Unclassified **ENV/JM/MONO(99)19/PART2**

Organisation de Coopération et de Développement Economiques
Organisation for Economic Co-operation and Development

OLIS : 09-Sep-1999
Dist. : 13-Sep-1999

English text only

ENVIRONMENT DIRECTORATE
JOINT MEETING OF THE CHEMICALS COMMITTEE AND THE WORKING PARTY ON CHEMICALS

ENV/JM/MONO(99)19/PART2
Unclassified

Series on Risk Management No. 10

PROCEEDINGS OF THE OECD WORKSHOP ON SUSTAINABLE CHEMISTRY PART2

Venice, 15 - 17 October, 1998

English text only

81259

Document complet disponible sur OLIS dans son format d'origine
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The Japanese Approach to Sustainable Chemistry

Hisao Ida
Ministry of International Trade and Industry
Japan

Introduction

The Government of Japan has been doing its utmost to upgrade the level of science and technology for the purpose of contributing not only to our socio-economic development but also to the sustainable development of human society. It is now trying to consolidate its "sustainable chemistry initiative" in cooperation with academic societies and related industrial associations, taking OECD initiatives into account.

This paper outlines the current Japanese approach to accelerating the implementation of the initiative by combining the existing knowledge and resources of academia, industry and the government.

Scope

Although definitions of sustainable development have frequently proved elusive, it might be acceptable to say that a holistic and preventive approach considering the materials' life cycle is more desirable than a symptomatic remedy for the purpose of designing a conceptual framework in relation to it. From such a point of view, the Ministry of International Trade and Industry (MITI) has tentatively introduced the following conceptual definition of "sustainable chemistry" or "green chemistry":

"Sciences and technologies aiming to reduce the adverse effects and/or increase the positive contribution to human health and the environment by chemicals at every stage of their life cycle, i.e. raw materials, production, utilization, disposal and recycling of chemical substances and products".

For practical purposes, it could be categorized as follows:

- Green Feedstock, e.g. renewable resources
- Green Process, e.g. simple chemical process
- Green Products, e.g. non-persistent chemicals
- Green Treatment/Remediation, e.g. zero emission
- Green Recycling, e.g. material recycle, chemical recycle
- Green Infrastructure, e.g. LCA, Assessment Methodology

It is noted that these general concepts go beyond the boundaries of existing piecemeal disciplines, and may include not only chemistry and chemical engineering but also biotechnology and other related branches of science and technology. They are intended to transfuse all advanced knowledge into both the arteries and veins of materials' life cycle.

And it must be stressed that the concept does not have any restrictive implication, but that it intends to encourage activities of scientists and engineers who conscientiously work hard for the purpose not only of meeting the needs of the present but also of meeting those of the future.

Organizational framework

It is obvious that a paradigm shift in the sciences and innovative reshaping of industrial processes will be required for the purpose of attaining the ultimate goal of sustainable chemistry. To organize a powerful engine to drive such a big task, it is required to agglomerate knowledge in different sectors, i.e. academia, industry and the government.

So far, the preparatory committee for the Japanese sustainable chemistry initiative has been started, composed of representatives from the following organizations:

Government and related organizations

- Ministry of International Trade and Industry (MITI)
- New Energy and Industrial Technology Development Organization (NEDO)

Academic Societies

- Chemical Society of Japan (CSJ)
- Society of Chemical Engineers, Japan (SCEJ)

Industrial associations

- Japan Chemical Industry Association (JCIA)
- Japan Bio-industry Association (JBA)

Not-for-profit foundations

- Research Institute of Innovative Technology for the Earth (RITE)
- Japan Chemical Innovation Institute (JCII)

Though the term "sustainable chemistry" or "green chemistry" was introduced to Japan quite recently, lots of activities have been accomplished by these organizations over a long period which coincide with the idea of it. Accomplished tasks relating to sustainable chemistry cover the following areas:

- Research and Development
- Communication and Education
- Awards and Other Incentive Programs
- International Cooperation

It is planned to mobilize these organizations and consolidate existing resources and measures into a kind of comprehensive policy package for the acceleration of the Japanese sustainable chemistry initiative. JCII, which was established this March for the purpose of enhancing chemical innovation for sustainable development, will play the pivotal role in this initiative and MITI will fully support it.

Some examples of current activities

Overview of the New Sunshine Project

Outline

In 1970s and 80s, MITI enforced three separate national research projects in the energy and environmental fields, the "Sunshine Project" for new energy, the "Moonlight Project" for energy conservation and the "R/D Project for Environmental Technology". It was recognized that technology development for each of the three projects needed to be operated under a close mutual relationship based on a comprehensive viewpoint, because energy utilization and environmental issues such as global warming are closely interrelated. Also, from a technological standpoint, new energy development, energy conservation and environmental measures overlapped. Consequently, it became apparent that flexible operation of these projects would ensure that progress in developing these technologies would be efficient and accelerated.

Thus, MITI unified these three projects and started the "New Sunshine Project" in 1993. The objective of the new program is to develop innovative technology to create sustainable growth while solving energy and environmental issues.

System of the New Sunshine Program

The New Sunshine Program comprises the following three technological systems:

- innovative technology development: the development of innovative energy and environmental technology is accelerated in order to implement the Global Warning Prevention Action Plan, while focusing on important subjects over the course of its progress.

- an international, large-scale collaborative research program is being promoted to implement "New Earth 2l".

- collaborative R&D on appropriate technology: a collaborative research and accelerated development program is being promoted for fitting energy and environmental technology to the conditions of the partner country, to ease energy restrictions and address environmental concerns in neighboring developing countries.

Research areas

The New Sunshine Program covers the following areas:

- Renewable Energy
- Advanced Utilization of Fossil Fuels
- Energy Transportation and Storage
- Systematization Technology
- Environmental Technology
- Basic & Fundamental Technology Related to Energy and Environmental Aspects
- Leading Research Program
- Proposal-Based Creative R&D Promotion Program

"Green Process R&D" under the New Sunshine Project

"Simple Chemistry" is a research program on "Green Processes", under the New Sunshine Project, which aims to introduce innovative concepts for future chemical processes by maximizing energy- and resource-saving and minimizing polluted emissions by simplifying the production process. For selecting specific themes for research, study groups are organized jointly by the Japan Chemical Engineers Society, the Japan Chemical Innovation Institute and/or the Japan Chemical Industry Association, on contract with NEDO. Once themes are selected and research plans are refined for further research, an adequate research consortium, composed of national institutes, universities and private companies, starts the necessary steps. In such a way, joint research efforts are promoted to develop sustainable and economically viable innovative process. At the same time, it is believed to enhance the diffusion of new ideas to the practice.

Besides "Simple Chemistry", several projects closely related to sustainable chemistry are under the umbrella of the New Sunshine Project. The "Leading Research Program on Advanced Utilization Technology of Supercritical Fluid" is among them.

Collaborative R&D on appropriate green technology under the New Sunshine Project

Emerging economies in Asia are facing serious environmental problems caused by air and water pollution and toxic substances. They have become more serious due to rapid economic growth and industrialization. Through the policy dialogue of the Green Aid Plan, these countries have requested collaboration on countermeasure technologies against environmental problems through projects involving joint research and technical guidance.

Responding to such requests for research cooperation to solve developing countries' environmental problems, which urgently need to be solved, research cooperation has been undertaken by NEDO with developing countries so as to improve R&D capabilities in order to implement self-supporting environmental countermeasures.

The following are examples of programs that have been carried out:

- Automated Industrial Waste Water Quality Monitoring Technology at a Model Industrial Estate (FY 1995: Thailand)
- Study on Waste Water Treatment on Straw Pulp Production (FY 1995: China)

Public Communication and Education

The "White Paper on Science & Technology" of this year indicates that the significance of the roles played by science and technology has been increasing in such aspects as technological innovations and economic development, feedback to consumers, and creation of culture. On the other hand, people have a mixture of expectations and anxiety about science and technology. Some young people view it too soberly. Science and technology need to become more readily acceptable within society, the report suggests.

The government will ensure that a national consensus on the promotion of science and technology receives wider and deeper support. It will do so in full consideration of the harmony between science/technology and our lives/society and nature, and the harmonious development of natural and cultural science.

The government is implementing greater measures to promote public understanding of, and interest in, science and technology. Such measures include: nation-wide dissemination, enlightenment and public relations; disclosure of research results; provision of necessary information; opening research facilities to the public; and provision of opportunities for discussions to increase interest in science and technology.

Regarding chemistry, special attention should be paid to public perception. It is expected that a consolidated national sustainable chemistry program will enhance public acceptance of chemistry and chemical engineering. It is important to provide easy-to-understand information on R&D activities to obtain strong social support.

Since public acceptance of science and technology seems to be a common issue throughout the world, strong international cooperation to tackle this problem seems to deserve consideration for future work.

Conclusion

The government of Japan has been endeavoring to accelerate its initiative towards "sustainable chemistry" based on a holistic and preventive concept. It aims to bring about the innovative reshaping of industrial processes by agglomeration of knowledge in academia, industry and the government. For such purposes, related organizations are mobilized and existing resources and measures are consolidated into a kind of comprehensive umbrella.

Under the umbrella, cooperative efforts among universities, industries and the government are emphasized. The newly established JCII is expected to be a focal point.

With such an established point of view, Japan has been promoting trans-disciplinary and trans-sectional activities, and also promoting international cooperation with industrialized and developing countries.

Communication with and education of the public is recognized to be important for promoting sustainable chemistry, and international cooperation on this aspect seems to be of common interest.

Contributions of the Austrian Chemical Industry to Sustainable Chemistry, with Special Emphasis on Activities by FCIO

Erwin Tomschik
Chemische Industrie Wirtschaftskammer Österreich
Austria

Due to increasing legal measures taken by the Austrian government, the Federation decided to install an environment protection concept for enterprises. This made reference to stocktaking of emissions (water, air, waste) and tried to induce companies to develop products and processes with a less negative impact for man and the environment. It also called for energy saving actions.

This was done as early as 1984 and was set up in the form of a number of questions.

In order to enhance this process, studies on emission for the Austrian chemical industry were undertaken.

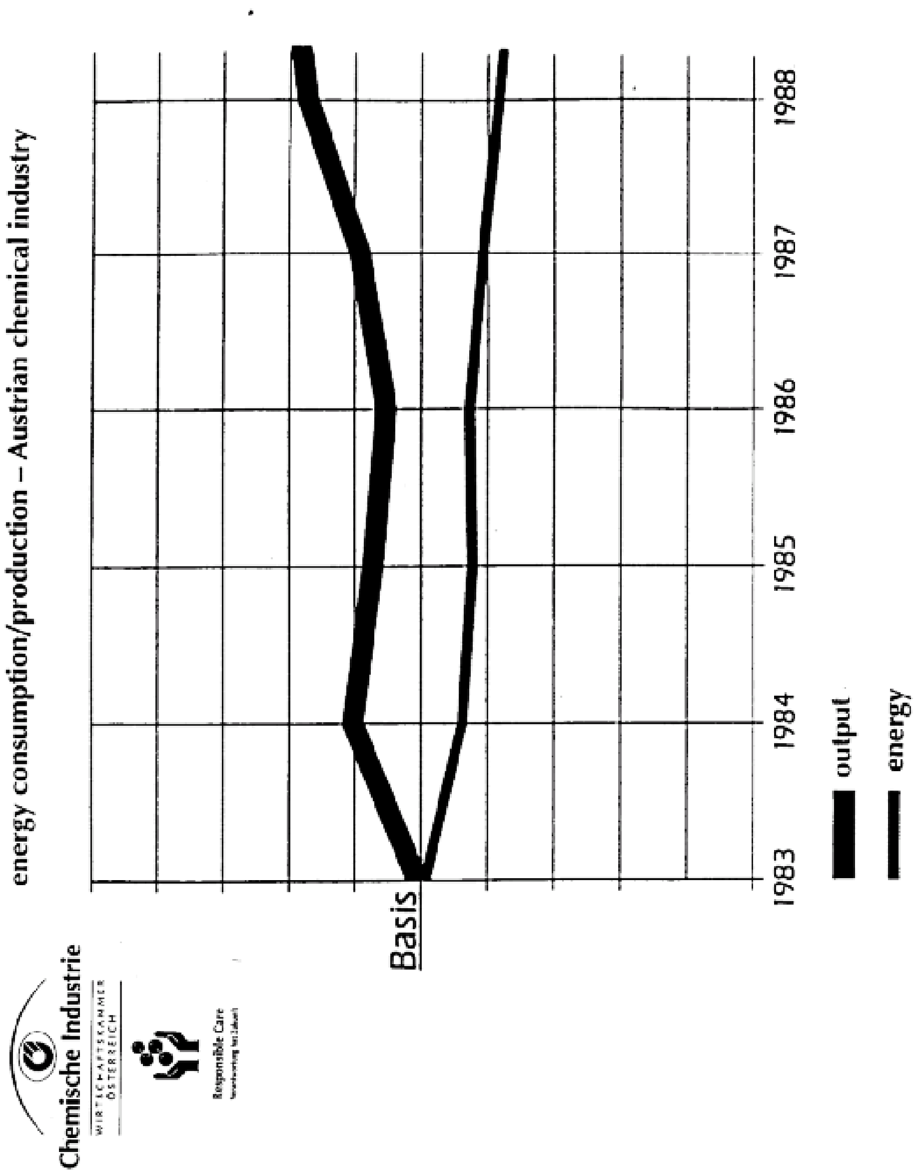
1988:	air, water
1990 and 1991:	waste
1993:	air, water

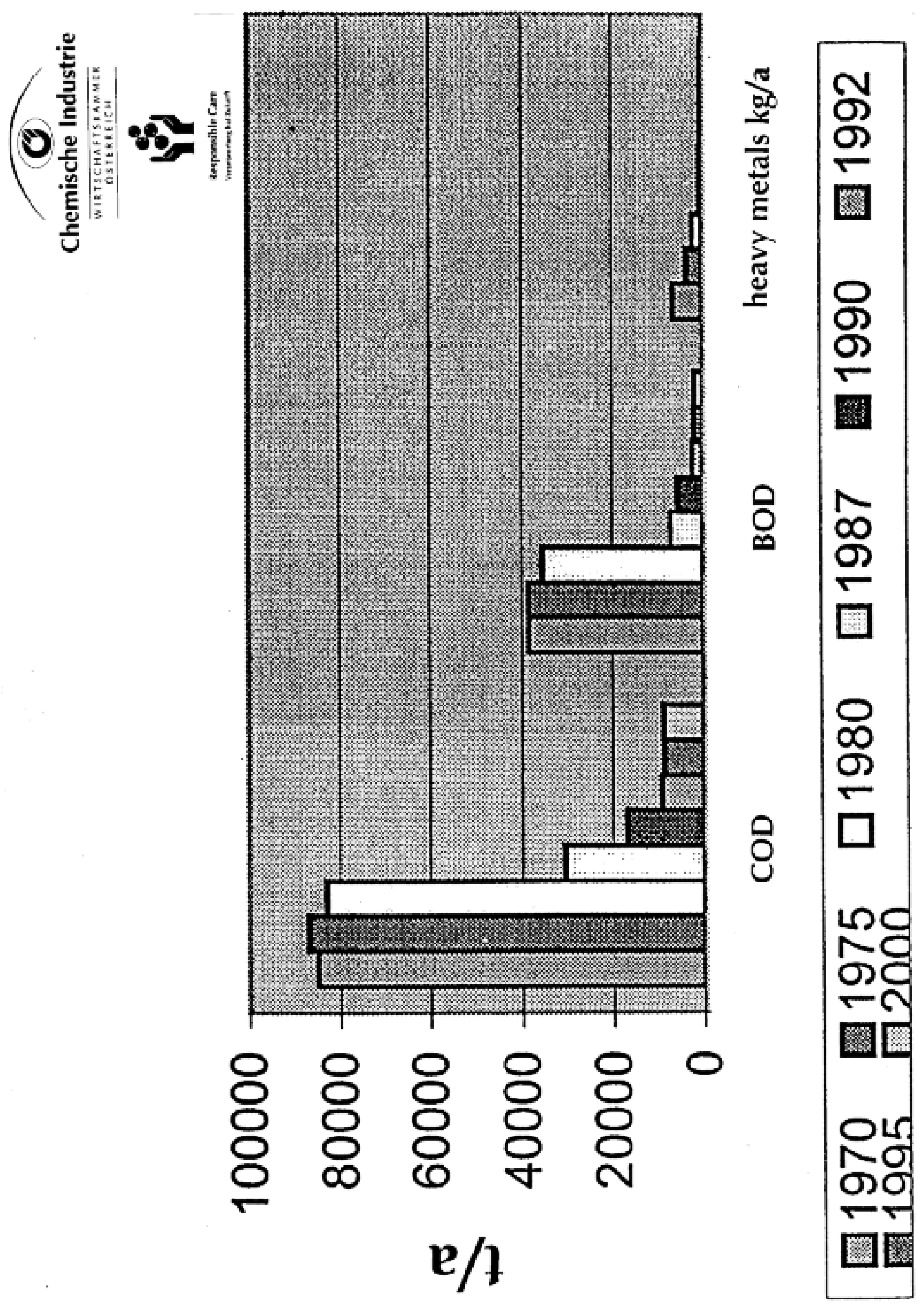
In 1998, a study on water management was finalized.

All these studies are available on request. In 1993, a new programme based on Responsible Care combined with about 200 questions on safety and environment protection was launched. These company checks are monitored by external auditors. We believe that all these activities prompted chemical companies into action and helped them to respond to environmental demands by society in a very effective manner. More than 40% of the Austrian chemical industry output is covered by this scheme.

