerful. It is more than interdependence: more than interna-

tional co-operation; more than technologies and resource transfer; more than interdisciplinarity; more than intergenerational equity; more than science and policy dialogues. "Our Common Future" provides the soul, the ethic, and the ethos for our actions. Without this, no sustainable development is possible" [2].

Now the meaning of the words "sustainable development" is included into the Rio Declaration on Environment and Development [7]:

"Principle 1

Human being are at the centre of concerns for sustainable development. They are entitled to a healthy and productive life in harmony with nature.

Principle 3

The right to development must be fulfilled so as to equitably meet developmental and environmental needs of present and future generations.

Principle 4

In order to achieve sustainable development, environmental protection shall constitute an integral part of the development process and cannot be considered in isolation from it.

Principle 8

To achieve sustainable development and a higher quality of life for all people, States should reduce and eliminate unsustainable patterns of production and consumption and promote appropriate demographic policies".

b. Environmentally Safe and Sound Technologies and Treatment of Wastes

Industrial production along with agriculture, transport and municipal activities, being important elements of the development process, are at the same time main sources of the pressure on the environment. In the case of industrial production chemical community shall pay now much more attention to the environmentally sound technologies, including waste treatment.

It is useful to rely on the so-called "triangle" approach, elaborated by the United Nations Centre for Science and Technologies for Development, with Development, Technology and Environment in the corners.

All technological processes convert raw materials and energy into other products, and, in doing so, create waste. There are no waste-free processes, nor is complete waste recycling possible. Consequently, there is no absolutely environmentally "sound" technology. "Environmental soundness" is determined relative to present practices.

"Environmentally safe and sound(*) technologies protect the environment, are less polluting, use all resources in a more sustainable manner, recycle more of their wastes and products, and handle residual wastes in a more acceptable manner than the technologies for which they were substitutes" ([1], p. 34.1).

(*) used below as "environmentally sound"

A new understanding of the impact of human activities on the environment is challenging industry and commerce to stop "business as usual". The previous model of development disastrous for the environment should be changed. Industry and business should be included in efforts to protect the environment, engaged in realization of the sustainable development conception.

For the past twenty years "end-of-pipe" pollution control devices have been developed and used widely. "Environmentally sound technologies in the context of pollution are "process and product technologies" that generate low or no waste for the prevention of pollution. They also cover "end of the pipe" technologies for treatment of pollution after it has been generated ([1], p. 34.2).

However, it is now accepted that it is generally less costly to prevent pollution by using cleaner production than to "cure" it at the end of the process.

Related to this is the concept of "cradle-to-grave" planning, whereby manufacturers take full responsibility for practices employed in every part of the production process, e.g., from the environmentally sound mining of raw materials to the final disposal of a good that has outlived its usefulness. All phases of the life cycle of a product are examined in order to prevent or minimize short- and long-term risks to humans and the environment.

"Environmentally sound technologies are not just individual technologies, but total systems which include know-how, procedures, goods and services, and equipment as well as organizational and managerial procedures" ([1], p. 34.3).

In order to stimulate transfer of environmentally sound technologies it is necessary:

- to develop international information networks on clean technologies which link national, regional and international systems ([1], p. 34.15—34.17);
- to "build up technology assessment capacity for the management of environmentally sound technologies, including environmental impact and risk assessment, with due regard to appropriate safeguards on the transfer of technologies subject to prohibition on environmental or health grounds" ([1], p. 34.26 a);
- to promote joint ventures between suppliers and recipients of technologies that could constitute important channel of transferring environmentally sound technologies ([1], p. 34.28);
- to stimulate the research, development and transfer of environmentally sound technologies ([1], p. 34.19).

"Technology, particularly the need to make such technologies universally available, is a major element in respect of many areas requiring actions. Of special importance are measures required to make such technologies and the capabilities to develop and apply them, available to developing countries under conditions which are fair and affordable" ([19], p. 28 e).