Let me just name a few activities performed by Austrian enterprises:

- replacement of conventional solvents in paints
- water-based paints
- powder coating
- replacement of aromatic solvents in adhesives
- replacement of cadmium and lead PVC stabilisers
- The Austrian chemical industry believes that this fight for environmentally sound products and processes must go on, while retaining or even improving the performance. It is vital that politics and policy only set goals and leave the realization to the industry concerned.


energy consumption/production – Austrian chemical industry
Basis
1983
1984
1985
1986
1987
1988
output
energy
Chemische Industrie

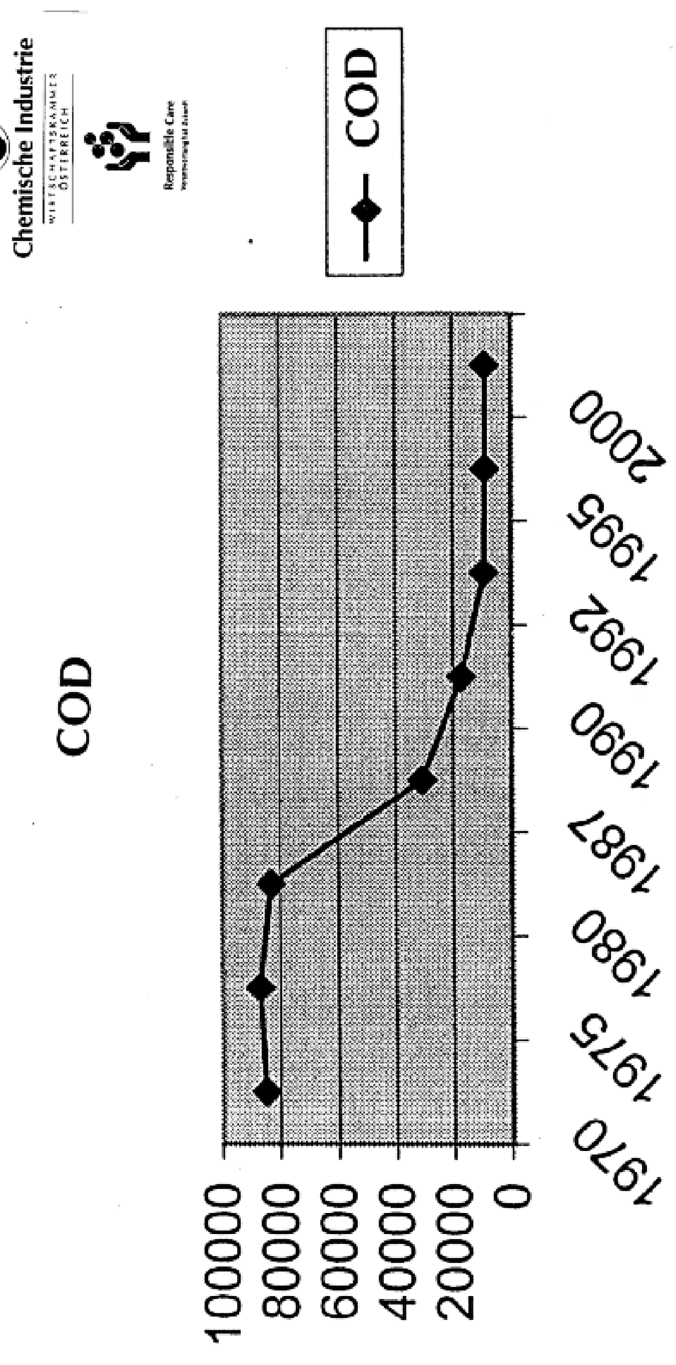

Chemische Industrie
WIRTSCHAFTSKAMMER ÖSTERREICH
t/a
1000000
800000
600000
400000
200000
0
COD
BOD
heavy metals kg/a
1970
1975
1980
1987
1990
1992
1995
2000

Chemische Industrie
WIRTSCHAFTSKAMMER ÖSTERREICH

Responsible Care

water emission
Austrian chemical industry

	COD t/a	BOD t/a	heavy metals kg/a
1970	85000	38500	6400
1975	87000	38500	3480
1980	83000	35500	2090
1987	30790	7159	406
1990	17110	5567	380
1992	9310	2228	118
1995	8800	1820	97
2000	8920	1772	76

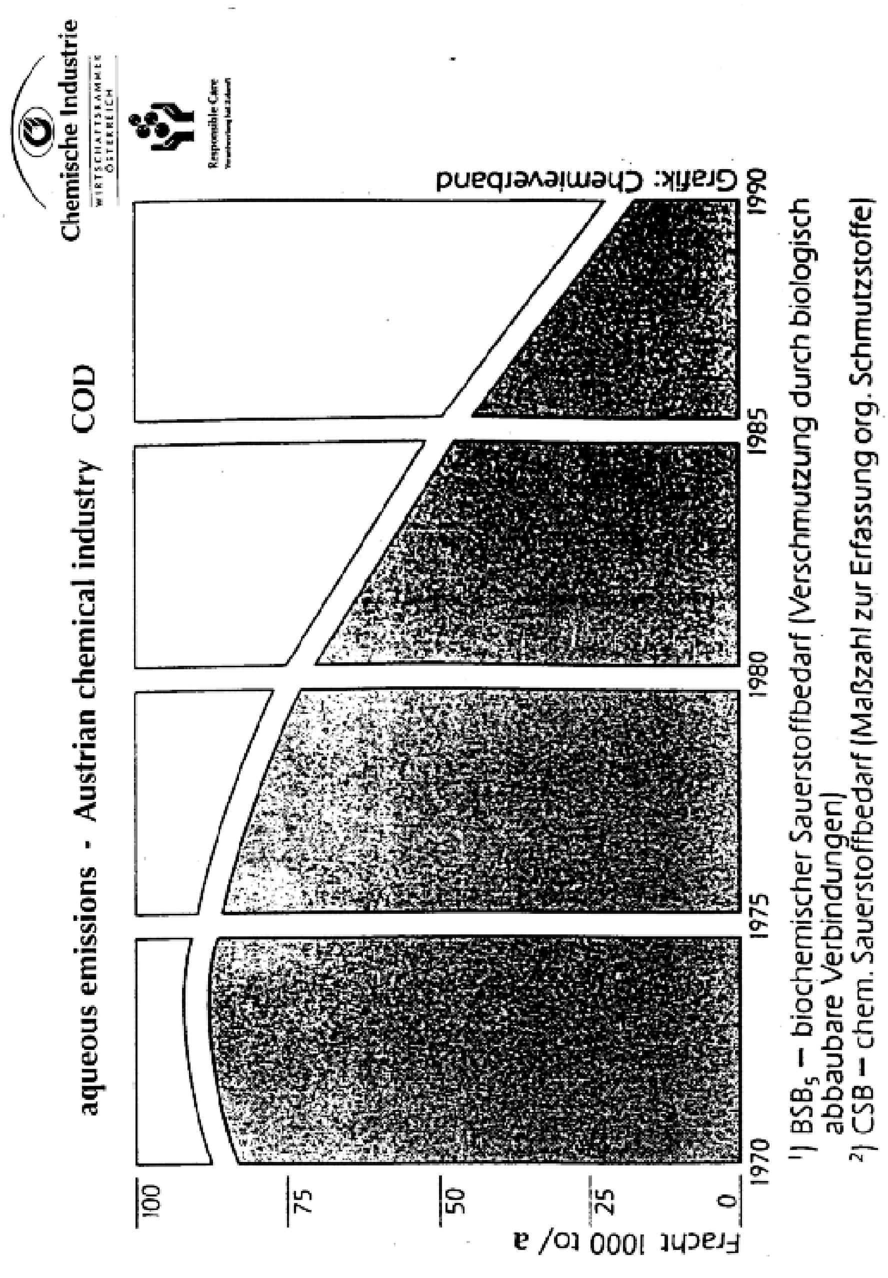

Chemische Industrie
Responsible Care
COD
COD
100000
80000
60000
40000
20000
0
1970
1975
1980
1987
1990
1992
1995
2000

Chemische Industrie
WIRTSCHAFTSKAMMER ÖSTERREICH

Responsible Care

Reduction waste water
Austrian chemical industry

emittent	1970	1990
org. compounds	85.114 to/a	19.904 to/a
BOD	39.181 to/a	5.595 to/a
Ammonium	4.819 to/a	3.001 to/a
mercury	4.075 kg/a	84 kg/a
chlorinated hydro-carbon	194.000 kg/a	350 kg/a

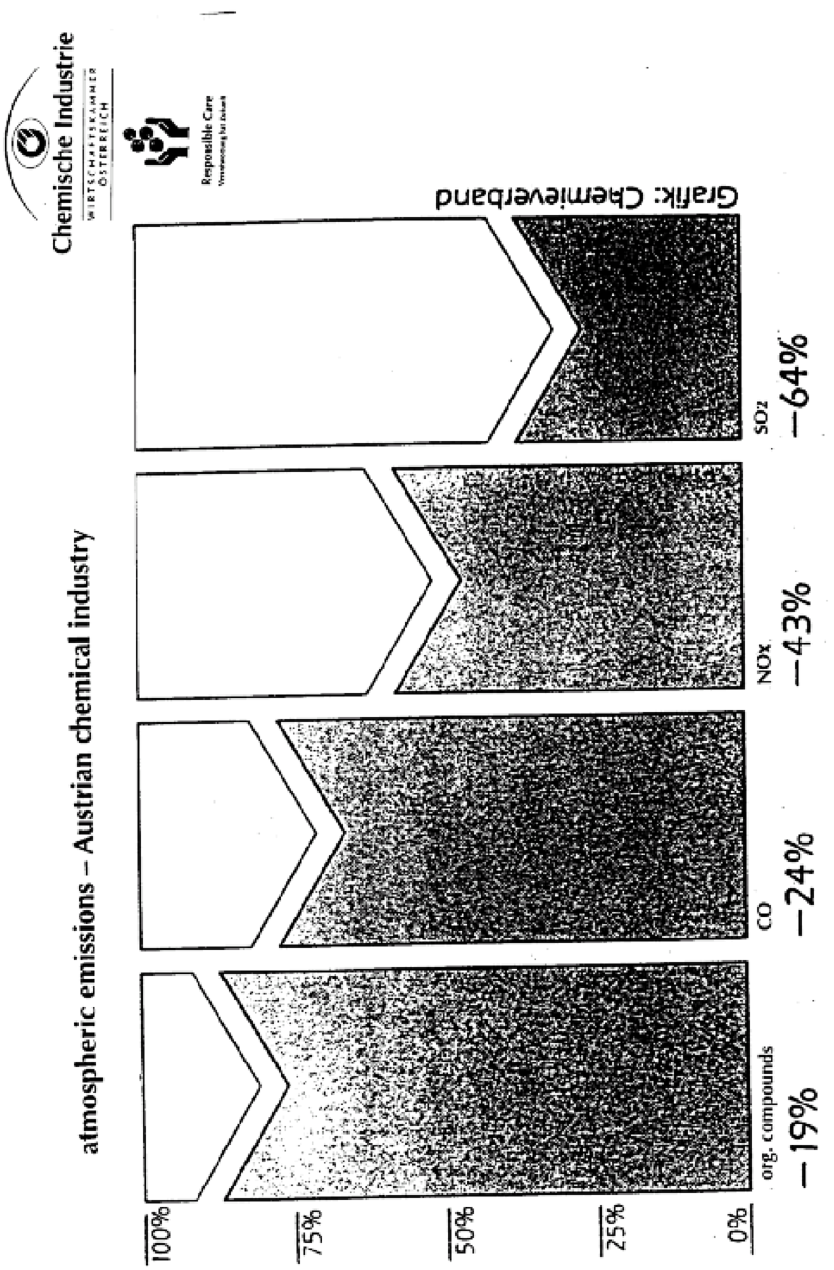

aqueous emissions - Austrian chemical industry COD
Chemische Industrie
Responsible Care
Fracht 1000 to/ a
100
75
50
25
0
1970
1975
1980
1985
1990
Grafik: Chemieverband
¹) BSB₅ – biochemischer Sauerstoffbedarf (Verschmutzung durch biologisch abbaubare Verbindungen)
²) CSB – chem. Sauerstoffbedarf (Maßzahl zur Erfassung org. Schmutzstoffe)

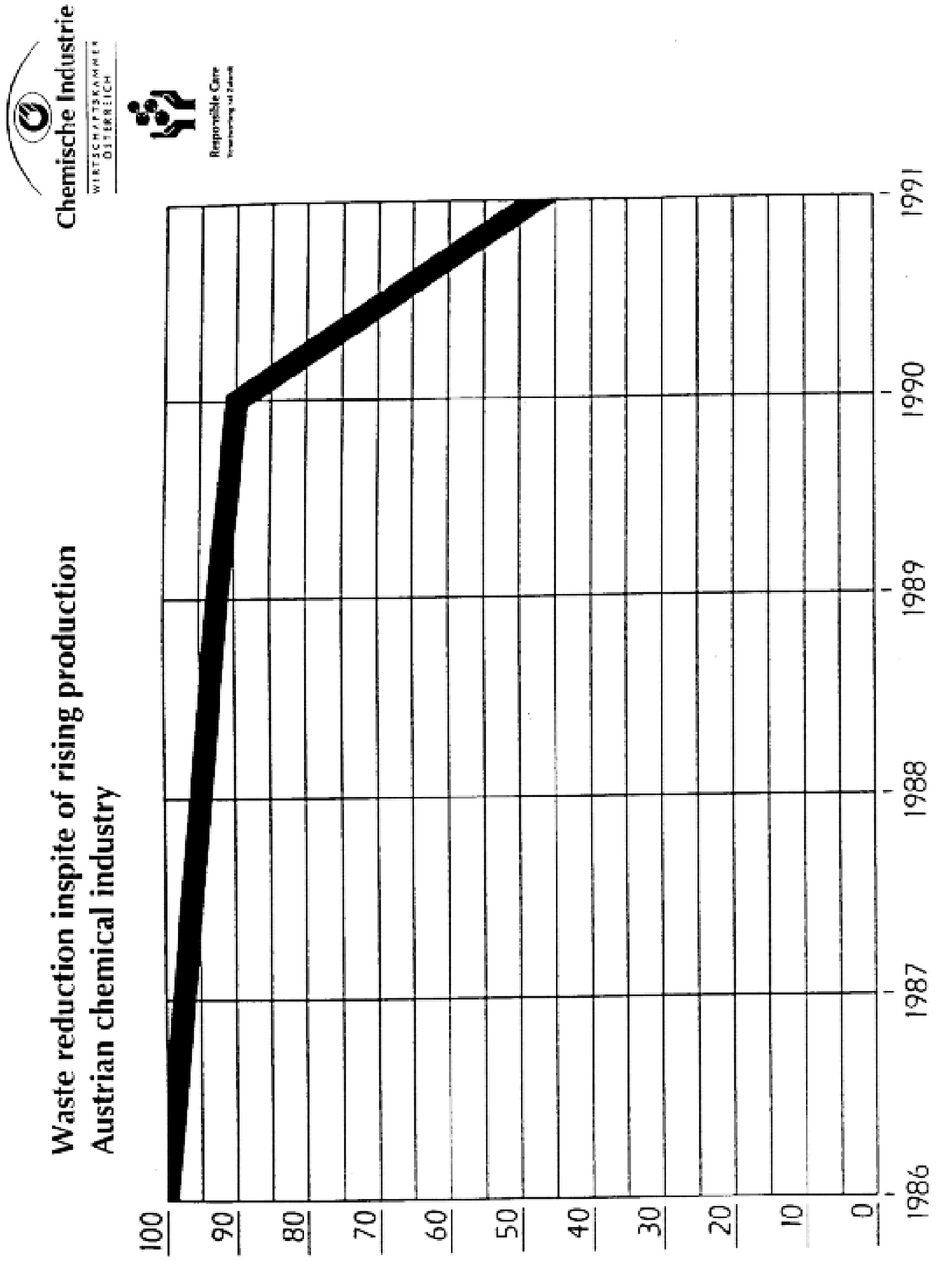
Chemische Industrie
WIRTSCHAFTSKAMMER ÖSTERREICH

Responsible Care

atmospheric emissions /development
Austrian chemical industry

process and energy related emission	1970 t/a	1990 t/a
org. compounds	10.392	8.455
CO	16.832	12.823
NOx	11.377	6.493
SO_2	20.539	7.443


Chemische Industrie
WIRTSCHAFTSKAMMER ÖSTERREICH
Responsible Care
atmospheric emissions – Austrian chemical industry
100%
75%
50%
25%
0%
org. compounds
−19%
CO
−24%
NOx
−43%
SO2
−64%
Grafik: Chemieverband


Waste reduction inspite of rising production
Austrian chemical industry
Chemische Industrie
WIRTSCHAFTSKAMMER ÖSTERREICH
Responsible Care
100
90
80
70
60
50
40
30
20
10
0
1986
1987
1988
1989
1990
1991

Chemische Industrie
WIRTSCHAFTSKAMMER ÖSTERREICH

Geprüftes Unternehmen
ResponsibleCare
Eine Initiative für Gesundheit, Sicherheit und Umwelt

In order to enhance the standards of health, safety and environment Austria's Chemical Industry has launched a further initiative: It has adopted the international idea of **Responsible Care** and set a series of voluntary measurements which exceed the legislation concerning health, safety and environment.

Responsible Care exceeds all activities which were set till now:

Responsible Care is an obligatory assessment for all companies participating. To be able to join the circle of participants, a company has to meet the requirements of the program and to submit to an external audit by independent civil engineers.

Responsible Care covers all parts of the enterprise which are relevant for health, safety and environment in the wider context. These are e.g. waste management as well as transport. For the participating company **Responsible Care** means, that each decision made by the enterprise has to be considered with regard to its effects on safety, health and environment.

The aim of all these efforts is to enhance all achievements concerning safety, health and environment reached thus far.
The motivation for this development is not laws or ordinances, but the high level of self-responsibility which the Austrian Chemical Industry proves with the **Responsible Care** program.

The Austrian Chemical Industries Association (FCIO) performs **Responsible Care** in the following way:

- self-control on the base of the documents and questionnaires of the FCIO
- registration for the audit
- examination of the company by independent WIFI-auditors
- validation of the reports by a council of the FCIO

If the requirements are fulfilled,

- the international logo may be used for a period of three years
- the enterprise is registered in the table of participants in **Responsible Care**

This table is updated and published regularly by the FCIO.

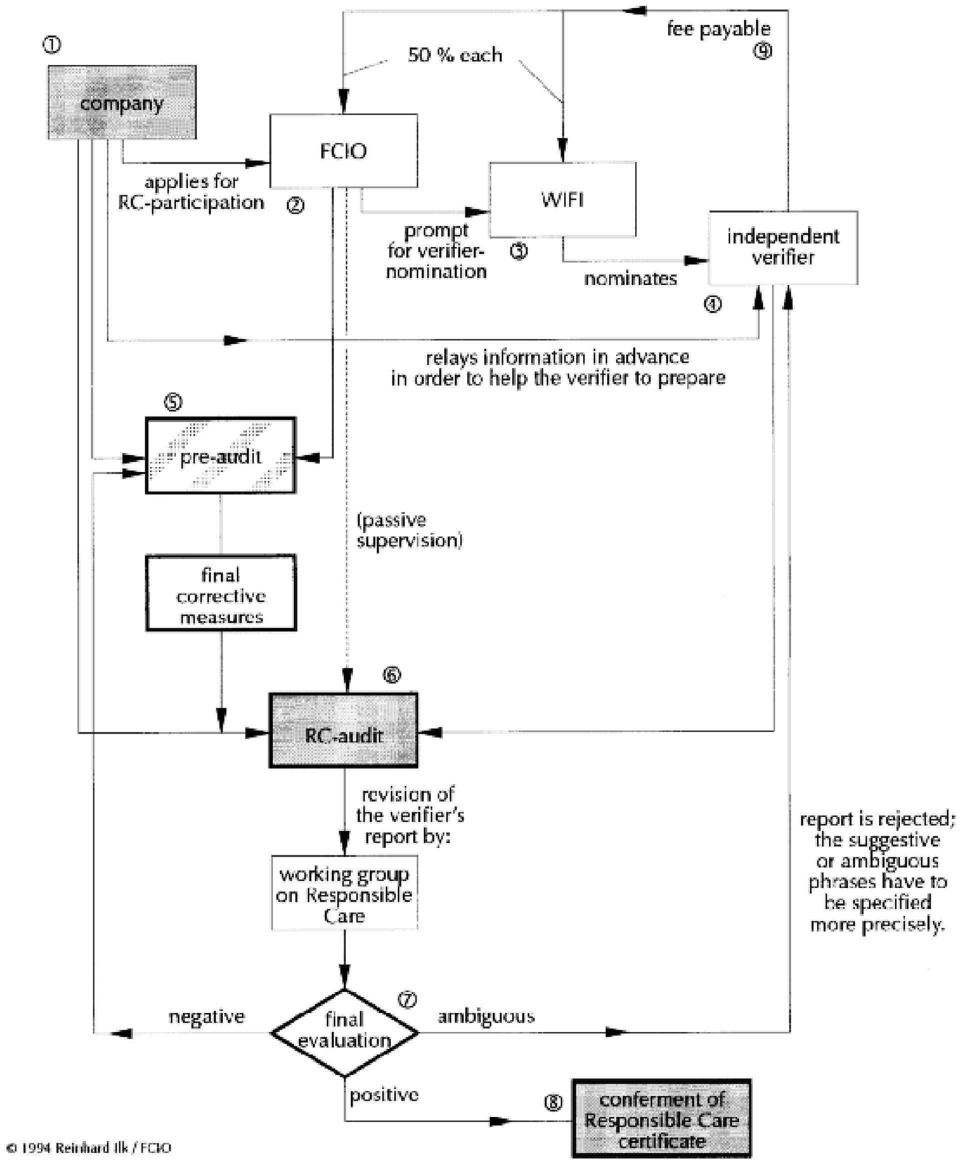
The principles:

We regard safety and protection of man and environment as a matter of utmost priority.

We are keen on developing and producing products, the transport, use and disposal of which is environmentally sustainable, and on running our plants in a way that a high level of safety, health and protection of the environment is guaranteed.

We are facing the dialogue with public, acknowledge other opinions and inform in an adequate way about our products, processes and plants, about impact on man and environment as well as about preventative protection measures.
We consult our customers about safe transport and handling and about the environmentally sustainable use and disposal of our products.
We are keen on working out new regulations, agreements and further measurements for the protection of our employees, the public and the environment in cooperation with the authorities.

Responsible Care - auditing flowchart



Version August 98

Query Catalogue for a Works Review within the Framework of Responsible Care© Working Party "Responsible Care"© 1992-1998

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3. Noise

4. Storage

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6. Production, employee protection

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8. Substances, preparations, finished products

9. Radiation protection

10. Transport

11. Environmental organisation

12. Water, waste water

Preliminary remark

This query catalogue serves not only as a preparatory document for the company, but also as a working reference for the examiner. Written comments and explanations have been largely dispensed with, in order to keep the extent of the document as brief as possible.

The allocation of points is fundamentally at the discretion of the examiner, but should be gauged according to the following degrees of fulfilment:

Completely fulfilled, 3 Points (100%). Satisfactorily fulfilled, 2 Points (at least 75%). To a large extent fulfilled, 1 Point (at least 50%).

Instructions for the examiner concerning the controls to be carried out have been placed in square brackets. For example, [Documentation] indicates that the company must put down in writing the requirements formulated in the query. The examiner must at least inspect the documentation and note down the identification information of the document such as date, record number, etc. in the examination report. If possible, a copy of the document is to be attached to the examination report as an enclosure (obtain consent of the persons responsible in the company!).

The addition “Euromanag.” indicates that this query has been taken from the Euromanagement-Environment program for the realisation of EMAS (in Austria, Öko-AuditVO). These queries relate exclusively to a management system.

Energy and energy generation

Addition

1.1 Does an energy balance for your company exist according to carriers (electricity, coal, heating oil, etc.) and consumers (production, office, etc.) and is it followed up and controlled periodically (arithmetical acquisition also permissible)?

1.2 Are energy-saving measures carried out - except questions 4, 5 - in buildings, at boiler installations, pipelines (regulating elements, heat exchanger, etc.)?

1.3 Are energy-saving measures planned - except questions 4, 5 - in buildings, at boiler installations, pipelines (regulating elements, heat exchanger, etc.)?

1.4 Are your heating installations continuously serviced and inspected? (Only with externally supplied heating)

1.5 Are thermal insulation measures planned or being carried out (buildings, pipelines, boiler, etc.)? © Working party “Responsible Care”

1.6 Are ecological concerns considered by the generation of energy (CO_2 potential, etc.)? “Euromanag.” (Only with externally supplied energy)

Disposal, recycling

2.1 Is waste collected separately at all places (production, laboratory, office, etc.) (waste, dangerous waste, recyclable - and reusable waste, etc.)?

2.2 Are dangerous wastes allocated an index number according to ÖNORM S2100?

2.3 Does dangerous waste occur at your company in the sense of the ÖNORMS 2101 and does your company have a waste-generation number? [Control of the report to the chief regional officer]

2.4 Does the recording liability comply with the Waste Management Act?

2.5 Does a waste management concept exist for your company, insofar as one is stipulated? © Working party “Responsible Care”

2.6 Do you hand over your dangerous waste to a collector or handler, and have you convinced yourself that that person is authorised to take over?

Addition

2.7 Insofar as no waste management concept is stipulated for your company, does a company-specific waste management plan exist?

2.8 Have all possibilities of company-internal recycling been exhausted?

if not

- Is an expansion of recycling planned? [Planning documents]

2.9 Does the possibility exist of recycling at external companies and is this utilised?

[Offer and/or orders]

2.10 Are you convinced that your waste is disposed of/handled properly by third parties? (random visit to the disposal company - Note!)

2.11 Have co-workers been accountably informed regarding the Waste Management Concept /plan?

[Bulletin, list of participants being trained, interview of co-workers]

(only if WMC is not stipulated)

Key-word reasoning for points allocation:

2.12 Do your co-workers utilise the collection installations provided in the Waste Management Concept/plan (waste separation)?

2.13 Is the company-internal handling of waste carried out in accordance with your Waste Management Concept/plan?

2.14 Is waste prevention practised in such a way that e.g. multiple packaging, reusable containers, etc. are utilised to prevent superfluous packaging?

Noise

3.1 Have the statutory industrial requirements imposed in the plant authorisation concerning noise been fulfilled?

3.2 Are the statutory conditions of employee protection regarding noise (e.g. by way of working instructions) adhered to?

3.3 Are the legally prescribed medical examinations of employees due to continuous severe noise encumbrance regularly carried out?

3.4 Do you have measured noise readings at your disposal (inside the company and outside)? © Working party “Responsible Care”

3.5 Are the noise protection systems provided in the company used by co-workers and is their use controlled?

Addition

3.6 Are low-noise or noise-dampened installations consequently procured (corresponding references in tender documentation)?

3.7 Are/have noise-protection measures being/been carried out to reduce the noise encumbrance inside and outside the location? The query relates to active as well as passive noise-protection measures:

Active are:

- Soundproofing measures for emitters, soundproofing shrouds

Passive are:

- Room alteration, room panelling (against reverberations)

Storage

4.1 Are your stores licensed according to the danger potential of the stored products (blasting materials, collodion cotton, peroxide, poisons, flammable liquids, etc.)? [Official rulings]

4.2 Is the adherence to official requirements controlled (amounts stored, storing together, equipment, facilities to operate the store, etc.)? [Working instructions - Control of execution]

4.3 Is there a storage plan in which the average amounts stored and the maximum permissible stored amounts of all dangerous and non-dangerous materials and preparations is visible? Is every endangering potential also evident from this plan? Is this plan continuously updated and also made available to the relevant emergency services (e.g. fire brigade)? "Euromanag."

4.4 Are the structural and safety installations regularly inspected, serviced and maintained (waterproof tanks, explosion protection, fire protection installations, sprinkler systems, extraction, gas displacement pipes, etc.) [Documentation]?

4.5 Do the internal transport systems correspond with the safety conditions or requirements (lifts, lifting trucks, stacker trucks, conveyor belts, etc.)?

4.6 Are personnel properly trained (stacker truck license, internal driving license, operating and safety instructions, etc.)?

4.7 Are the storage facilities (shelves, containers, transportation devices, etc.) regularly inspected, serviced and maintained [Documentation]?

4.8 Is the required protective equipment (safety glasses, safety gloves, protective helmets, protective clothing, etc.) available in sufficient quantity and in proper condition, and is its use and condition regularly inspected? [Documentation]

4.9 Are the prescribed protective areas and escape routes marked and are they kept free?

4.10 Are partially emptied drums/containers properly sealed and stored? Addition

4.11 Are there any preventative measures against leakage of stored products/raw materials/wastes (working instructions and equipment)?

4.12 Are specific storage conditions for products/raw materials/wastes adhered to and inspected (storage temperature, etc.)? [working instructions]

4.13 Are available storage installations (buildings, containers, etc.) correspondingly marked in accordance with the stored amount and danger potential?

4.14 By storage of your products/raw materials/wastes by a third party, is it guaranteed that the relevant storing regulations corresponding to the danger potential are observed [Documentation of the inspection]?

Clean air preservation

5.1 Are the statutory regulations and officially imposed conditions (trade-and-industry-,Forestry- and clean air preservation laws) adhered to (Documentation)?

5.2 Does a recording of air-polluting installations exist at your place of business and a summary of the emission burden (Emission balance)?

5.3 Are existing clean-air preservation systems used appropriately and is their implementation inspected [operating instructions]?

Addition

5.4 Are existing clean-air preservation systems continuously serviced, maintained and the pertinent measuring systems calibrated (Documentation)?

5.5 Do odorous or dust emissions issue from your plant and have counter-measures already been provably carried out?

5.6 Do odorous or dust emissions issue from your plant, and are provable measures planned to reduce or stop these emissions?

5.7 Are periodical measurements carried out for all kinds of air pollution, even if they are not prescribed [Documentation]?

Production, employee protection

6.1 Are co-workers provably informed regarding the use of active and passive safety equipment?

6.2 If safety helmet obligation exists - does every co-worker have an approved safety helmet at his/her disposal which is in good condition, and is their use inspected?

6.3 Does - if the obligation of respiratory equipment exists - every co-worker have an approved mask as well as the necessary fresh filter, and is their use controlled?

6.4 Are safety glasses and safety gloves available in required quantities and appropriate quality when dealing with dangerous materials, and is their use controlled?

6.5 Is necessary protective clothing available in appropriate qualitative and quantitative amounts, and is their use controlled?

6.6 Are suitable safety shoes available in sufficient quantities, and is their use controlled?

6.7 Is there sufficient room for manipulation available (access to system components, floor space, maintenance space, etc.)?

6.8 Are the safety measures required for rotating, moving and radiating parts of apparatus available?

6.9 Are climbing aids, stairways, catwalks and open shafts secured against falling down?

6.10 Are the hot surfaces of pipes, apparatus, etc. protected against contact to the required extent?

6.11 Is the necessary equipment available, as well as instructions, for descent and entry (container examination, external examinations, etc.) and is their implementation/adherence controlled (Release certificate)?

6.12 Are the prescribed escape routes and escape doors free, marked and fully functional?

6.13 Are the prescribed emergency showers available, freely accessible, marked and fully functional?

6.14 Is the prescribed emergency lighting available, and is its functioning ability provably controlled?

6.15 Are apparatus and devices in production regularly serviced and maintained [Documentation]?

6.16 Is it ensured that with servicing and maintenance work, the necessary safety precautions are taken and adhered to (work instructions)?

6.17 Are pipes and armatures marked in conformity with standards (ÖNORM Z1001)?

6.18 Is it guaranteed that with emergency shutdown or energy failure, the process can be interrupted or ended without danger [operating instructions]?

6.19 Do the appropriate plans for explosion protection areas exist?

6.20 Is it guaranteed that only explosion-proof devices and spark-proof tools and aids are used in explosion-protection areas [conformity certificate]?

6.21 Are the prescribed structural installations for explosion protection areas available (ventilation openings, air locks, self-closing doors, etc.) and is their functioning ability regularly inspected [Documentation]?

6.22 Has/is an evaluation according to ASchG taken place/being prepared [Examination of documentation]?

6.23 Do appropriate extraction installations exist by open systems and are these regularly serviced and maintained [Documentation]?

Addition

6.24. Is, for work with open systems, when due to this an endangering of, or annoyance to the co-workers exists, a conversion to closed systems possible, and is this conversion planned [Examination of planning documents]?

6.25 Can dangerous raw materials be replaced by less dangerous raw materials (e.g.: through process conversion) and are such conversions planned or have they already been carried out? [Documentation] © Working party "Responsible Care"

6.26 Is a calculation carried out for each process with a view to optimising that process (material usage, energy usage, waste, by-products, etc.)? [Documentation]

6.27 Is the necessary attention given to orderliness and cleanliness?

6.28 Are environmentally relevant shocks which emanate from your plant recorded, documented and minimised?

6. 29 Are the causes of industrial accidents documented and analysed, and are measures derived from them? "Euromanag."

Emergency precautions, plant safety

7.1 Is your plant subject to the StörfallVO (serves only for information) - if yes, why? Keyword reasoning:

7.2 Are the statutory regulations of StörfallVO complied with (notification of proneness to danger, safety analysis, plan of measures)? [Examination of documentation]

7.3. Are/have the recurrent inspections according to GewO (§82b) being/been carried out?

7.4. Is there a current, standard fire protection plan that has been co-ordinated with the fire brigade? [Examination]

7.5 Are prescribed notifications to the proper authorities carried out as defined by the StörfallVO (plant installations liable to obligatory monitoring)? [Examination]

7.6 Do regular alarm exercises take place with personnel?

7.7 Is the plant subject to the Disruption Information Regulation and is the obligation to provide information provably complied with? [Documentation]

7.8 Are all co-workers informed and trained regarding precautions and behaviour in cases of danger (disruptive incidents or dangerous operational disturbances)? [Documentation, questioning of personnel]

7.9 Is it ensured that during servicing and maintenance work (welding, etc.), even by external companies, the necessary safety precautions are taken and adhered to?

7.10 Are the causes of disruptive incidents documented and analysed, and are measures derived therefrom? [Documentation] Addition (Plant not subject to StörfallVO; not applicable for danger-prone plants):

7.11 Does a risk assessment for relevant safety areas exist for your plant? [Documentation]

7.12 Does a catalogue of precautionary measures exist for your plant in analogy to the plan of precautionary measures according to StörfallVO, and is this continuously adapted? [Examination]

Addition (for all plants)

7.13 Are there persons responsible for co-ordination with the fire brigade, rescue service, executive organ? [Documentation]

7.14 Are exercises regularly held with the fire brigade, rescue service and executive organ and have these emergency services been informed, with respect to their action, about plant-specific peculiarities (environmental danger)?

7.15 Are the fire extinguishing facilities, especially water installations for fire-fighting (suction pipes, suction points, hoses, collection reservoir for fire-fighting water, etc.) regularly serviced and maintained?

7.16 Do danger-limiting installations exist within your plant to combat the release of substances? [exact description of the installation]

7.17 Are periodical, environmentally relevant, plant-safety inspections carried out and documented by a person authorised by the management (internal audit)? [Examination]

7.18 Is the plant suitably secured against unauthorised intrusion? [Description of corresponding installations]

Substances, preparations, finished products

8.1 May the substances employed be brought into circulation in Austria (Fulfilment of the statutory obligations to report and inform, in accordance with ChemG)? [Proof]

8.2 Are the limitations and prohibitions adhered to in accordance with ChemG?

8.3 Are the dangerous substances and preparations classified in accordance with Chemical Regulations and/or EU guidelines?

8.4 Do the markings of dangerous substances and preparations comply with the rules of the Chemical Regulations/EU guidelines?

8.5 Are the prescribed tactile markings fitted to the corresponding products (only necessary for delivery to non-commercial consumers)?

8.6 Are the appropriate products equipped with the prescribed child-proof locks fitted (only necessary for delivery to non-commercial consumers)?

8.7 Does the packaging for substances and preparations comply with the Chemical Regulation guidelines?

8.8 Is there a toxicant procurement authorisation at hand (concession, toxicant procurement grant, certificate, license)? [Examination]

8.9 Are the recording duties adhered to in accordance with the Toxicant Regulation? [Examination]

8.10 Is it ensured that toxicants can only be handed over to authorised persons? [e.g. working instructions]

8.11 Are toxicants also additionally fitted with markings according to the stipulations of the Toxicant Regulation (only necessary for delivery to non-commercial consumers)?

8.12 Are safety data-sheets, which conform to EU guidelines and ChemG, available for all dangerous substances and preparations? [Documentation]

8.13 Is the product observation liability exercised in accordance with ChemG? [e.g. Literature list]

8.14 Are the instruction and information obligations concerning risks through handling dangerous substances regularly and provably complied with in accordance with ASchG? [Documentation]

8.15 Are the prescribed medical examinations carried out at each of the prescribed time periods to evaluate suitability and exposure? [Examination of documentation]

8.16 Have the prescribed notification and recording obligations for dangerous working substances been fulfilled in accordance with ASchG? [Examination of documentation]

Addition

8.17 Do you avoid environment-polluting substances by the material composition of your products, and do you substitute, when possible, dangerous substances with safe substances? [Documentation]

8.18 Are your products able to integrate easily into the biological (degradability) or technical circulation (recycling)?

8.19 Are safety data-sheets, which conform to EU guidelines and ChemG, for all non-dangerous substances and preparations available in the German language? [Documentation]

Radiation protection

Is the plant governed by the Radiation Protection Law ? Yes No. If yes, all of the following questions are applicable!

9.1 Is there an authorisation at hand for every radiation emitter (Radiation Protection Law, EU guidelines for import)? [Examination]

9.2 Are the prescribed dosimeters regularly inspected and evaluated? [Documentation]

9.3 Is the marking of radioactive substances carried out in accordance with the Radiation Protection Regulation?

9.4 Does the storage of radioactive substances take place according to the Radiation Protection Regulation?

9.5 Does the internal transportation of radioactive substances take place according to the Radiation Protection Regulation? [Working instructions]

9.6 Are the documents concerning the official control of encased radioactive substances available and are the imposed requirements fulfilled? [Examination]

9.7 Are the ranges of influence for encased radioactive substances shielded by way of technical measures and marked correspondingly?

9.8 Have the prescribed medical examinations been carried out [Documentation]?

9.9 Is there a list of radiological safety officers (name, telephone number) evident at the entrance to the plant, and is at least one radiological safety officer available around the clock? [Examination]

9.10 As far is technically possible, are substitutionary measures for the sources of radiation planned or being carried out? “Euromanag.”

Transport

10.1 Have you marked your products/raw materials/wastes according to national or international regulations (drum or packaging markings, delivery notes, accident leaflet)?

Road

Rail

Inland waterways

Maritime shipping

Air

Post

Delivery notes, markings, accident leaflet (in the required languages)

10.2 Is every product/waste which is subject to road traffic regulations, allocated an approved means of packing, and is the use of this controlled? [Documentation]

10.3 Are your carriers inspected for statutory certification (dangerous goods driving license, HGV equipment, gas displacement connection, tanker pressure inspection)? [Work instructions, question personnel]

10.4 Are prohibitions against loading together observed and controlled? [Work instructions, question personnel]

10.5 Are prohibitions against packing together observed and controlled? [Work instructions, question personnel]

10.6 Do you have the transfer of transport documents confirmed? [Documentation]

Addition

10.7 Are design tests available for the approved means of packing? [Examination of attestation]

10.8 Is it ensured that the co-workers concerned are appropriately informed regarding the classification of dangerous goods? [Documentation and questioning of co-workers] © Working party "Responsible Care"

10.9 Are there controls for proper and workmanlike loading/stowage of dangerous goods in the means of transport? [Work instructions]

10.10 Does an obligation to report back immediately after the occurrence of an accident or safety-relevant event exist for your carrier (Documentation)?

Environmental organisation

11.1 Are precautions taken in the company (insurance, reserves) to cover damages from environmental accidents?

Addition (if applicable, those points falling under prescript are to be summed up under regulations)

11.2 Is there, in your company, an organigram for the entire company? "Euromanag."

11.3 Is there, in your company, an organigram for environmental management? [Examination]

11.4 Is there, in your company, an organigram for environmental protection and does this also contain linear responsibility "Euromanag."

11.5 Is there a list of valid rulings/requirements? [Examination]

11.6 Are the guidelines and targets of the environmental policy of the company laid down in writing, approved and signed by the management and are they regularly updated? [Documentation]

Are the following basic principles observed:

- Adherence of all national legal environmental regulations?
- Obligation of continuous improvement?
- Adherence of "good management practices"?

11.7 Are the guidelines and targets of the environmental policy of the company published and known to the co-workers? [Documentation and questioning of personnel] ©Working party "Responsible Care"

11.8 Is the responsibility in the field of external environmental communication clearly defined? "Euromanag."

11.9 Is there a person defined at the highest level of management who is responsible for maintaining the environmental management system? [Documentation]

11.10 Is the conformity of management activities with the guidelines and targets of the environmental policy of the company verified? [Documentation - e.g. management decisions made in the sense of these guidelines and targets]

11.11 Is there an annual environmental protection campaign program (environmental targets) and is its realisation controlled, documented and published? [Examination of documentation]

11.12 Are the environmental targets determined quantitatively? “Euromanag.”

11.13 Are the environmental effects from the utilisation of resources (soil, water, etc.) examined and documented? [Examination of documentation]

11.14 Are the persons responsible for the achievement of environmental targets clearly defined? “Euromanag.”

11.15 Do any internal committees exist concerned with the topic of environmental protection or particular areas of it? “Euromanag.”