"It is in the interest of the world community as a whole to accelerate technology cooperation, because without the transfer of environmentally benign technology global envi-

ronmental problems promise to undermine the prosperity and security of even the richest nations" [21].

"A large body of useful technological knowledge lies in the public domain. There is a need for the access of developing countries to such technologies as are not covered by patents or lie in the public domain" ([1], p. 34.9).

"Proprietary technology is available through commercial channels, and international business is an important vehicle for technology transfer" ([1], p. 34.11).

C. Economics of Sustainable Development of Industry.

Sustainable development does not mean a return to a pre-industrial era. It calls for continued economic growth on the basis of environmentally sound technologies.

We should overcome the belief that industrial progress and environment protection are mutually opposing goals and stop to shift the environmental costs to future generation.

"Cleaner production technologies often require a higher initial investment than traditional technology. However, the payback is often surprisingly short (two or three years). Thanks to savings in raw materials and energy use, and lower treatment costs, numerous secondary benefits such as improved quality control and lower accident rates are also obtained" [22].

An experience of last years indicates that the industry has great environmental reserves. Japan has lowered pollution levels since 1975 with simultaneous reducing by 40 per cent the energy required to produce a unit of gross domestic

product and effecting a similar reduction in raw materials use. Chemical industry of France has halved pollution levels over the past 10 years while raising production by 25%.

Many companies are convinced that it is profitable to pay for preventing pollution than to clean it up, and that concern for the environment leads to financial savings and increased competitiveness.

"Governments ... should adopt a national strategy for sustainable development based on, inter alia, the implementation of decisions taken at the Conference (UNCED), particularly in respect of Agenda 21. ... Its goals should be to ensure socially responsible economic development while protecting the resource base and environment for the benefit of future generations" ([1], p. 8.7).

"Environmental law and regulation are important but cannot alone be expected to deal with the problems of environment and development. Prices, markets and governmental fiscal and economic policies also play a complementary role in shaping attitudes and behaviour towards the environment" ([1], p. 8.27).

"Sustainable development requires that environmental resources be allocated now in such a way that the potential average quality of life of future generations is not endangered. At present the use we make of environmental resources does jeopardize the welfare of future generations, and this is largely because those resources are not priced at their true social and environmental cost. ... It is crucially important to face resource users with the true cost of these resources, and to devise instruments such as resource user

fees, emission charges or tradeable quotas, which will "correct" the prices for such resources struck in the market" [2].

"During the past several years, many governments ... have been making increasing use of economic approaches, including those that are market-oriented. Examples include the polluter-pays principle and the more recent natural-resource-user-pays concept" ([1]. p. 8.28).

It is very important:

- to incorporate environmental costs in the decisions of producers and consumers, to reverse the tendency to treat the environment as a "free good" and to pass these costs on to other parts of society, other countries, or to future generations" ([1], p. 8.31 a);

- to move more fully towards integration of social and environmental costs into economic activities , so that prices will appropriately reflect the relative scarcity and total value of resources and contribute towards the prevention of environmental degradation" ([1], p. 8.31 b).

Governments should try to:

- establish effective combinations of economic, regulatory and voluntary (self-regulatory) approaches;

- reform or recast existing structures of economic and fiscal incentives to meet environment and development objectives;

— move towards pricing consistent with sustainable development objectives ([1], p. 8.32 a, c, e).

"Given the recognition that the use of economic instruments and market mechanisms is relatively recent, exchange of information about different countries experiences with such approaches should be actively encouraged" ([1], p. 8.35).

III. Bases of Using Chemical Science For Sustainable Development.

The role and the use of sciences in supporting the prudent management of the environment and development for daily survival and future development of humanity are very high. "It will be essential to enhance scientific understanding, improve long-term scientific assessments, strengthen scientific capacities in all countries and ensure the sciences are responsible to emerging needs" ([1], p. 35.1).

"One key objective is to improve the fundamental understanding of the linkages between human and natural environmental systems and improve the analytical and predictive tools required to better understand environmental impacts of development options by:

a) Carrying out research programmes in order better to understand the carrying capacity of the Earth as conditioned by its natural systems, such as the biogeochemical cycles, the atmosphere/hydrosphere/litosphere/cryosphere system, the biosphere and biodiversity, the agro-ecosystems and other terrestrial and aquatic ecosystems;

b) Developing and applying new analytical and preventive tools in order to assess more accurately the ways in which the Earth's natural systems are being increasingly influenced by human actions, both deliberate and inadvertent" ([1], p. 35.11 a, b).

Thus, the first goal of science in relation to the environment is the better understanding of the united Earth system for more reliable prognosis of possible changes under influence of anthropogenic activities. This requires national and international multidisciplinary collaboration in various areas.

Many of important research areas are covered now by international programmes in which the chemistry plays its important role.

A very ambitious programme is established by the International Council of Scientific Unions (ICSU) in 1986 — the International Geosphere-Biosphere Programme (IGBP). In the framework of this programme it seems desirable to draw attention to the International Global Atmospheric Chemistry (IGAC) project. Close to it, but in a more detailed form, are Recommendations of CHEMRAWN—VII Conference [5] that relate to the chemistry of depletion of stratosheric ozone layer under the influence of chlorofluorocarbons; to the global warming under the influence of main greenhouse gases such as carbon dioxide, methane, nitrous oxide, chlorofluorocarbons and tropospheric ozone; to the chemical aspects of formation and consequences of acid rains.

In the framework of ICSU a special Scientific Committee on Problems of the Environment (SCOPE) is working, among

others, on problems of biogeochemical cycles of main elements (carbon, oxygen, nitrogen, phosphorus and sulfur) and toxic metals (lead, mercury, cadmium and arsenic); on artificial radionuclides behaviour in the environment (RADPATH); on methods for the assessment of effects of chemicals on ecosystems (SGOMSEC) and so on.

Many aspects of impacts of chemicals on the health of population and on the environment are considered in the framework of the International Programme on Chemical Safety (IPCS) organized jointly by the United Nations Environment Programme (UNEP), the International Labour Organization (ILO) and the World Health Organization (WHO). This programme includes, in particular, the UNEP's International Register on Potentially Toxic Chemicals (IRPTC).

Assessing the risks to human health and the environment hazards that chemicals may cause is a prerequisite to planning for its safe and beneficial use. Many synthetic chemicals appear not only in the various environmental media but also in commercial products and in food. Therefore industry should apply adequate standards in order not to damage human health. In the area of land agriculture and its products, the Food and Agriculture Organization (FAO) of the United Nations works in many cases in collaboration with other international organizations. It is possible to mention, as an example, the joint FAO/WHO Codex Alimentarius Commission on residues of pesticides, fertilizers, etc., in food and other commercial products.

The chemical science and the International Union of Pure and Applied Chemistry (IUPAC), as a professional non-governmental organization of chemists, are involved in

the activities of all these programmes quite strongly. Now efforts of the Union are united in the framework of the IUPAC Programme on Chemistry and the Environment that covers six main areas:

- analytical procedures for determination of chemicals in air, water, soil, living organisms, and food;
- measurement of physicochemical parameters relevant to the environment;
- transfer and transformation of chemicals in the environment;
- toxicology of synthetic and natural substances;
- prevention of pollution of the environment;
- chemical safety.

Many other more multidisciplinary subjects are covered by CHEMRAWN series of conferences.

Now the chemical community ought to pay special attention to the linkage of chemical science with various branches of industry in order to have possibilities to produce necessary chemicals by more environmentally sound and more economical ways.

"Since it is now abundantly clear that "more has to be done with less", science and technology have a crucial role in raising productivity... Science plays an essential role in the search for pathways to produce goods and services without degradation of the natural environment..." ([4], ii. 27, 28).

The chemical society should therefore collaborate more strongly with the Industry and Environment Office (IEO) of UNEP and with the United Nations Development Organization (UNIDO).