11.16 Is there an organisational structure that guarantees that possible effects of planned activities on the environment are investigated, and if necessary, appropriate measures are taken? [Documentation]

11.17 Is it guaranteed that in the organisational structure mentioned in question 14, the persons responsible mentioned in question 33 are bound in accordance with the possible effects? “Euromanag.”

11.18 Has a plan been worked out to achieve the environmental targets?

11.19 Does an environmental statement exist with reference to the recording of all types of emission (air, water, waste - UIG)? [Documentation]

11.20 Has your company already published an environmental report? [Documentation]

11.21 Are all co-workers informed of the environmental targets? “Euromanag.”

11.22 Is there an internal suggestion system and/or employee competitions aimed at improvements in environmental protection? [Documentation]

11.23 Are co-workers regularly informed about the environmental effects in normal operation? “Euromanag.”

11.24 Do action plans exist that are used by non-adherence to the (officially and/or internally) defined environmental-protection requirements, and are these known to employees? [Documentation]

11.25 Are the co-workers provably informed about the possible consequences of non-adherence to the environmental-protection requirements? [Documentation and questioning of employees]

11.26 Is it guaranteed by way of written work instructions, that co-workers or employees from outside companies carry out their work in the sense of the environmental policy of the company, and are these continuously updated? [Examination]

11.27 Are there environment-related purchasing guidelines and is the responsibility for their adherence documented?

11.28 Does information material exist for the public with reference to the environmental behaviour of your products? [Examination]

Note: Questions 29-32 are only applicable if the plant gives off the corresponding emissions.

11.29 Do you know the air immission at the locality of your plant? [Documentation]

11.30 Do you know the water immission at the locality of your plant? [Documentation]

11.31 Do you know the ground immission at the locality of your plant? [Documentation]

11.32 Do you know the noise immission at the locality of your plant? [Documentation]

11.41 Is a control and documentation of all relevant emissions carried out (also for extraordinary events, e.g. serious accidents) and is there an organisational structure in place that guarantees that in the case of unsatisfactory results, remedial action is provided by way of corrective measures? [Documentation and examination of the organisational structure]

11.42 Are the analyses and corrective measures that are carried out in the case of unsatisfactory results (see question 41) documented, and is the effectiveness of the corrective measures controlled? [Examination]

11.43 Are you prepared to make your knowledge concerning the characteristic features of substances and preparations available to institutions such as rescue service, fire brigade, etc. when required (accident, release, danger to third parties, etc.) and is this willingness documented? [Examination]

11.44 Are you also willing, for those cases listed in question 43, to provide personnel to assist, and is this willingness documented? [Examination]

11.45 Do you take part in an information and assistance scheme (e.g. TUIS)? [Documentation]

Water, waste water

12.1 Is there an authorisation at hand for the drawing of water from natural resources (springs, waters), and are the imposed requirements adhered to? [Documentation]

12.2 Is there an authorisation at hand for the feeding-in of service water, and are the imposed requirements adhered to? [Documentation]

12.3 Is there an authorisation at hand for the discharge of waste water into the drainage canal or public waste-water treatment systems, and are the imposed requirements adhered to? [Documentation]

12.4 Are the limit values of corresponding emission regulations controlled, adhered to and documented? [Documentation]

12.5 Is the canalisation system regularly inspected for impermeability and functionality? [Documentation]

12.6 Is the waste water treatment system regularly inspected for impermeability and functionality? [Documentation]

Addition

12.7 Is there an assessment of the water consumption in your company (if necessary, canal separation system)? [Documentation]

a. Fresh water consumption

b. Service water consumption

c. Waste water volume

d. Drainage into the canalisation

e. Drainage into own purification system

f. Drainage into the drainage canal

12.8 Is a water consumption reduction planned or being implemented? [Documentation]

12.9 Are all co-workers informed regarding possible endangering of the waters (e.g. carbon copy instructions)? [Documentation and questioning of co-workers]

12.10 Are all co-workers informed about safety installations for counteracting water contamination, and are these installations continuously maintained? [Documentation, questioning of co-workers]

Sustainable Chemistry and Energy Use in Less Industrialized Nations

Ernst Bayer
Research Center for Nucleic Acid and Peptide Chemistry
University of Tübingen
Germany

Report on a project to use renewable resources on a larger scale in the Southern Hemisphere. Funded by CNPq, Brazil and BMBF, Germany. Brazilian Coordinator: Prof. Dr. R.N. Damasceno, Universidade Federale Fluminense, Niteroi. German Coordinator: Prof. Dr. E. Bayer, Universität Tübingen.

Sustainable development comprises ecology, economy and social aspects, and considers the present and future generations. Certainly sustainable chemistry must be regarded as part of sustainable development, and it seems to be logical that also an optimization in the triangle ecology, economy and social aspects is necessary for sustainable chemistry. Therefore a restriction to pure technical aspects without life cycle thinking will not result in any improvement. It is evident that optimization in the triangle is neither equal for specific regions nor for different technologies.

This is valid also for a global view, especially addressing the further advancement of less industrialized nations.

One mature concern which has not been solved is the increasing demand of energy and feedstocks for the chemical industry during industrialization of less industrialized regions. If one accepts that in the next century the demand of energy and feedstocks for the chemical industry of less industrialized regions will gradually approach the standards of industrialized regions, a depletion of fossil energy resources and an increase of environmental hazards like global climate change, and regional and local environmental damage can be expected. This is especially true if less industrialized nations just follow the example of industrialized nations. Since one cannot expect that developing countries will sacrifice their development to severe environmental or other restrictions, both political and social unrest can result. The migration from country sites to cities, as well as from less developed to advanced regions, is already going on. Already implementation of restrictions for the use of hazardous chemicals like FCKW is different in developed and less developed regions, and global agreements are reached slowly.

It can be concluded that it is mandatory to seek both in energy and chemistry politics a different, innovative approach, and not just the implementation of the traditional concepts of the developed regions. This brings also the chance that innovative new approaches will be the result of such sustainable developments, to the benefit of less industrialized nations.

Since less industrialized nations often have access to large amounts of biomass (primary biomass, and secondary biomass like sludges, agricultural waste), and the climate is often favorable for producing biomass, a much higher percentage of renewable resources can be used for energy and as raw material for industry in comparison to industrialized regions.

It may be reminded that only a small fraction of the amount of biomass produced annually by photosynthesis is utilized for food and as raw material for products and chemicals.

A study was initiated in 1995 to address the use of biomass for producing fuel (coal, oil) and feedstocks for the chemical industry in Brazil. This study is still going on. It is funded by the Brazilian CNPq and the German Federal Ministry of Education and Research (BMBF). The work is done by the Universities of Tübingen/Germany and the Universidade Federale Fluminense Niteroi/Brazil. Since 1998 CENPES, the research center of PETROBRAS, supports the project. The objective of the project is, under environmentally benign conditions, to transform biomass to oil and coal, which can be used for energy and as raw material for chemicals.

Brazil has achieved during its development in the last two decades an impressive way of its own, especially in the use of biomass. As Table 1 shows, the gasoline consumption doubled from 1990 to 1996. 22% of alcohol produced from sugar cane is added to the gasoline (22%). With the increase of gasoline consumption, the amount of added ethanol increased. The ethanol is supported. However, gasoline prices in all countries are not market prices, but rather loaded with taxes, and it seems appropriate if taxes on fossil fuels are used for renewable fuels which are not contributing to CO_2 increase in the atmosphere.

Another area of use of biomass instead of fossil fuel is charcoal from biomass. Whereas in all other steel producing countries coke from coal is used, Brazilian steel factories use charcoal from biomass. In 1994 Brazil produced 25.7 millions tons of crude steel. About 34% of Brazilian pig iron, and 18% of the steel, is based on charcoal. Unfortunately a considerable part of the charcoal is obtained from native forests[1)], which is not desirable.

Table 1
Increase gasoline used and alcohol added to gasoline, 1990-1996
(source: CENPES-PETROBRAS)

Year	**Gasoline (million m³)**	**Alcohol in gasoline (million m³)**
1990	8.978	1.95
1991	9.285	2.04
1992	9.574	2.10
1993	10.561	2.32
1994	11.664	2.57
1995	14.042	3.09
1996	16.422	3.61

The objective of our project was to investigate if the thermocatalytic process of low temperature conversion[2-4], which mimics the occurrence of fossil fuels, generating oil and coal from biomass under relatively mild conditions (380°C, normal pressure, anaerobic), is a promising technology for biomass.

This process makes available an oil similar to diesel oil and a charcoal of high quality in large quantities, and therefore is an alternative source to fossil fuels. Biomass can be converted on a large scale to products similar to fossil petroleum and coal.

Therefore the products could be fed in the existing channels of petrochemistry, oleochemistry or energy use. The process could be classified as soft chemistry, because hazardous chloro-organic compounds like dibenzodioxines are simultaneously destroyed and the reaction conditions are very mild.

Consecutive steps of the case study are:

- Identification of suitable primary biomass and biomass waste (secondary biomass)
- Availability and geographical distribution of biomass
- Mass balance and use of products
- Local, regional and global ecological aspects
- Economy and marketing
- Social aspects and acceptance
- Relevance for other nations in the southern hemisphere
- Study of implementation.

The case study considers only the aspects and requirements of the southern hemisphere, and is not governed by forced implementation of technologies of the technologically advanced regions. However it considers the general scientific and technical knowledge. Forced implementations of western views and technologies to developing countries are one of the main reasons for the failure of many development programs.

Up to now, the first five topics are nearly completed and partially published[5]. The total case study will be completed by the end of 1999.

So far one can say that the public opinion accepts very much this green and soft approach, since a considerable shift from fossil materials to renewable resources seems to be possible under environmentally acceptable conditions. Feasiblility studies show that several types of biomass can be converted to oil and coal economically.

Difficulties are experienced in discussions with experts, who are regarding fossil fuels and raw materials as main resources. This traditional view may cause difficulties in implementation.

After completion of the case study, we will select two types of biomass for larger scale conversion, to demonstrate feasibility and environmental safety. Already investigations of necessary funds for such a demonstration plant are underway.

On the other hand, an “Institute for Sustainable Development of the South” will be established in Rio next spring. Besides technical and ecological follow-up of development projects, this institute will especially set criteria for sustainable chemistry, considering also the social aspects of the southern hemisphere. As already mentioned, the triangle of sustainability ecology, economy and social impact is of different importance in different regions and must be defined. If this is not achieved, no mutualunderstanding is possible. However not only these aspects are important, but also ethics, which unfortunately is rarely considered in discussions of sustainable develoment.

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Sustainable Chemistry: Greenpeace Policy and Projects

Manfred Krautter
Greenpeace
Germany

Our planet's survival is determined primarily by ecological laws. Our aim is therefore for people to use the natural bases of life in a sustainable way. The first guiding principle in all commercial activity has to be: securing the ability of our environment to survive, with the social priority being not growth but the preservation of nature.

Shortcomings of the materials industry today

Environmental damage through environmental prices being too low

Industry on average spends 0.7% of the value of its production on environmental protection in Germany; in the chemical sector the figure is 1.9%. Labour costs, on the other hand, are as much as 39% (DIW economics institute, 1993). There is a drastic discrepancy between damage to the environment and expenditure on its protection - in the case of Germany the ratio is about 15:1 (UPI, Heidelberg).

The present structure of costs is designed in such a way that vital natural resources are wasted, the environment is polluted and labour, an environmentally friendly production force, is rationalised away. **Raw materials and products must have their true environmental price in future.**

Explosion of material flows through resources being too cheap

Natural resources are overexploited, particularly by industrialised countries, and nature's ability to absorb our economy's "waste" is overtaxed. The production of chemicals, which has increased explosively since the 1950s, their increased diversity and release into the environment have led to the latter becoming "chemicalised". World production of chemicals rose from about one million tonnes in 1940 to about 400 million tonnes in 1990.

The use of fossil fuels has trebled in this century; industrial production has increased over fifty-fold.

The North produces the greatest wastage. Twenty-two percent of the world's population live in the North. But it consumes 70% of the energy, 75% of extracted metals, 85% of the timber and wood used, and 60% of the food harvested.

A major pre-requisite of sustainable develoment is that the quantities of flows of materials are restricted. Making resources more expensive is an important means to this end. There must be an **resources and energy tax** for there to be a changeover to sustainable development.

Continued economic growth cannot be sustainable

In its statement of April 1991 the International Chamber of Commerce took the view: “We regard sustainable development as an essential international goal which requires real economic growth, as only such growth can create the capacity to solve environmental problems...”

But there is a clear distinction to be made between “growth” and “development”. Growth is always a quantitative increase; development is a qualitative improvement in which potentials are developed. Since human economic management is a sub-system in a finite global eco-system which, although it changes, does not grow, continued economic growth cannot be sustainable. In the long term economic growth and sustainable development cannot be reconciled.

Release of chemicals fraught with risks

The number of known chemical substances worldwide is today about 16 million, and is increasing daily by about 1,600. In the EU over 70,000 synthetic substances are marketed in commercial quantities. But only a few hundred of them have even begun to be analysed toxicologically. The chemical industry’s knowledge of the effects of most of the substances released by it is either entirely inadequate or nil.

The same uncertainty applies to chemicals which appear in the environment. Only 10% of the AOX in the waters of the Rhine can be identified as specific substances.

The release of hazardous or inadequately analysed substances is irreconcilable with sustainable development.

Resistance by the chemical industry

Despite its avowed belief in sustainable development, the chemical industry in practice often greatly resists innovation in this direction. In many countries the industry pursues a roll-back of environmental standards (impeding bans on hazardous substances, e.g. with PCP and chlorinated paraffins; getting rid of the precautionary limit for pesticides in the EU drinking water ordinance; campaigning against ecotaxes). As examples in Greenpeace’s campaigns for sustainable products show, the chemical industry often opposes innovations.

Clean Production

Principles of a sustainable material policy

In its principles for “Clean Production” Greenpeace makes specific demands the chemical industry needs to meet in order to be sustainable.

1. Reduction in consumption of energy and resources

    - Efficiency: there must be a marked improvement in efficiency in the use of energy and resources by the chemical industry’s production and use of products.

- Sufficiency: per capita consumption of materials must be drastically reduced - mainly in industrialised countries.

2. Renewable sources of energy and raw materials

   - Sustainable and renewable sources of raw materials should be preferred in the materials economy.
   - The rate of exploitation of renewable raw materials may not exceed its ecologically acceptable rate of renewal.
   - Non-renewable resources may only be used to the extent to which they can be replaced by renewable resources.

3. Creation of material cycles

   - A materials economy needs to be cyclical because of the scarcity of resources and the limited capacity of natural sinks to absorb substances.
   - All raw materials, especially those that are non-renewable, have to be led into a cycle. In future a raw material/product/raw material cycle with a minimum of loss must replace our present system of raw material/product/waste.
   - The materials cycle must be as free from pollutants as possible.
   - Unnecessary additional consumption of resources is countered by long-life products which can be easily repaired and maintained.

4. Minimising risks

   Hazardous technologies and products whose impacts are irreparable or irreversible, or which can lead to disasters, must be replaced. Chemical processes and plants must be inherently safe.

5. Integrated environmental protection instead of end-of-pipe measures

   Sustainable production methods avoid producing emissions, unwanted by-products and wastes at source.

6. No release of hazardous substances

   Hazardous substances (substances which are, for example, persistent, bioaccumulative or toxic) may not be released into the environment from either point or diffuse sources.

   - Substances which have not been classified or adequately analysed toxicologically or eco-toxicologically will be treated as “hazardous substances”.
   - Only chemicals which are not hazardous are authorised for use in products which are open to the environment. Hazardous substances must be substituted.

7. Precautionary principle for nature

   Concentrations of synthetic substances in the environment should be “zero” and concentrations of hazardous substances normally existing in nature should be at the level of their natural background concentrations. This also applies to mass material flows such as nutrients and acidifiers.

Immediate company policy measures for implementing Clean Production[1]

1. The company sets the same environmental standards for production and products worldwide, and enables their application to be verified by independent agencies.

2. The company only produces in inherently safe facilities where an “event” will not cause a disaster. Only facilities insured by a commercial insurer for unlimited liability for damages will be operated.

3. The company shall reduce the number of chemical products; only specific chemicals or defined mixtures of substances are put on the market.

4. There will be a drastic cutback in the introduction of chemicals into the environment, be they from production or products.

5. The company makes detailed declarations of what substances are contained in the products made by it.

6. Substances which have not been thoroughly analysed for their toxicity to humans and the environment shall not be put into circulation. Hazardous substances (substances which are for example persistent, bioaccumulative or toxic) shall not be employed in uses which are open to the environment, nor released into the environment; they will be replaced as soon as possible by environmentally acceptable substances.

7. The company confines itself to producing chemicals for which there are analytic procedures. It emits only chemicals which are not hazardous and can be analysed, and whose composition is defined.

8. The company shall make life cycle analyses of all the products made by it. The aim is to swiftly replace particularly environmentally harmful products.

9. Eco-audits shall be made for production and waste disposal facilities. Their key criteria will be balances for energy, raw materials, pollution and waste.

10. The company shall orient its research and development on the criteria for Clean Production, and will set a timetable for developing products which are alternatives to environmentally harmful substances.

11. Consumption of non-renewable raw materials and sources of energy will be drastically reduced, as will the accrual of environmentally harmful waste.

12. The decomposition paths of all the company’s products are known to it. No intermediate products potentially harmful to the environment may arise in their decomposition.

[1] Criteria under use of Hamburger Umweltinstitut, 1993: "Kriterien für eine umweltgerechte Produktion"

13. Closed cooling and production water cycles are installed. The quality of the resources used - air, water and soil - after production will in principle not be worse than before it.

14. The use of technologies which, on account of their impact in terms of energy, raw materials and waste, are nonetheless used through lack of alternatives, will be for a limited period. The goal is to use processes with integrated environmental protection.

15. Groundwater is not polluted through the company’s production or by the products made by it.

16. The company acknowledges its duty to provide information on all relevant environmental data, as it does its duty to declare any hazards which may emanate from its plants or products.

17. Critics of technical methods or construction plans shall receive know-how and information on the company similar to that provided to users or experts working at the company’s behest.

18. In testing chemicals, the company will in principle strive to avoid experiments on animals; a plan with set dates will be arranged for the cessation of experiments on animals.

19. The company does not manufacture chemical or biological weapons.

20. The company assumes responsibility for the results of damage and historical waste from past production.

21. The company shall remain in possession of its inalienable products until they can be disposed of or recycled in an environmentally acceptable way. The company shall effect the maximum possible rates for the recycling or re-utilisation of its products.

22. The company has full liability for the products made by it. The “polluter pays” principle applies without restriction.

23. The company actively supports international environmental protection organisations and international bodies in creating higher and internationally harmonised environmental standards and establishing expert, independent controls.

24. Long-term environmental goals shall be regarded as having a priority equal to the company’s other goals.

25. The company actively supports ecological tax reform to make energy and resources more expensive and labour cheaper.

26. The precautionary principle is the basis of the companies environmental policy.

Greenpeace innovation with sustainable chemistry

It is our aim at Greenpeace to develop "sustainable chemistry" products ourselves and to place them on international markets. In the past we have, for example, been instrumental in introducing chlorine-free bleached paper and the *Greenfreeze* refrigerator which works without CFCs or HFCs. Plans for further products are currently being prepared.

Our experience shows that developing and producing such products frequently fails to obtain the support of the industry affected and even has to be carried out in the face of opposition from companies and industrial organisations. Innovations for sustainable products need the support, not the resistance, of industry and the market.

A short history of our campaigns for chlorine-free bleached paper and the CFC/HFC-free refrigerator shows how Greenpeace implements solutions applying sustainable chemistry.