The IEO of UNEP has published several technical guides relating to problems of various branches of chemical and neighboring industries [8—16] and has organized the International Cleaner Production Information Clearinghouse (ICPIC) [22].

The UNIDO encourages the development and transfer of technology, provides technical assistance and maintains an Industrial and Technological Information Bank (INTIB) as well as an inquiry service which provides information to developing countries.

We also should take into account possibilities of international and regional industry-based non-governmental specialized organizations such as:

- International Environmental Bureau of the International Chamber of Commerce,
- International Association for Clean Technologies (IACT),
- European Council of Chemical Manufacturers' Federations (CEFIC),
- Ecological and Toxicological Association of the Dyestuff Manufacturing Industry (ETAD),
- International Group of National Associations of Manufacturers of Agrochemical Products (GIFAP),

— European Confederation of Pulp, Paper and Board Industry (CEPAC),

— International Primary Aluminium Institute (IPAI),

— Lead Development Association (LDA)

and so on.

Industry has caused many environmental problems and it should demonstrate possible ways of their solution.

In this connection it is desirable to mention that the Second World Industry Conference on Environmental Management (April 1991) has supported the Business Charter for Sustainable Development (Principles for Environmental Management) created by the International Chamber of Commerce [17]. Several principles of this Charter are given as examples below:

"1. Corporate priority.

To recognize environmental management as among the highest corporate priorities and as a key determinant to sustainable development; to establish policies, programmes and practices fully into each business as an essential element of management in all its functions.

6. Products and services.

To develop and provide products and services that have no undue environmental impact and are safe in their intended use, that are efficient in their consumption of energy and natural resources, and that can be recycled, reused, or disposed of safely.

8. Facilities and operations.

To develop, design and operate facilities and conduct activities taking into consideration the efficient use of energy and materials, the sustainable use of renewable resources, the minimization of adverse environmental impact and waste generation, and the safe and responsible disposal of residual waste.

9. Research.

To conduct or support research on the environmental impacts of raw materials, processes, emissions and wastes associated with the enterprise and on the means of minimizing such adverse impacts.

13. Transfer of technology.

To contribute to the transfer of environmentally sound technology and management methods throughout the industrial and public sectors".

Of course, we should use all above-mentioned decisions, statements, programmes and achievements as the basis for realization of sustainable development conception in application to chemical science and industry.

IV. Recommendations for Chemical Industry and for Chemical Science in Connection with the Conception of Sustainable Development.

"The substantial use of chemicals is essential to achieve the social and economic goals of the world community and today's best practice demonstrates that chemicals can be widely used, cost effectively, and with high degree of

safety. The products of the chemical industry help to meet mankind's basic needs for food and health. They are fundamentally important for materials of all kinds and for transportation" ([18], p. 13). Thus Western Europe exported chemicals worth some USD 52 billion in 1991, the United States USD 39 billion and Japan USD 16 billion. The former USSR operated the world's third largest chemical industry with over 2 million persons employed. "Delay in further developing the chemical industry would, therefore, inevitably result in the decline in the rate of the technological progress and in living standards" ([18]. p. 19).

"Delays would also affect environmental performance. Damage to human health and the environment have been commonplace in some of the world's most important industrial areas. Restoration will require major investments and development of new techniques. The issue of long-range transboundary pollution, which could alter the fundamental chemical and physical processes of the Earth's atmosphere and climate, has only recently become the subject of concerted action. The convention of Environmental Impact Assessment in a Transboundary Context and on Transboundary Effects of Industrial Accidents are examples of legal instruments... A great deal remains to be done in order to expand the environmentally sound management of hazardous chemicals, the use of chemicals in support of sustainable development and the improved quality of life in every country and every community across the globe" ([18], p. 20).

The term environmentally sound technology denotes an extremely broad and heterogeneous group of technologies. In

some ways it is useful to define three main categories of such technologies [20, 22]:

- processes and materials that are developed for neutralizing the environmentally harmful effects of a given operation without necessary introducing fundamental modifications in the original process (for example, flue gas desulphurization, catalytic converters for gas emissions, water treatment and detoxification, etc.);

- process modifications, including the introduction of novel monitoring and control techniques or changes in the raw materials which may be incorporated into existing technologies to eliminate or minimize their negative environmental effects (for example, the introduction of advanced on-line measurement, control and computerized optimization of chemical technologies);

- novel and traditional technologies that are inherently sound from an environmental point of view (for example, ion exchange, reverse osmosis and membrane separation processes, use of oxygen instead of chlorine for bleaching in the pulp and paper industry, novel industrial transformations that are based on biotechnology).

Over past twenty years, efforts towards implementing some environmentally sound technologies in the various branches of the chemical industry have concentrated on identifying and reducing emitting pollutants. This was largely done by adding one effluent treatment unit and flue gas scrubbing

units. Process changes have, for instance, taken place in the chlor-alkali industry with the introduction of membrane separation to replace mercury-based techniques. Many companies have been able to substitute dangerous organic solvents such as benzene and trichlorethylene with less hazardous alternatives. However, only a few substantial changes have actually been implemented — for example, the "Unipol" process used by Union Carbide for manufacturing polyethylene and the introduction by Ciba Geigy of a novel process for the production of naphthalene sulfuric acids that reduces pollution by 90% [20, 22].

"It is generally accepted that if the chemical industry is to make further significant decreases in the amounts of pollutants it generates, it must resort to more radical changes in technology" [20].

"Some of these technologies will relay on novel scientific developments and recent results from research and development laboratories. Polluting catalysts such as tin and mercury, for example, will probably be replaced by enzymatic catalysts that have been immobilized on suitable substrates. Several biotechnology-based conversions are also expected to be adopted by the chemical industry" [20].

"The manufacture and use of chemicals can be potentially hazardous for the environment and human health. The chemical industry is aware that the protection of the environment is an integral part of good business practice and that the industry requires chemical products to be manufactured, handled, transported, used and disposed of safely and without risks to human health and the environment. As stated in the Bergen Ministerial Declaration on Sustainable Development,

"policies must be based on the precautionary principle. Environmental measures must anticipate, prevent and attack the causes of environmental degradation. Where there are threats of serious or irreversible damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation" ([18], p. 29).

"Improving the image of the chemical industry — by establishing sound communication with the public and listening to its concerns, by careful product monitoring, and by fostering broad basic education in chemistry — is a challenging and urgent task requiring coordinated action by industry, and which will open the way to stable relationship with the community" ([18], p. 22).

"The chemical industry believes that the key to improving public acceptability of the industry is both its commitment to achieving ecologically sound sustainable development and improved performance and transparency. In this respect, the chemical industry has launched an initiative entitled "Responsible Care" under the guidance of the International Council of Chemical Associations (ICCA). Under this concept, chemical companies are committed, in all aspects of safety, health and protection of the environment, to seek continuous improvements in performance, to educate all staff and work with customers and communities regarding product use and overall operation" ([18], p. 32).

"Environmental problems require a greater and more systematic use of both science and scientific knowledge. Environmental science activities must therefore be strengthened nationally and internationally. The chemical industry, with its advanced research capabilities and technology, is play-

ing an increasingly central role in the fight against environmental pollution as well as in the emerging field of material recycling" ([18], p. 28).

"There is now a symbiotic and synergistic relationship between science and technology". "We have seen how the rapid development of science results in technology, which can then result in applications which are transforming society and its functioning" [4].

As was mentioned earlier, chemical community should use all achievements and general recommendations concerning the conception of sustainable development. We should also take into account goals of science and technology arising from the Agenda 21 [1]. But more detailed recommendations are also very desirable. Such recommendations were formulated by the participants of the CHEMRAWN—VIII Conference and are given below.

(will be prepared in the course of the Conference).

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