Chlorine-free bleached paper

- The Problem:

  Greenpeace showed the effect of chlorine bleaching on our rivers and seas.

- The Cause:

  Greenpeace showed who was responsible for the pollution.

- The Confrontation:

  Greenpeace demanded chlorine bleaching be phased out.

  Industry alleged that "only chlorine bleached paper is strong enough for printing on with modern printing machines."

- The Solution:

  Greenpeace proved a clean alternative was technically feasible:

  It printed chlorine-free bleached paper.

  It printed a "plagiarism", of the highest quality, of a leading magazine.

- The Result:

  In Germany, 100% of paper production is free of chlorine bleaching.

In the world, there has been an 80-90% reduction in chlorine in paper production.

Greenfreeze CFC/HFC-free refrigerator

- The Problem:

Ozone depletion and global warming caused by CFCs and HFCs.

- The Cause:

Multinational chemical companies (DuPont, Hoechst, ICI, etc.) produced CFCs; several industrial sectors used them. One main application was for refrigerators.

- The Confrontation:

Greenpeace demanded CFCs and HFCs be phased out.

Industry alleged that “cooling is impossible without CFCs. In opposing CFCs Greenpeace is willing to tolerate children dying in developing countries.”

- The Solution:

  Greenpeace and the Foron company started development of a refrigerator without CFCs or HFCs.

  Greenpeace collected 70,000 advance orders for the fridge.

  Greenpeace presented *Greenfreeze*, the first refrigerator to work without CFCs or HFCs.

- New Allegations by Industry, and Greenpeace with the Facts:

  Higher energy consumption *Greenfreeze* is 10% superior to refrigerator with HFCs, which are hazardous for the consumer-explosive.

  Only very small quantities of hydrocarbons; no objections by responsible authorities, no incidents only for industrialised countries; *Greenfreeze* introduced in China more expensive, same price.

  Greenpeace received international recognition for helping to reduce ozone depletion through technical innovation, for example through the United Nations Global Ozone Award in 1997.

- The Result (1998):

  In Germany, all domestic fridges are produced with the *Greenfreeze* technology.

  In the world, 15 million *Greenfreeze* fridges have been produced so far, with a 12% market share.

  Greenfreeze is available all over Europe, Argentina, Chile, Brazil, Egypt, Tunisia, China and Australia.

Greenpeace continues to make inroads in hostile markets such as those in the US and Japan.

Chronology of Greenpeace's campaign for non-chlorine bleached paper

1985
Greenpeace draws attention to the dangers of bleaching pulp using chlorine in an action against the paper manufacturer, PWA, at Mannheim-on-Rhine. Chlorine reacts with constituents of pulp, an intermediate product in making paper, to form toxic, persistent organic chlorine compounds, and these can accumulate in the food chain. They enter rivers and seas with the pulp works' bleaching effluent. Oxygen, which is not hazardous, should be used as a bleaching agent. While not aggressive like chlorine, it is, however, less effective. The pulp and the paper made from it cannot be quite so white.

1987
Greenpeace publishes a confidential report by the US Environmental Protection Agency, the EPA, which establishes that in chlorine bleaching the most hazardous group of organochlorines, dioxins, are also produced and get into the environment. The industry makes more intensive efforts to find alternatives.

1989
Greenpeace publishes results of analyses which show that traces of organochlorines are also to be found in products such as cotton wool, nappies, tampons and coffee filter papers, which are hygienically particularly sensitive. The press and consumer organisations are shocked. The industry reacts by putting non-bleached products on the market.

Greenpeace Germany prints its own magazine on the world's first printed paper made from non-chlorine bleached pulp. This is made by the Swedish paper producer, Holmen. Greenpeace announces it will "turn the paper market upside down". The German paper industry fears losses in quality and declares that non-chlorine bleach is only possible with low-bleachability sulphite pulp, which plays no role on the international market on account of its low strength. The kraft pulp in the main produced could not, however, be bleached without chlorine.

At the same time, the biggest kraft pulp producers in Scandinavia and North America present their solutions to the problem of chlorine and dioxin. The pure element chlorine ought to be eliminated from use as a bleaching agent, and in its place the compound chlorine dioxide should be used. Being lower in chlorine, this bleach is euphemistically called "chlorine-free", even though small amounts of chlorine are still present in the process and organochlorines are still produced and enter the environment.

1990
German pulp producers begin to bleach without chlorine. This now has to be called "totally chlorine-free" so as to distinguish it from "chlorine-free".

In February Greenpeace conducts simultaneous direct actions at the head office of the biggest German paper producer and pulp importer, Feldmühle, in Dusseldorf, and before that of the Swedish pulp and paper company, Stora (which Feldmühle shortly afterwards buys out), in Falun. Confronted with the slogan "Don't bleach the North Sea to death", the two companies are called on to introduce chlorine-free bleaching at their jointly-operated kraft pulp works in Norrsundet in the Gulf of Bothnia in Sweden. The sediment of the Gulf of Bothnia is already polluted throughout with persistent organochlorines from the numerous Swedish and Finnish chlorine bleaching plants on its shores. Deformities and sicknesses in fish have been found increasingly in Norrsundet bay.

At Feldmühle, in discussions the Board angrily rules out the possibility of bleaching kraft pulp without chlorine. Although Greenpeace shows that kraft pulp has already been successfully bleached without chlorine in the laboratory, and was only not quite so brilliantly white, Feldmühle and Stora stick to chlorine dioxide and organochlorines continue to enter the highly polluted Baltic.

However, two Swedish kraft-pulp producers have for a long time been pondering on the successful laboratory results and break ranks with the chlorine-dioxide bleachers. Still in spring, Aspa, a small producer, makes the world's first non-chorine bleached kraft pulp. The amount is only a few thousand tonnes, insignificant alongside an annual world production of eighty million tonnes of bleached pulp. But in the same year Södra, one of the biggest suppliers of bleached pulp on the international market, follows suit. The chloride-dioxide bloc has been broken.

Greenpeace conducts informal talks with the big German news and magazine publishers to inform them about the possibility of using chlorine-free pulp; from it, thin gravure printing paper containing kraft pulp can now be made for mass print publications. The publishers are unresponsive and Greenpeace therefore decides to have a printing paper like this produced itself, and on this paper it prints a plagiarism of the news magazine, *Der Spiegel*. After making a few attempts, the paper manufacturer Haindl declares itself ready in the autumn to produce a coated magazine paper from a special charge of chlorine-free kraft pulp supplied by Aspa, the Swedish company. The paper would be made at Haindl's factory in Duisburg. The real *Spiegel* also procures part of its printing paper from there.

1991
The first of March sees the publication of *Das Plagiat*, the plagiarism of the *Spiegel*, in a direct action before the magazine's offices. The plagiarism is a complete success. The world's first printing paper made of non-chlorine bleached kraft pulp is not noticeably less white than the original. The paper can be printed on equally well as with the original, and it is just as strong. In the next few weeks and months it will become known to the pulp and paper industry, graphic artists, publishers, printers and advertising agencies, in and outside Germany.

The confrontation with the pulp and paper industry reaches a new level. Pulp producers realise more clearly than ever before that not only do the requirements of their immediate customers, the paper manufacturers, matter; the requirements of their customers - the publishing houses - matter too. The *Plagiat* was also a means of making an industrial solution known, one which all the world's pulp bleachers could now be confronted with.

The producers react defensively. Possible shortcomings in quality are emphasised; the new technology has yet to fully develop. At the same time the trend towards it cannot be ignored, and suppliers of chlorine-free pulp and paper made from it subsequently shoot up all over the place. Södra begins a pointed, aggressive advertising campaign for chlorine-free pulp with a “Z” logo meaning zero chlorine. In doing so the company runs into fierce clashes with almost all the rest of the big pulp industry at industrial conferences and in the *Pulp and Paper International* business magazine.

1992
Paper made from chlorine-free pulp acquires enormous market shares in all spheres of use. At the end of the year the *Spiegel* and *Stern* news magazines announce they will as of now be printed only on non-chlorine bleached pulp. They are joined by the Austrian publication, *Profil*.

In Sweden, ozone is introduced as a bleaching agent. As a result the difference in whiteness between chlorine bleached and non-chlorine bleached pulp further diminishes.

1993
Apart from one works in Thüringen which sometimes uses chlorine dioxide, German pulp manufacturers, all of whom use the sulphite process, only bleach without chlorine. Having begun at a few thousand tonnes three years beforehand, the supply of chlorine-free kraft pulp worldwide is several million tonnes.

1994
In Sweden Södra presents the world's first kraft pulp works producing only chlorine-free pulp. In its “Z” advertising campaign the company announces its aim of being the first in the world to completely convert all its works, a total production of a million tonnes, over to chlorine-free bleach within the next three years.

In Germany paper made from chlorine-free pulp has attained an estimated market share of over 50 per cent.

1995/96
The market for chlorine-free pulp begins to stagnate. There are increasing indications that chlorine bleached pulp and paper made from it are being marketed as chlorine-free in Germany. In a mark of the success of Greenpeace's activities, chlorine-free paper is now well thought of in Germany; but there is nonetheless a desire to save the somewhat higher costs of chemicals involved in bleaching pulp without chlorine.

This shows that developments can slide back if Greenpeace does not continue to reprimand those concerned over a long period of time. The organisation must reinforce its activities in support of chlorine-free bleaching if it is to secure this success for the environment on a permanent basis.

Sustainable Process Innovations Derived from Basic Concepts

Achim Zickler
German Federal Ministry of Education, Science, Research and Technology (BMBF)

Introduction

The lecture presents some features of the German approach to sustainable chemistry and engineering. Particular attention is drawn to the imminent role research and development has to play. Sustainable chemistry is and will be of ever increasing importance, as an integral part of policies and measures to be taken as a part of worldwide efforts to reach true "sustainable development” in a future "global village”.

Activities of the German Federal Government

There is a frame for environmental research activities which are initiated and funded by the Federal Government. This governmentally led programme comprises all research and development on the federal level supervised by the different ministries (Environmental Protection, Science & Technology, Agriculture, Transportation, and Economy). The main objectives are:

- Orientation towards sustainability
- To ease the burden on the environment
- To reduce costs of environmental protection
- To improve competitiveness and to extend share of the world market in environmental goods
- To preserve jobs in industry

The research areas of this programme (600 million-US$) can be specified as

- Regional and global environmental engineering, as rural areas, urban agglomerations, and global change
- Approaches to sustainable economy, as clean production, ecological products by design, and environmental management
- Environmental education

The research area "Approaches to Sustainable Economy” aims to

- Activate the innovation potential of the economy
- Lower burdens on the environment
- Decouple economic growth from resource consumption

- Develop possibilities for cost reduction
- Strengthen the competitiveness of the German environmental industry

For more details of this programme, refer to websites www.bmbf.de or www.gsf.de/PTUKF/UFPE.pdf.

There are three main lessons or approaches to be followed concerning the challenges in environmental policies:

- Environmental protection must become an integral part of a networked process on innovation in industry, commerce, and society.
- Environmental protection must be tackled on a global level.
- The costs of environmental protection must be reduced by means of intelligent solutions.

Innovation for environmental technologies is driven by technology push, regulatory push, and market pull. Put in concrete terms,

- reduction of energy and resource consumption
- image improvement
- environmental awareness

are important incentives in this context.

What is needed is the broad and mutual consensus to be reached by open and fair discussions with all relevant partners in the field. It was exactly this integrated view and approach which led the German Federal Ministry of Education, Science, Research, and Technology (BMBF) to a platform established last year in parallel to the research programme for environment, called the "Chemie-Dialog", for strengthening the competitiveness of education and research in Germany.

Given the imminent importance of chemistry and the chemical sector for the German economy, it is not surprising that the government initiated this dialogue. The key figures are shown in Table 1.

All organisations and unions relevant to the topics "education and research” were integrated in the mentioned dialogue. The spectrum of the discussions covered all relevant fields including cooperation between academia and industry as well as focal points in research funding.

BMBF Programme “Chemical Research and Technologies”

Specific features of the BMBF funding activities within ”Chemical Research and Technologies” are:

- Precompetitive R&D projects towards industrially relevant key technologies
- Contribution to sustainable development: higher raw material efficiency, less waste and emissions, lower energy consumption, safer processes and process units
- Advancement of collaboration between industry and academia
- Strengthening industrial competitiveness

Importance of Chemistry for German Economy

Industry (1997):

- Employees: 505,000
- Turnover: 189,000 millionDM
- R&D Expenditure: 12,000 millionDM

Education (1997):

- Universities: 55
- Students: 23,455
- PhD's: 2,275

Public Funding (1997):

- MPG - basic research
- DFG
- BMBF - mission-oriented research

about 200 million DM

Table 1:

Scientific and chemico-technical aspects of this activity cover fields which will probably influence chemistry and chemical technology in the coming decade:

- Catalysis
- Supramolecular Systems
- Non-linear Dynamics in Chemical Processes
- Combinatorial Chemistry
- Microreaction Technology

Most topics - except catalysis - are emerging fields where public support will help to identify their real potentials. But also in catalysis, industry and science presently cannot perform a rational design of new and more efficient catalysts. However, catalysis research will play a key role in improving chemistry and chemical processes with respect to sustainability.

One example of a project for research on new catalysts, funded by the BMBF, is production of synthetic rubber. The process is based on a gas-phase reaction, so that no solvent for transportation of the materials in the reactor is needed. This facilitates the design of the reactor and shortens the number of process units. Use of a catalyst leads to lower energy consumption and more efficient use of raw materials. In this project, it is expected that today’s 85% efficiency in use of raw materials will be increased up to nearly 99%. Additionally the waste gas produced in this process can by used as fuel in the power plant of the production facility.

In a pilot project on "model-based processing with non-linear regulation and control methods" the BMBF was promoting the development and testing of optimal regulation and control strategies for batch and semi-batch reactors. These kinds of reactors are of growing importance in the chemical industry since they are widely used in the production of fine and bulk chemicals, specialties and other high value products. Conventional regulation strategies are based on existing knowledge of the chemical process. The aim of this project was the development of an optimal regulation strategy which is based on model calculations of the process. The large potential of this "model-predictive control" was shown for a selected technical polymerization reaction with a production volume of several 1000t/a. In comparison to conventional processing, reaction time could be decreased by almost 25%. This leads to a significant reduction of running costs, as well as lower emissions. Furthermore, model-predictive control may lead to higher product qualities and an increase of the safety of the process.

Microreaction technology can be considered as a spin-off from Microsystem Technology. This technology (in Germany also funded by a BMBF programme) has led to microstructured components which can be used to assemble a chemical production plant on a silicon wafer. This approach offers several benefits:

- At mobile plants, hazardous or unstable compounds could be produced where and when they are needed, thus avoiding expensive storage and transport.
- Processes which produce a lot of heat could be carried out in a controlled and safe way.
- In large-scale plants, processing under unsteady state conditions or near the explosion regime is very difficult to control. In contrast, microreactors might open a way to "exotic" process conditions under which products are formed with higher selectivity and quality.

This year, the first projects of a federal funding programme have started which aim to evaluate possible benefits in selected technical production processes. An additional benefit of funded projects is achieved by education of young scientists within current topics of science, as well as aspects concerning sustainable chemistry for direct transfer of know-how from academia to industry.

Furthermore, first lectures on aspects of sustainable chemistry have been started in several German universities.

Conclusion

- At present a great variety of approaches on different levels to sustainable chemistry are funded by the BMBF.
- Cooperation between politics, industry, academia and the society plays a crucial role for achieving the common goal. In Germany the BMBF has to this end organized a platform to improve the framework conditions necessary for sustainable innovations.
- Intensified cooperation seems to be necessary. Scientific and technological developments are a good vehicle for this. Integrated environmental approaches, like the example of the gas-phase polymerisation, instead of end-of-pipe technologies are probably a demanding and promising field where international cooperation can contribute to pertinent questions of mankind.

REPORT OF THE WORKSHOP

OECD Workshop on Sustainable Chemistry

Hosted by the Interuniversity Consortium Chemistry for the Environment (Venice)

Co-sponsored by the Governments of Germany, Italy, Japan and the United States in co-operation with the International Union of Pure and Applied Chemistry (IUPAC) and the Business and Industry Advisory Committee to the OECD (BIAC)

15th to 17th October 1998

held at the Fondazione Cini
Venice, Italy

FINAL REPORT

The following kindly contributed to the funding of this workshop:
Interuniversity Consortium Chemistry for the Environment;
the Government of Germany; the Government of Japan; the
Government of the US; IUPAC; and the following BIAC organisations:
Euro Chlor, Japan ChemicalInnovation Institute, Verband der Chemischen Industrie e.V.
(VCI, Germany)

REPORT OF THE WORKSHOP ON SUSTAINABLE CHEMISTRY

INTRODUCTION

At the February meeting of the Joint Meeting, Member countries endorsed the start of work on a new initiative called "Sustainable Chemistry" which would encourage fundamental breakthroughs in chemistry that prevent pollution and in most cases improve performance and reduce costs. As a first step, Member countries agreed that a workshop should be held on the policy and programmatic aspects of Sustainable Chemistry initiatives.

The workshop was hosted by the Inter-university Consortium Chemistry for the Environment (Italy) and co-sponsored by the Governments of Germany, Italy, Japan, and the United States in co-operation with the International Union of Pure and Applied Chemistry (IUPAC) and the Business and Industry Advisory Committee to the OECD (BIAC). The following kindly contributed to the funding of this workshop: Inter-university Consortium Chemistry for the Environment; the Governments of Germany and the US; the Japan Chemical Innovation Institute; IUPAC; Euro Chlor; and Verband der Chemischen Industrie e.V. (VCI, Germany).

Joe Carra (US Environmental Protection Agency) and Pietro Tundo (Ca' Foscari University) co-chaired the workshop. Seventy-five experts attended, representing 16 Member countries, the European Commission, industry and non-governmental organisations. (The agenda for the workshop can be found in annex 1.)

The workshop focused on the policy/programmatic aspects of Sustainable Chemistry[1] initiatives with a mandate to:

1. **identify the types of Sustainable Chemistry activities underway, supported in part by the results of an OECD-wide survey that was conducted before the workshop (described below);**

2. **identify effective techniques and approaches in the field of Sustainable Chemistry (including educational approaches), considering problems and highlighting solutions; and**

3. **Identify activities that can further the development and use of Sustainable Chemistry programmes and document achievements.**

---

[1] Within the broad framework of sustainable development, we should strive to maximise resource efficiency through activities such as energy and non-renewable resource conservation, risk minimisation, pollution prevention, minimisation of waste at all stages of a product's life-cycle, and the development of products that are durable and can be re-used and recycled. Sustainable Chemistry strives to accomplish these ends through the design, manufacture and use of efficient and effective, more environmentally benign chemical products and processes.

With respect to 3), the Workshop focused specifically on mechanisms to:

i) *recognise and promote as models Sustainable Chemistry accomplishments by the chemical industry and scientists in universities and research institutions;*

ii) *disseminate technical information and event information related to Sustainable Chemistry (e.g. via the Internet);*

iii) *promote incorporation of Sustainable Chemistry principles into various levels of chemical education;*

iv) *support and promote the research, discovery and development of innovative Sustainable Chemistry technologies; and*

v) *develop guidance on how to implement Sustainable Chemistry programmes for use by OECD Member countries and others*.

Prior to the workshop a survey was conducted to collect basic information on Sustainable Chemistry activities recently completed or on-going in Member countries. This includes activities initiated by governments, academia and industry, and which are managed solely by one of these parties, or managed in a collaborative fashion (e.g. government/industry partnership). The US EPA developed a report which summarised the responses received and identified trends in Sustainable Chemistry activities across Member countries. This report was distributed to participants a few weeks before the workshop, and EPA introduced the report at the workshop.

It was evident from the workshop that there is considerable interest and enthusiasm within academia, industry, governments and NGOs for both the basic concepts and practical developments in the field of Sustainable Chemistry. Italy, Japan, Germany, the US and Austria presented considerable information on developments in the field of Sustainable Chemistry. The keynote speaker, Professor John Warner (University of Massachusetts), spoke of the **imperative and desirability of integrating Sustainable Chemistry thinking into the fields of chemistry and environmental sciences** and throughout the vast array of industrial sectors that they affect. Poster sessions demonstrated that very promising cutting-edge research and commercialisation have begun.

Following the formal opening presentations, the Workshop divided into five breakout sessions in order to address the objectives stated above. The text that follows is a **consolidation** of the results of those breakout session discussions. The original breakout session reports, which describe the context for discussions, the recommendations proposed by breakout session participants, and the rationale for why the recommendations are important, are provided in annexes 2-6.

WORKSHOP OUTCOMES

I. Conclusions/Workshop Statement

Workshop participants agreed that Sustainable Chemistry provides a cost-effective means of:

- reducing chemical threats to health and the environment;
- accelerating the pace of chemical innovation; and thereby
- contributing to economic competitiveness and sustainable development.

Workshop participants also agreed that efforts should be made to promote the establishment of such programmes by governments, industry and academia.

II. Recommendations

In order to achieve this aim, the workshop made a number of recommendations either of a **general** nature that apply to all aspects of Sustainable Chemistry, or of a more **specific** nature that apply to one of the objectives listed above.

A. General Recommendations

The following two overarching recommendations would facilitate the promotion of Sustainable Chemistry in general and also the implementation of the more specific workshop recommendations.

***Recommendation 1*: The existing OECD Steering Group that was formed to organise the workshop should remain intact and take on the new responsibility of overseeing the implementation of these recommendations. As part of these duties, the Steering Group should form work groups or study groups as necessary.**

***Recommendation 2*: OECD should publish the proceedings for this workshop (including the results from the OECD-wide survey), *provided funds are available*.**

B. Specific Recommendations

The following recommendations are organised according to the themes that were the focus of the five breakout sessions:

- Research and Development

- Awards and Recognition for Work on Sustainable Chemistry
- Exchange of Technical Information Related to Sustainable Chemistry
- Guidance on Activities and Tools to Support Sustainable Chemistry Programmes
- Sustainable Chemistry Education

(For additional discussion on how the recommendations were developed and the rationale for why they are necessary, please see the individual breakout session reports in annexes 2-6.)

1. Research and Development

***Recommendation 3**: While it is recognised that OECD cannot fund or carry out actual research, OECD should (1) encourage Member countries to undertake Sustainable Chemistry research and (2) facilitate the development of effective research activities in institutions and other organisations. In particular, OECD should:*

a) encourage governments to initiate research programmes. The approach and specific rationale for doing so can be developed by the Steering Group or other experts as it sees fit;

b) organise Member country expert meetings to identify basic (i.e. "pre-competitive") research agendas to facilitate the exchange of information and experiences and to foster co-operation;

c) monitor the implementation of and results from research programmes for the purpose of improving the effectiveness of future programmes; and

d) encourage national and multi-national research funding organisations to increase research funding for Sustainable Chemistry and foster international collaborations for both short and long-term research.

2. Awards and Recognition for Work on Sustainable Chemistry

***Recommendation 4**: OECD should begin an activity which (1) establishes an international programme for rewarding and recognising work in the area of Sustainable Chemistry; and (2) provides guidance to countries interested in establishing national programmes. This activity will promote the incorporation of Sustainable Chemistry concepts into all aspects of chemistry and environmental sciences and the industrial sectors they affect by recognising the value of this approach with respect to environmental and economic sustainability.*

a) OECD should assist in the establishment and implementation of an annual **international** awards programme to recognise excellence in the area of Sustainable Chemistry. The following elements would be important to the successful implementation of this awards programme:

  - The OECD Steering Group should create a work group to manage this programme that includes representatives from international and regional professional societies, relevant inter-governmental organisations, non-governmental organisations (NGOs), and industrial trade associations;
  - the official presenter of the awards should be a multi-national governmental body;

- the exact nature of the non-monetary award should be defined and established; and
- eligible recipients of the awards can include representatives from academia, industry, government, and non-governmental organisations.

b) OECD should develop guidance on methods to design **national** awards and recognition programmes in the area of Sustainable Chemistry.

The workshop recognised that the essential elements of an effective international or national awards and recognition programme would require:

- the award or recognition be given by a group which is highly respected by the public;
- the award be highly visible to both the scientific and industrial communities as well as to the general public; and
- the information collected during the award nomination process (including, for example, information on the economic and environmental benefits of a particular innovative technology that incorporates the principles of Sustainable Chemistry) should be made available to the relevant community.

3. Exchange of Technical Information Related to Sustainable Chemistry

***Recommendation 5*: OECD should establish an information exchange activity on Sustainable Chemistry to promote the development and functioning of an international Sustainable Chemistry community. To do so, OECD should:**

a) identify existing information dissemination and communication channels;

b) co-ordinate among these channels within OECD countries;

c) encourage the development of new channels deemed necessary;

d) formulate a common framework and terminology for such communication; and

e) encourage dissemination beyond OECD countries.

The purpose of this activity is to help promote the development and functioning of an international Sustainable Chemistry community by:

- facilitating the exchange of information through established programmes;
- providing enabling information to developing programmes; and
- communicating programme opportunities and results to both technical and non-technical audiences.

4. Guidance on Activities and Tools to Support Sustainable Chemistry Programmes

***Recommendation 6*: OECD should assist in the development of guidance on Sustainable Chemistry activities and tools to improve awareness and support of Sustainable Chemistry activities in Member and non-member countries.**

a) To improve awareness and adoption of Sustainable Chemistry it is recommended that:

- Stakeholders in Sustainable Chemistry be identified and informed about the initiative. OECD should facilitate contact with international organisations; national governments; industry and trade associations; labour and trade unions; environmental and other NGOs; academia and other relevant parties;
- SME activities in Sustainable Chemistry be stimulated by engaging innovative companies, trade associations, governments and professional associations through mentoring, education and training of SMEs;
- Academia, industry, governments and other institutions develop opportunities and support greater co-operation between the various fields of chemistry (e.g. organic chemistry, catalysis, analytical chemistry, physical chemistry, engineering) and other related disciplines on the design and implementation of Sustainable Chemistry projects.

b) It is recommended that tools be developed to support national Sustainable Chemistry programmes. These tools could include the following:

- developing new (or adapting existing) mechanisms for monitoring progress, exchanging information and benchmarking; and
- exploring, through existing OECD programmes, economic incentives including the internalisation of environmental costs.

c) It is recommended that national governments or others should, as appropriate, establish qualitative or quantitative targets with realistic time scales.

5. Sustainable Chemistry Education

***Recommendation 7*: OECD should promote the incorporation of Sustainable Chemistry concepts into chemical education (within and outside of academia) and provide support material to do so.**

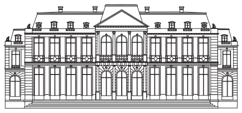
a) It is recommended that approaches and material be developed that can describe and promote the benefits of Sustainable Chemistry education programmes to:

- business communities (through publications in the relevant press, provision of material to relevant conferences/meetings, and targeting of existing programmes (such as Responsible Care), etc.);
- the scientific community; and
- the public.

b) It is recommended that OECD develop guidance on how to implement Sustainable Chemistry education programmes based on materials from existing programmes and new materials developed to meet unique needs. This could involve:

- surveying existing Sustainable Chemistry education programmes (including documenting experiences on what worked and what didn't work);
- identifying educational needs, including identifying barriers and drivers to meeting those needs (i.e. identify gaps);
- developing materials to meet unique educational needs that cannot be met by existing programmes (i.e. fill gaps);
- compiling materials from existing sustainable education programmes and newly developed materials, and developing guidance on how to use these materials;
- convening educators at a workshop to more thoroughly asses the situation; and
- disseminating the package of guidance/material (e.g. using the Internet, conferences/ meetings, continuing education programmes, networks, professional societies, trade associations, media, etc.).

ANNEX 1



OECD WORKSHOP ON SUSTAINABLE CHEMISTRY

FINAL AGENDA

15-17 October 1998

Fondazione Cini
Venice, Italy

Hosted by the Interuniversity Consortium Chemistry for the Environment, Venice

Co-Sponsored by
the Governments of Germany, Italy, Japan, and the US in co-operation with the Interuniversity Consortium Chemistry for the Environment, Euro Chlor, Verband der Chemischen Industrie e.V., and the International Union of Pure and Applied Chemistry (IUPAC)

Thursday, 15 October 1998

7h30 to 8h30 Registration

PLENARY SESSION

8h30 **Introduction by the Co-Chairmen (**Prof. Pietro Tundo, Interuniversity Consortium Chemistry for the Environment, Venice; Joe Carra, US Environmental Protection Agency)

9h15 **Keynote Address** (Prof. John Warner, University of Massachusetts Boston; “Green Chemistry: Theory and Practice”)

10h00 **Sustainable Chemistry Activities in OECD Countries: Survey Results** (Tracy Williamson, US EPA)

10h45 COFFEE BREAK

11h15 Case Studies of Sustainable Chemistry Programmes

Italy

- ***The Interuniversity Consortium "Chemistry for the Environment"*** (Prof. Pietro Tundo, Ca' Foscari University)
- (Dr. Corrado Clini, Ministry of the Environment)
- ***Italian Chemical Industry and Environmental Issues: Commitment and Results*** (Ing. Paolo Giuiuzza, Federchimica)

US

- ***International Diffusion of Sustainable Chemistry*** (Joe Carra, US EPA)
- ***The Green Chemistry Institute: An Overview*** (Joe Breen, The Green Chemistry Institute)

13h15 LUNCH

14h45 Case Studies (cont.)

Japan

- ***Sustainable Chemistry in Japanese Chemical Industry*** (Akira Kanai, JCII)
- ***Cooperation in Sustainable Chemistry between Academia and Industry through CSJ*** (Makoto Misono, Chemical Society of Japan/University of Tokyo; Takeshi Tomura, CSJ)
- ***Japanese Approach to Sustainable Chemistry*** (Hisao Ida, MITI)

Austria

- ***Contribution of the Austrian Chemical Industry to Sustainable Chemistry with Special Emphasis on Activities by FCIO*** (Erwin Tomschik, Austrian Federal Chamber of Commerce)

16h15 COFFEE BREAK

16h45 Case Studies (cont.)

Germany

- ***Sustainable Chemistry and Energy Use in Less Industrialized Nations*** (E. Bayer, Institute of Organic Chemistry, University of Tügbingen)
- ***Sustainable Chemistry: Greenpeace Policy and Products Projects*** (Manfred Krautter, Greenpeace)
- ***Contributions from Ministry for Education, Science and Technology to Sustainable Chemistry*** (A. Zickler, BMBF)

18h00 Close of First Day

16 October 1998

BREAKOUT SESSIONS

9h00 Breakout sessions will be held in parallel to discuss mechanisms to:

1. **recognise sustainable chemistry accomplishments by the chemical industry and scientists in universities and research institutions** *(Co-chairs: Paul Anastas, US EPA*; *Prof. Ferruccio Triffiro, Dipartimento di Chimica Industriale e dei Materiali)*
2. **disseminate technical information and event information related to sustainable chemistry** (e.g. via the Internet) *(Co-chairs: Joe Breen, The Green Chemistry Institute; Dr. Alvise Perosa, Universita Ca' Foscari, University of Venice)*
3. **support and promote the research, discovery and development of innovative sustainable chemistry technologies** *(Co-chairs: Dr. Junshi Miyamoto, IUPAC/Sumitomo Chemical Co.; Dr Masao Kitajima, Japan Chemical Innovation Institute)*
4. **develop guidance on how to implement sustainable chemistry programmes for use by OECD Member countries and others** *(Co-chairs: Dr. Peter Hinchcliffe, UK Department of Environment, Transport and the Regions; Prof. Dr. Herwig Hulpke, Bayer AG)*
5. **promote incorporation of sustainable chemistry principles into the various levels of chemical education** *(Co-chairs: Tracy Williamson, US EPA; Dr. Giuseppe Blasco, Interuniversity Consortium, Chemistry for the Environment)*

PLENARY SESSION

17h00 Oral Presentations by the Chairs of Each Breakout Session (Questions and Answers)

(During the evening, the chairs of the breakout sessions will work together to draft a consolidated report. Copies of the report would be made available the following morning before the beginning of the opening Plenary Session.)

17 October 1998

PLENARY SESSION

9h00 The Co-Chairs of the Workshop will provide an oral report describing the consolidated paper

Questions and Answers and Modification of Consolidated Paper

12h00 Workshop Closure

ANNEX 2

Breakout Session 1

Awards and Recognition for Sustainable Chemistry

(Co-chairs: Paul Anastas and Ferruccio Triffiro)

Goal

The goal of this initiative is to provide effective awards and recognition for the purpose of promoting Sustainable Chemistry.

Background

In order to promote the incorporation of Sustainable Chemistry into all aspects of the chemical enterprise, it would be useful to have a system in place which recognises the value of this approach to environmental and economic sustainability. There are barriers to the incorporation of Sustainable Chemistry which could be addressed through an effective awards and recognition programme. In contrast to these barriers there are also factors which drive the incorporation and implementation of Sustainable Chemistry. These drivers could be enhanced with the effective implementation of an awards and recognition programme.

Barriers

- Lack of knowledge of the approach of Sustainable Chemistry
- Lack of knowledge of the economic and environmental benefits of Sustainable Chemistry
- Public disillusion with chemistry and chemicals

Drivers

- Economic benefits derived from Sustainable Chemistry
- Public support and acceptance of the chemical enterprise
- Environmental improvements derived from Sustainable Chemistry

Essential Elements

- The award or recognition must be given by a group which is considered to be highly respected by the public and whose stature is unequivocally respected by the receiving community.
- The award must be highly visible to both the scientific and industrial communities as well as to the general public.
- The information, case studies, economic and environmental benefits captured through the award nomination process must be made available to the relevant community.

Recommendations

The breakout group recommended that OECD establish a programme for awards and recognition in the area of Sustainable Chemistry to promote the incorporation of Sustainable Chemistry into all aspects of the chemical enterprise by recognising the value of this approach to environmental and economic sustainability.

OECD should assist in the establishment of an annual international award programme to recognise excellence in the area of Sustainable Chemistry. The following steps would be important to the successful implementation of an awards programme:

- The OECD Steering Group should, through a work group (consisting of representatives from international and regional professional societies, relevant multinational governmental bodies, non-governmental organisations (NGOs), and industrial trade associations), design, develop, and implement the awards programme;
- Engage a multinational governmental body as the official presenter of the awards;
- Establish the exact nature of the non-monetary award;
- Include academic, industrial, government, and non-governmental organisations in the eligibility consideration;
- OECD should develop guidance for individual countries on methods to design national awards and recognition programmes in the area of Sustainable Chemistry.

ANNEX 3

Breakout Session 2

Exchange of Technical Information Related to Sustainable Chemistry

(Co-chairs: Joe Breen and Alvise Pero; Rapporteur: Dennis Hjeresen)

Goal

Promote the development and functioning of an international Sustainable Chemistry community by:

- *facilitating the exchange of information between established programmes;*
- *providing enabling information to developing programmes;*
- *communicating programme opportunities and results to both technical and non-technical audiences.*

Barriers

- Language differences between participating countries
- Terminology differences between participating countries
- Lack of co-ordination between existing programmes
- Lack of education in the field of Sustainable Chemistry
- Limited access to communications channels (e.g. Internet) in some countries
- Diversity of levels of economic development across countries
- Limited identification of Sustainable Chemistry, as such, in existing publications and communications

Drivers

- Existing international community of practitioners is vibrant and productive
- Maximise the efficient use of limited resources
- Capitalise on public awareness of environmental concerns
- Promote environmental achievements of the chemical industry
- Exert pressure on non-practitioners to extend the Sustainable Chemistry model

Essential Elements/Necessary Steps

A successful programme needs to identify and understand the target audiences for Sustainable Chemistry information dissemination and select the best mechanisms to reach them. Target audiences include:

i) Researchers

ii) Product manufacturers

iii) Users of chemicals

iv) Governments (local, regional, national)

v) Students

vi) Developing countries

vii) General public

Recommendations

The breakout group recommended that OECD establish an information exchange programme on Sustainable Chemistry. To do so, the OECD should:

- identify existing communication channels;
- co-ordinate among these channels within OECD countries; and
- encourage the development of new communication channels deemed necessary.

The purpose of this programme is to help promote the development and functioning of an international Sustainable Chemistry community by:

- facilitating the exchange of information through established programmes;
- providing enabling information to developing programmes;
- communicating programme opportunities and results to both technical and non-technical audiences.

ANNEX 4

Breakout Session 3

Research and Development

(Co-chairs: Masao Kitajima and Junshi Miyamoto; Rapporteur: Uwe Wolcke)

Goals

Stimulation of interest of governments, industry, academia and the public in Sustainable Chemistry as a basis for national and international research programmes.

Identification of mechanisms to support/promote research. Description of ways to implement research programmes

Barriers

- Lack of understanding in academia, industry, and governments hampers people from realising the scientific and economic potentials of research in Sustainable Chemistry.
- External costs reduce chances of competitiveness of sustainable chemistry approaches versus existing approaches.

Drivers

- Global competition between chemical companies
- Chance to modify the public's opinion concerning "chemistry"
- Reduction of costs for environmental control measures
- Chance to overcome the limits of control measures

Essential Elements

- Identification of societal parties to be addressed
- Identification of specific arguments to convince the various parties
- Declaration of political will
- Definition of particularly important fields in research
- Provision of public funding
- Provision of publicly respected awards
- Organisation of national/international meetings (for the public, interdisciplinary meetings, disciplinary meetings) as fora for information exchange and a chance to learn from examples

- Definition and implementation of incentives
- Organisation of further OECD workshops.

Recommendations

The breakout group recommended that OECD encourage Sustainable Chemistry research in Member countries and assist in the development of research activities in institutions and other organisations. To do so, OECD should:

- suggest/encourage governments' initiation of research programmes based on arguments worked out by Member country experts;
- organise Member country expert meetings to collect pre-competitive research agendas to encourage exchange of experiences and to foster co-operation;
- monitor implementation and results of research programmes for the purpose of improving the effectiveness of future programmes; and
- encourage national and multinational research funding organisations to increase research funding for Sustainable Chemistry and foster international collaborations for short- and long-term research.

ANNEX 5

Breakout Session 4

Mechanisms to Develop Guidance on How to Implement Sustainable Chemistry Programmes for Use by OECD Member Countries and others

(Co-chairs: Peter Hinchcliffe and Herwig Hulp; Rapporteur, John Keating)

Introduction

Group 4 was tasked with developing guidance to enhance the use of Sustainable Chemistry (SC) and recommend activities in support of SC for consideration by the OECD, Member countries and others. Eighteen representatives from government, industry, academia, environmental and other NGOs actively participated in the one-day session.

The Group discussed and developed lists relating to barriers and drivers that would impede or assist in the adoption or promotion of SC in OECD countries. Based on these lists, the Group identified elements and/or steps essential for establishing successful SC programmes. Following this, a series of recommendations were developed for consideration in the final report to the OECD Working Party on Risk Management. These proposals include concepts, strategies and tools. Below are details relating to the barriers, drivers, essential elements and necessary steps as well as recommendations that were developed.

Barriers

Conflict - There were general concerns raised that the concept of SC was understood in many different ways. Papers, poster sessions and presentations during the plenary session on day 1 of the workshop demonstrated that countries, industry sectors and others have undertaken different approaches towards SC, but may have been equally effective. Participants felt that the proposed definition of SC developed by the OECD Steering Group and endorsed by the Working Party on Risk Management was limited in its scope and therefore reduced the potential for greater acceptance and implementation of SC by Member countries, industry sectors and others. A more holistic approach based on a sustainable development framework was suggested along with broader principles that could form a core concept of SC. Some of the principles raised included the “Seven Dimensions of Eco-efficiency.” Distrust was also expressed regarding the duplication of voluntary initiatives by regulation and how this can reduce the support of voluntary activities by industry.

Awareness - The knowledge and understanding of SC by the public, SMEs and user industry was identified as being far too limited.

Non-tariff Trade Barriers - Barriers such as non-harmonised standards, legal regulations and varying levels of enforcement were raised as being possibly counter-productive for SC in certain cases.

Drivers

Customers - An increased awareness of SC by consumers can enhance the requirement for end-users and producers to develop SC products.

Academia - Greater support from prominent scientists and the education system will support SC.

Risk Considerations - Risk assessment and management tools are well developed and their inclusion in SC will enhance the acceptance and adoption of SC by countries and others.

Non-OECD - Wide acceptance and implementation of SC activities in OECD countries will assist in promoting the adoption of SC in non-OECD countries.

Essential Elements and Necessary

The group considered the following elements or steps to be essential in overcoming the barriers and making best use of drivers.

- *Involve all Stakeholders* - OECD and other relevant international organisations; national governments; industry and trade associations; environmental and other relevant NGO's; labour; academia and others.

- *Adopt a Core Concept* - an agreed non-definitional vision of Sustainable Chemistry at the international level that can be refined and adopted to meet national priorities and be developed further in time.

- *Raise Awareness and Exchange Information* - a need to stimulate Sustainable Chemistry activities of SMEs through information programmes and mentoring; education, research and development, and therefore a need to involve academia; exchange of information and ideas arising from the successful (and less successful) implementation of Sustainable Chemistry; monitoring and benchmarking.

- *Set Priorities* - Selection, funding, or other criteria should be established to support decision-making on R&D or other projects for Sustainable Chemistry.

- *Develop Targets* - Where targets are needed, qualitative or quantitative targets need to include a time-scale.

Recommendations

The breakout group recommended the following activities for consideration by the OECD and others to improve awareness of and support for Sustainable Chemistry activities in Member and non-member countries.

- Adopt or modify as appropriate the following draft core concept for Sustainable Chemistry, recognising that this is an evolving concept which countries may wish to adapt based on national priorities. Within the broader framework of sustainable development, Sustainable Chemistry (SC) aims at the development and use of chemicals and their production processes which are effective, efficient and safer for humans and the environment. This includes maximising resource efficiency through activities such as energy and non-renewable resource conservation, pollution prevention, risk minimisation, low levels of waste at all stages, and enhancing durability, reuse and recycling.

- Improve awareness and adoption of Sustainable Chemistry through a number of activities including:

  - Stakeholders in Sustainable Chemistry should be identified and informed about the initiative. OECD should facilitate contact with international organisations; national governments; industry and trade associations; labour and trade unions; environmental and other NGOs; academia and other relevant parties;

  - SME activities in Sustainable Chemistry should be stimulated by engaging innovative companies, trade associations; governments and professional associations through mentoring, education and training of SMEs;

  - academia, industry, governments and other institutions should develop opportunities that support greater co-operation between the various fields of chemistry and other related disciplines (e.g. analytical chemistry, physical chemistry, engineering) on the design and implementation of Sustainable Chemistry projects.

- Develop tools to support Sustainable Chemistry activities. These tools could include the following:

  - The OECD should initiate and support national programmes by developing or adapting existing mechanisms to monitor progress, information exchange and benchmarking; and

  - Economic incentives including the internalisation of environmental costs could be explored through existing OECD programmes.

- Mechanisms to establish priorities for research and development. This was seen to be important, but it was recognised that the activity was being addressed in Breakout Group 3.

- National governments or others should, as appropriate, establish qualitative or quantitative targets with realistic time scales.

ANNEX 6

Breakout Session 5

Sustainable Chemistry Education

(Co-chairs: Tracy Williamson and Giuseppe Blasco; Rapporteur: John Warner)

Goal

Educate all those involved in designing chemical products and processes, including those who currently are involved (i.e. industry) as well as those who will be involved in the future (i.e. academia), about the concept and practice of Sustainable Chemistry.

Barriers

- Do educators have knowledge of Sustainable Chemistry?
- Is there a desire for the educators to include this topic in new and existing educational activities?
- Do educators have the capability?
- Are materials available?
- Are there financial limitations?
- Are there institutional/structural barriers?
- Inertia (resistance to change)
- Communication/influence (lack of communication between institutions involved in Sustainable Chemistry)

Drivers

- Ethics (awareness of consequences of chemical activities)
- Intellectual stimulation/challenge
- Financial incentives (from, for example, industry or government)
- Academic requirements/standards (can be local, regional, country-wide)
- Professional standards (from various certifying boards, for example)
- Recognition of topic by scientific community
- Communication/influence (communication about planned and existing education programmes)

Recommendations

The breakout group recommended that OECD encourage/advocate international education on Sustainable Chemistry. To do this:

- Activities should be undertaken that illustrate Sustainable Chemistry benefits to enhance Sustainable Chemistry education programmes:

    - to business communities through publications in the relevant press, relevant conferences/meetings, by targeting existing programmes (such as *Responsible Care*), etc.;

    - to scientific communities;

    - to the public.

- Activities should be undertaken that provide guidance to countries on how to implement Sustainable Chemistry education programmes based on materials from existing programmes and new materials developed to meet unique needs, including:

    - surveying existing Sustainable Chemistry education programmes (including experiences on what worked and what didn't work);

    - surveying educational needs (including barriers and drivers that either inhibit or enhance these needs being met) (identify gaps);

    - developing materials to meet unique educational needs that cannot be met by existing programmes (fill gaps);

    - compiling materials from existing Sustainable Chemistry education programmes and newly developed materials, and developing guidance on how to use these materials;

    - convening educators at a workshop to more thoroughly asses the situation;

    - assisting in disseminating guidance/materials packages (i.e. using the Internet, conferences/meetings, continuing education programmes, networks, professional societies, trade associations, media, etc.).

POSTERS DISPLAYED AT THE WORKSHOP

RESEARCH ACTIVITIES OF THE BOLOGNA 3 UNIT

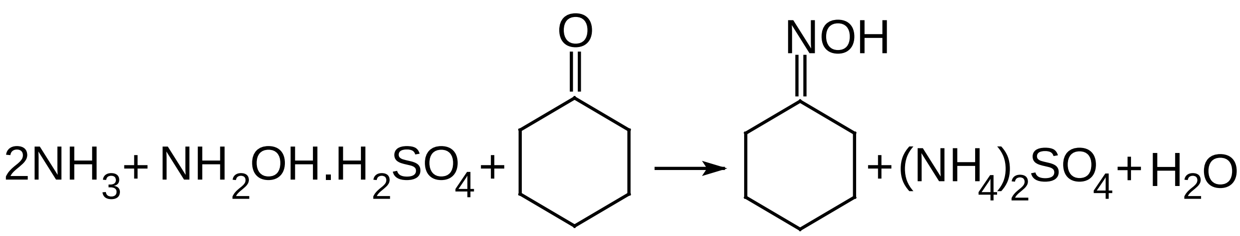
F. Cavani, G. Fornasari, F. Trifirò, A. Vaccari

Dip. Chimica Industriale e dei Materiali,
Viale Risorgimento 4, Bologna (I)

CYCLOHEXANONE OXIME PROCESS

✓ **Cyclohexanone oxime is the reactant for the production of ε-caprolactam, the monomer of nylon 6**

✓ **The conventional process is based on the hydroxylamine route**

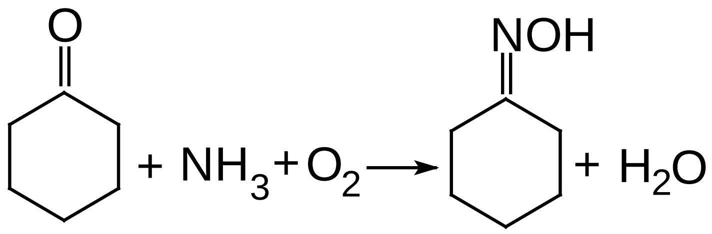


✓**Drawbacks:**

- **formation of ammonium sulfate**
- **safety problems**
- **complexity due to the several steps**

✓ **Alternative process:**
ammoximation route in gas phase

ALTERNATIVE ROUTE AMMOXIMATION IN GAS PHASE



✓ **Features of the reaction:**

- oxygen (air) as oxidant

- amorphous silica as catalyst

✓ **Key features:**

- low cost of oxidant

- no formation of ammonium sulfate

- one step process

✓**Drawbacks:**

- poor selectivity to oxime

- fast deactivation of catalyst

✓ **Efforts are necessary to develop more selective catalysts**

ε-CAPROLACTAM PRODUCTION

- ✓ **ε-Caprolactam is the monomer for the production of nylon 6.**
  The production is 2 million tons / year

- ✓ **The last step of the conventional process is based on the Beckmann trasposition in liquid phase with sulfuric acid as catalyst**

  cyclohexanone oxime ⇒ caprolactam

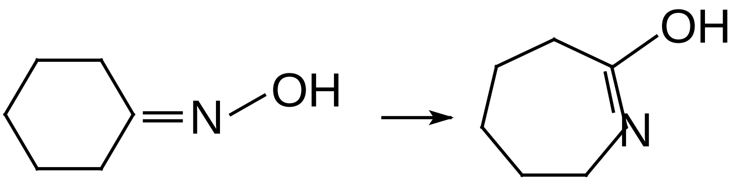
- ✓ **Drawbacks:**

- formation of stoichiometric amounts of ammonium sulfate

- use of corrosion resistant materials

- ✓ **Alternative process:**
  Beckmann transposition in gas phase

ALTERNATIVE ROUTE:
BECKMANN TRANSPOSITION IN GAS PHASE



✓ **Features of the reaction:**

- **reaction temperature about 350°C**
- **solid acids as catalyst**

✓ **Key features:**

- **no formation of ammonium sulfate**
- **no corrosion problem**

✓ **Drawbacks:**

- **fast deactivation of catalyst**

✓ **Efforts are necessary to understand the deactivation mechanism and to develop more stable catalysts**

METHYL METHACRYLATE PRODUCTION

✓ **Methyl methacrylate is the monomer for the production of polymethyl methacrylate. The production is over 2 million tons / year**

✓ **The conventional process is based on the acetone cyanohydrin route**

acetone + hydrocyanic ac. + methanol ⇒

methyl methacrylate

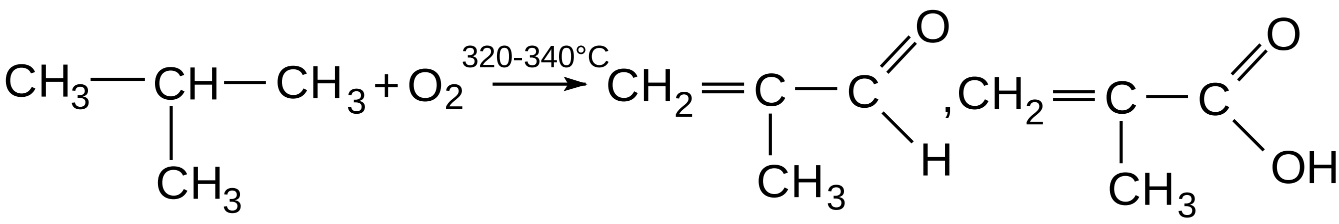
✓ **Drawbacks:**

- use of HCN and formation of acetone cyanohydrin

- formation of ammonium sulfate

✓ **Alternative process: oxidation of isobutane**

POTENTIAL PROCESS ISOBUTANE ROUTE



✓**Features of the reaction:**

- oxygen (air) as oxidant

- heteropolyacids as catalyst

✓ **Key features:**

- low enviromental impact process

- low reactant costs

- low investement costs

- simple process

✓ **Drawbacks:**

- very low conversion

✓ **Efforts are necessary to develop more active catalysts**

FRIEDEL-CRAFTS ACYLATION

- ✓ **Friedel-Crafts acylation of aromatics is a key step in the production of pharmaceuticals, fragrances, dyes, etc.**

- ✓ **The conventional processes are based on the use of homogeneous Lewis acid catalysts, such as $AlCl_3$**

- ✓ **Drawbacks:**

- use of catalyst in higher than stoichiometric amounts

- no possible reuse of catalyst

- toxicity and corrosion

- significant waste and HCl production

- ✓ **Alternative process:**
  acylation with heterogeneous catalyst

ALTERNATIVE ROUTE HETEROGENEOUS CYLATION

acyl chloride + aromatic ⇒ aromatic ketone

✓ **Features of the reaction:**

- **operation in liquid phase**
- **solid acid as catalyst**

✓ **Key features:**

- **environmentally friendly catalysts**
- **relatively low price catalysts**
- **use of catalyst in catalytic amount**
- **simple recover and/or reuse of catalyst**

✓ **Drawbacks:**

- **lower selectivity**
- **water removal**

✓ **Efforts are necessary to develop more selective catalysts**

NO_x SELECTIVE CATALYTIC REDUCTION PROCESS

✓ **The removal of NO_x from the effluents of power plants is a relevant task**

✓ **The conventional process is the selective catalytic reduction (SCR) by ammonia using vanadium and tungsten oxides on titania as catalysts**

✓**Drawbacks:**

- progressive loss of activity

- slips of ammonia

- large costs for waste disposal

✓ **Alternative process:**
adsorption on solid materials

ALTERNATIVE ROUTE ADSORPTION ON SOLIDS

✓ **Features of the adsorption:**

- solid adsorbents

- formation of nitrates or nitrites inside the adsorbents

✓ **Key features:**

- no use of toxic reagents

- no slip of reagents

- regeneration of adsorbent

✓ **Drawbacks:**

- low adsorption capacity

- sensitivity to the effluent composition

✓ **Efforts are necessary to develop materials with more adsorption capacity**

Sustainable Development of Chemicals: The Human Health Point of View. Prediction of Undesirable Properties from Restricted Information by Modelling Tools

Ulrike Bernauer, Wolfgang Diener, Ingrid Gerner, Barbara Heinrich-Hirsch, Gerd Jänig, Eva Schlede, Bärbel Vieth, Ursula Gundert-Remy and Ulrich Schlottmann*

Dept. Assessment of Chemicals, BgVV, Berlin,

***Dept. Chemicals Safety, Ministry of Environment, Bonn, Germany.**

Sustainable chemistry is understood as the development, production and use of chemicals and chemical products with less negative impact on environment by preventing pollution and reducing hazardous waste. Although the term sustainable chemistry has been coined primarily having in mind reduction of environmental risks, it is nevertheless indisputable that the ultimate goal is to reduce the risks for human health by designing and developing safer chemicals.

In the drug area, some modelling methods exist, have been extensively tested and have contributed to the development of efficacious and safe new chemical entities. Present activities are very promising for new modelling methods.

A new proposed action in the framework of COST (Co-operation in the Field of Science and Technology) is focused on the current status and future possibilities of modelling methods.

One of the objectives of this proposed new action is the transfer of technology and methodology between the area of drug development where some experience is already present and the area of designing and developing safe chemicals.

The scientific program shared by both areas encompasses the extrapolation from physico-chemical properties and from in vitro data to in vivo behaviour in animals. Extrapolation from in vivo behaviour in animals to in vivo behaviour in man is an additional field of scientific interest. It is expected that in this field the safety assessment of chemicals may profit from the expanding predictability concerning drug safety.

It is hoped that further development of scientific knowledge of the key physico-chemical properties responsible for the mechanisms eliciting undesired reactions will be useful for guiding the design of chemicals which are “sustainable“ with respect to reduction of both environmental and human health risks.

Examples for the prediction from physico-chemical properties are given below, together with prediction of local metabolism of benzene in man from in vitro experiments.

The “target“ scientists participating in the new action will be representatives of academia, the pharmaceutical and chemical industry as well as governmental entities from Europe.

Having been involved in the preparation of the new COST action, we would like to present the basic ideas of this approach in order to ask for broader co-operation.

The memorandum of understanding has been signed by Germany, the Czech Republic and the Slovak Republic, with Denmark, Finland, Spain and Switzerland being about to sign.

EXAMPLE 1

ELECTRONIC DATA BASE FOR THE PREDICTION OF TOXIC HAZARD OF NEW CHEMICALS

For new chemical substances to be notified within the European Community, physico-chemical and toxicological data sets have to be submitted to the national regulatory authorities. We developed an electronic data base containing data on approximately 1200 chemicals notified according to this notification procedure. This data base is used for the development of decision support systems for the prediction of skin and eye damaging and skin sensitizing properties.

Within this data base the chemical structure of a substance is characterized by

- specific particular substructures within the structural formula
- the empirical formula
- the molecular weight

The thermodynamic substance properties are characterized by

- vapour pressure [Pa] at 20^{o}C
- melting point [^{o}C]
- boiling point [^{o}C]

the toxicokinetic properties by

- lipid solubility [g/kg] at 37^{o}C
- aqueous solubility [g/l] at 20^{o}C
- n-octanol/water partition coefficient log P_{ow} at 20^{o}C

and physical interactions and chemical reactions with water by

- surface tension of a saturated aqueous substance solution [mN/m] at 20^{o}C
- pH value of this saturated aqueous solution at 20^{o}C
- likeliness of hydrolyzation of the substance in contact with water

The local irritant properties of a chemical substance (as detected by Draize tests on skin and eyes of rabbits) are characterized within the data base by

- R (risk) phrases for skin and eye irritancy (classification of hazard)
- detailed evaluation of all described effects on skin (erythema and oedema, strength and duration of these effects, their contribution to overall toxicological irritancy evaluation).
- detailed evaluation of all described effects on the eyes (erythema and oedema of the conjunctivae, irritation of the iris, opalization of the cornea, strength and duration of these effects, their contribution to overall toxicological irritancy evaluation).

LD50 / LC50 values characterize the results of acute toxicity testing (oral, dermal and inhalation exposure), the results of skin sensitization testing are characterized by the respective regulatory classification (R phrase).

PREDICTION OF LOCAL IRRITATION BASED ON SAR / SPR CONSIDERATIONS

(Electronic Decision Support System of BgVV)

At the Chemicals Department of the German Federal Institute for Health Protection of Consumers and Veterinary Medicine (BgVV), a data base with physico-chemical and toxicological data sets on properties responsible for skin and eye lesions caused by a single contact with a chemical substance has been evaluated. By applying statistical software and a special module of the data base, correlations between specific physico-chemical data and skin and/or eye corrosion/irritation were established and implemented as rules in a decision support system (DSS).

By means of these simple rules, for 74 out of a total of 100 substances decisions on severity of skin irritant/corrosive properties could be made, resulting in 67 correct and 7 false predictions. Thus, a rough pre-selection with respect to probability of acute hazardous substance properties can be made based only on physico-chemical data to be submitted for the notification of new chemicals in the EU. This pre-selection can be used to differentiate

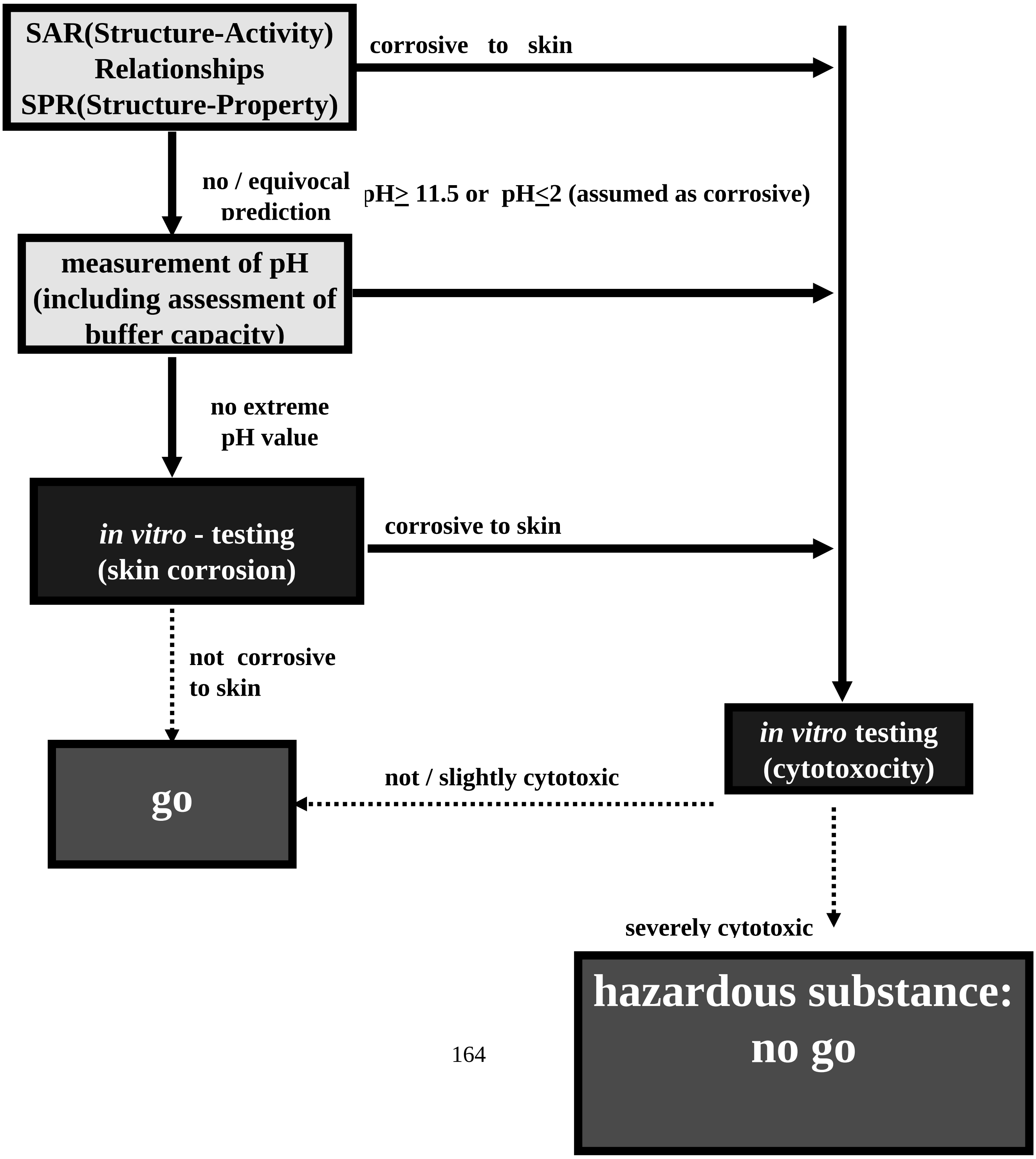
- between substances that need further evaluation of their skin corrosive properties and substances presumed to pose minor hazard with respect to effects caused by skin contact
- between substances that can be classified as corrosive on physico-chemical considerations or using non-animal “alternative tests“ and substances that need animal testing in order to reliably assess a possible skin irritation hazard

In addition, a special module was developed to evaluate the structural formula of the specific chemical in order to compare the new substance with substances already tested for the property in question. At present, this structure evaluation module is used to support the prediction made on the basis of physico-chemical data.

We plan to establish a decision support system for the prediction of skin sensitization using the structure evaluation module.

ASSESSMENT OF SUITABILITY OF A COMPOUND (HEALTH ASPECT)

(Estimation of Chemical Hazard as a Decision Aid)



A Decision Support System for the Introduction of Alternative Methods

EXCEPTION RULES

Example:

IF

molecular weight
> 1200 g/mol

Then

no or only marginal effects
to the skin expected

Explanation:

Out of 1029 substances being tested for skin irritation, only 148 were labelled as showing effects.

MW > 500: 9 substances (6.1%)

MW < 400: 67 substances (45.3%)
90.6%
MW < 200: 67 substances (45.3%)

EXAMPLE 2

SUSTAINABLE DEVELOPMENT OF CHEMICALS: METABOLIC ASPECTS

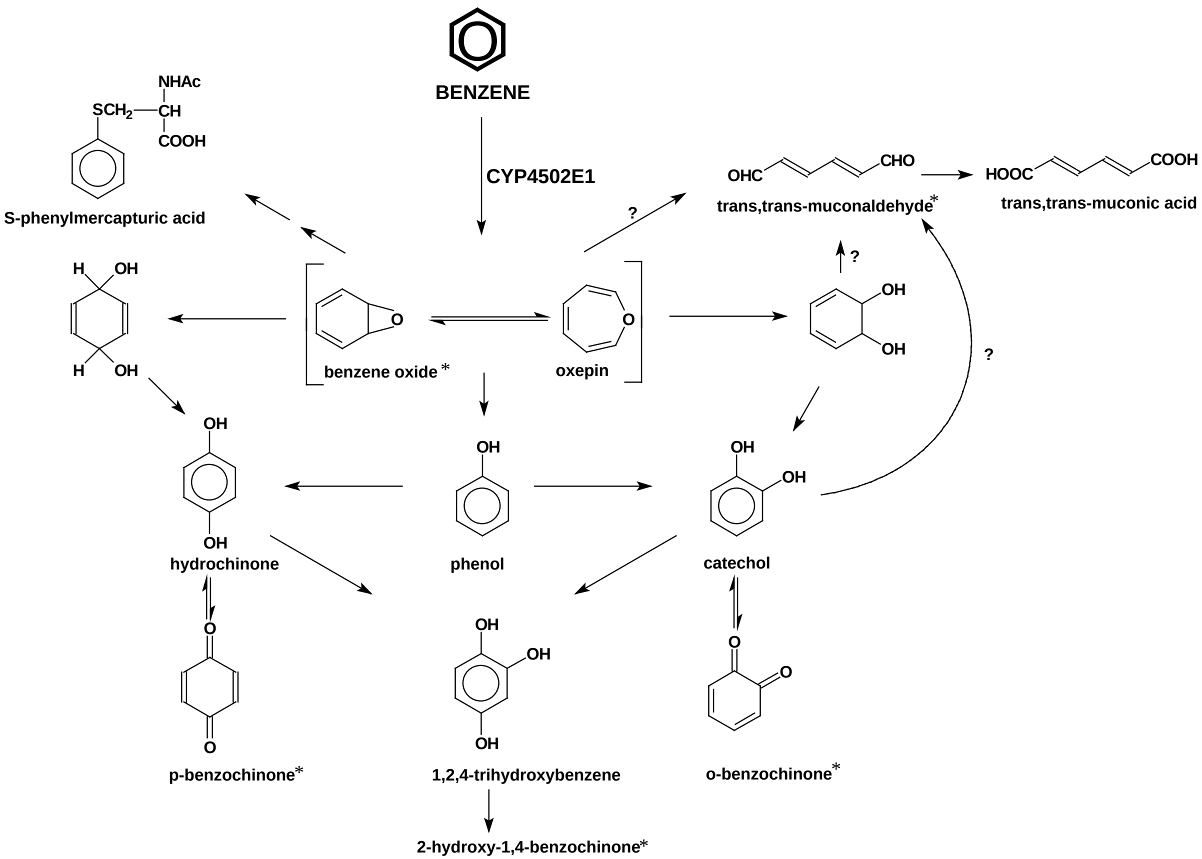
Most chemicals require metabolic activation to produce adverse effects. Thereby, phase-I enzymes, mainly those belonging to the cytochrome P450 (CYP450) family, play a major role. Organ-specific toxicities can be explained by the pattern of expression of CYP enzymes in various tissues and various cell types. For the prediction of possible adverse effects of certain chemicals, several determinants are of great importance. (I) The specific enzymes which are involved in the conversion of a certain compound must be identified. (II) The physico-chemical properties of chemicals determine their toxicokinetic behaviour, distribution and bioavailability, thus influencing the accessibility to certain CYP enzymes. (III) Polymorphisms and inter-individual variations in the expression of CYP enzymes should be taken into consideration; additionally, for any extrapolation between the *in vivo* behaviour of chemicals in animals and the *in vivo* behaviour in man, species-specific variations have to be considered.

Regarding these aspects, we made an attempt to explain the hematotoxic effects of benzene and the differences between benzene and phenol (a major metabolite of benzene) which can be observed in the hematopoietic system after chronic exposure of rodents. Additionally, we tried to draw connections from these findings to the human situation, where acute myelogenous leukemia has been clearly associated with benzene exposure.

Benzene exerts its adverse effects after metabolic conversion by CYP2E1; possible toxic metabolites are formed by the pathways shown in the figure. Although benzene metabolism occurs in the liver, the bone marrow represents the target organ of benzene toxicity. Bone marrow toxicity could be explained by the fact that the lipophilic benzene is able to reach the target tissue where it is metabolised.

To test the possibility of benzene metabolism taking place in the bone marrow, CYP2E1 has been analysed by Western blotting and by activity measurements in the bone marrow of various strains of mice which have been used in long-term studies. For species-specific extrapolation, CYP2E1 has also been investigated in the bone marrow of Wistar rats and in stem cell rich leucopherese samples obtained from human volunteers.

Results of the determinations of CYP2E1 dependent chlorzoxazone hydroxylase activities in bone marrow of various strains of mice, in comparison to the hepatic activities, are given in the table. The results show that the bone marrow may be competent in CYP2E1-dependent metabolic conversion of suitable substrates, as for example benzene. This should be taken into consideration for all chemical entities which have the ability (based on their physico-chemical properties) to reach the bone marrow. Although myeloid CYP2E1 hydroxylase activities are considerably lower compared to the liver, CYP2E1-dependent benzene metabolism in the bone marrow may be crucial due to the formation of toxic and/or reactive metabolites in the target tissue. CYP2E1 protein has also been detected in bone marrow samples of Wistar rats. These results suggest that the bone marrow of various species may be competent in CYP2E1-dependent metabolism, and that the myelotoxic effects of benzene as well as differences between phenol and benzene (concerning the hematopoietic system) may be explained on the basis of these findings. Summarising, the results demonstrate the importance of the identification of enzymes involved in metabolic conversion of foreign compounds at an early stage of development of chemicals; the results also show the importance of the knowledge of strain-specific and inter-individual variations of metabolically competent enzymes, as well as the pattern of distribution of these enzymes in body tissues and tissue cells.


BENZENE
CYP4502E1
NHAc
SCH2—CH
COOH
S-phenylmercapturic acid
OHC
CHO
trans,trans-muconaldehyde*
HOOC
COOH
trans,trans-muconic acid
?
H
OH
benzene oxide *
O
oxepin
OH
hydrochinone
phenol
catechol
p-benzochinone*
1,2,4-trihydroxybenzene
o-benzochinone*
2-hydroxy-1,4-benzochinone*

Comparison between constitutively present CYP2E1 hydroxylase activities in liver microsomes and bone marrow homogenates of different strains of mice, and tumour response in the hematopoietic system after chronic benzene exposure

Strain	CYP2E1 activity [nmol/mg protein/min][1)		Exposure regimen	Tumour response of the hematopoietic system		Reference
	liver microsomes	bone marrow		lymphatic	myelogenous	
AKR	8.2 (7.8 - 8.9)	0.4×10^{-3} ($0.3 - 0.4 \times 10^{-3}$)	inhalative (100 and 300 ppm, 6h/d, 5d/w) lifetime	no increase of tumour rate of lymphomas		Snyder et al., 1980; Goldstein et al., 1982
C57Bl/6	5.2 (4.1 - 7.0)	0.5×10^{-3} ($0.2 - 0.7 \times 10^{-3}$)	inhalative (300 ppm, 6h/d, 5d/w) lifetime	hematopoietic lymphoma		Snyder et al., 1980
CD-1	5.8 (5.5 - 6.3)	0.6×10^{-3} ($0.6 - 0.8 \times 10^{-3}$)	inhalative (300 ppm, 6h/d, 5d/w) lifetime		chronic myelo-genous leuke-mia; acute myeloblastic leukemia[2)	Goldstein et al., 1982
CBA/Ca	6.0 (6.3 - 12.2)	0.8×10^{-3} ($0.5 - 1.2 \times 10^{-3}$)	inhalative (300 ppm, 6h/d, 5d/w) 16 weeks	malignant lymphoma	myelogenous neoplasms	Cronkite et al., 1989; Farris et al., 1993
B6C3F1	10.2 (4.8 - 6.6)	0.2×10^{-3} (each 0.2×10^{-3})	oral, 25, 50, 100 mg/kg/d, 5d/week, 2 years	malignant lymphoma		Huff et al., 1989

1) Arithmetic mean from three independent preparations

2) In this study, the incidence of myeloproliferative disorders was not significantly higher than in untreated controls; due to the absent background incidence of acute and chronic myelogenous leukemia in CD-1 mice, the authors suggest a direct effect between the observed tumour response and benzene exposure.

Catalytic Processes in Water: Synthesis of Building Blocks for Pharmaceuticals by Aqueous Two-Phase Hydroformylation of Functionalized Olefins

C. Botteghi[a], S. Paganelli[a], M. Marchetti[b], M. Zanchet[a]

[a] **Dipartimento di Chimica, Università di Venezia, Calle Larga S. Marta, 2137, I-30123 Venice, Italy**

[b] **I.A.T.C.A.P.A.-CNR, Via Vienna 2, I-07100 Sassari, Italy**

In recent years aqueous two-phases catalysis has come to play an outstanding role among transition metal catalyzed processes and has already achieved industrial scale importance in hydroformylation. In this field our research work has been mainly concentrated on the preparation of aldehydes, bearing various substituents, by *oxo* reaction of 1,1-diarylethenes, aryl vinyl ethers and diaryl vinyl carbinols, catalyzed by rhodium complexes with water soluble phosphine ligands. In some cases, the chemoselectivities are higher than those obtained with the related homogeneous processes using traditional hydrocarbon solvents.

Heterogeneous Catalysts for Sustainable Chemical Processes

S. Coluccia[1], L. Marchese[1,2], G. Martra[1], L. Prati[3] and M. Rossi[3]

[1] **Dipartimento di Chimica IFM, Università degli Studi di Torino, Via P. Giuria 7, I-10125 Torino - Italy; e-mail: martra@ch.unito.it**

[2] **Facoltà di Scienze MFN, Università del Piemonte Orientale "A. Avogadro", c.so Borsalino 54, I-15100, Alessandria - Italy; e-mail: marchese@ch.unito.it**

[3] **Dipartimento di Chimica Inorganica, Metallorganica e Analitica, Università degli Studi di Milano, Via Venezian 21, I-20133 Milan - Italy; e-mail: Laura.Prati@unimi.it**

Heterogeneous catalysis offered and will continue to offer attactive, economical solutions to improving our environment. Recent results on the preparation and characterisation of innovative heterogeneous catalysts (oxides, transition metal ions and metal particles dispersed on various supports) for environmental friendly selective oxidation processes will be presented.

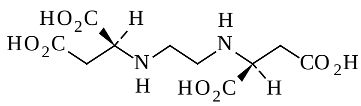
Development and Applications of [S,S]-Ethylene Diamine DiSuccinic Acid ([S,S]-EDDS), a New and Rapidly Biodegradable Strong Transition Metal Chelator

Diederik Schowanek, Tom C.J. Feijtel, Christopher M. Perkins, Frederick A. Hartman, Thomas W. Federle and Robert J. Larson

The Procter & Gamble Company, Brussels and Cincinnati

Transition metal chelators such as aminopolycarboxylates (EDTA, DTPA, etc.) or aminopolyphosphonates (EDTMP, DETPMP, HEPD, etc.) are broadly used in a variety of consumer products and processes, e.g. in the pulp & paper, textile, metal, photographic, leather, cosmetic and detergent industries. These molecules are, however, essentially non-biodegradable and because of their wide usage, are frequently identified in surface and drinking water (e.g. Van Dijk-Looyaard et al., 1990; AWWR, 1994; Kari & Giger, 1995). While the (eco)toxicity of these materials is typically moderate to low, there has been concern that their persistence and metal affinity could trigger remobilization of heavy metals from sewage sludge and sediments, thereby increasing direct exposure to water organisms and indirect exposure to humans via drinking water.

Procter & Gamble has recently been able to identify and commercially develop a chelator that performs similarly to the traditional materials, but with a greatly improved environmental profile; [S,S]-Ethylene Diamine DiSuccinate ([S,S]-EDDS).



This poster describes the identification process of the uniquely biodegradable [S,S]- stereoisomer of EDDS, its key environmental and physico-chemical properties, as well as some current and potential application areas.

Renewable Resources: Chemistry from Nature. Henkel's Contribution to a Sustainable Chemistry

Frank Hirsinger, Henkel KGaA, Düsseldorf, Germany

Henkel has over half a century's experience in processing natural resources into products for the household, trade and industry. Due to this fact, Henkel has become a word leader in the chemistry of renewable resources. In Henkel's Oleochemicals Division, over 900 000 tons of natural oils and fats (from vegetable and animal sources) are processed annually. Beside this, in our plants we utilize other renewable resources like starch, sugar, protein, cellulose, fragrances, resins, natural vitamins, etc. These are used in the manufacturing of detergents, surfactants, cosmetics, adhesives, speciality chemicals -- just to mention a few of the many applications in which we consider renewable resources to be very efficient, safe and competitive.

Many of our products are advantageous because they are easily biodegraded. Nature easily identifies what it has synthesized and is therefore able to break the product up readily into its basic components. Renewable resources, in comparison with petrochemical resources, have the decisive advantage that they do not increase the world's atmospheric CO_2 level. This is because, during biodegradation, products from renewable resources release the same amount of CO_2 that was utilized by the plants during photosynthesis.

APG - New surfactant made 100% from renewable resources

Henkel has been systematically concerned with environmental performance for more than 40 years. Agenda 21, the outcome of Rio '92, did not cause any fundamental change in our behaviour, but instead shows that we are heading in the right direction. We decided long before Rio to start research on a surfactant made solely from renewable raw materials and having excellent environmental compatibility: APG (Alkyl Polyglycoside). Precisely in '92, the year the Earth Summit took place, we put into operation the world's largest production plant in Cincinnati, USA. In '95, we enlarged production capacity with an additional plant in Düsseldorf.

But why is APG an example?

- It saves petrochemical resources from a limited stock.
- Detergents can be formulated with a 25% lower surfactant content.
- It has a significantly reduced contribution to greenhouse effects.

So APG perfectly addresses the demand of Agenda 21 to 'reduce impact on resource use and the environment.' APG is an example of our pro-active research strategy aiming at products with superior eco-efficiency.

At Henkel we see renewable resources as a service, provided by nature, that should be further pursued. It is sustainable in a much broader sense than many developments of this high-tech world.

CHEMRAWN XIV: World Conference on Green Chemistry

Dennis L. Hjeresen, Joseph Breen

The Green Chemistry Institute, working with the CHEMRAWN (CHEMical Research Applied to World Needs) Committee of the International Union of Pure and Applied Chemistry (IUPAC), has proposed a world conference centered on Green Chemistry. Green Chemistry is the design of chemical products and processes that reduce or eliminate the use and generation of hazardous substances. Green Chemistry represents a unifying theme that encompasses all aspects and types of chemical processes which reduce impacts on human health, energy consumption, and the environment relative to the current state of the art.

The objectives of CHEMRAWN XIV are:

- conduct an objective assessment of the technical state-of-the-art in Green Chemistry and Engineering and the contribution it can make to world sustainability;
- define scientific gaps and research priorities in order to provide decision-makers in industry, government, academia and the non-governmental sector with the knowledge required to craft policy and accelerate implementation of Green Chemistry principles;
- promote an educational program for Green Chemistry that spans educational levels, national boundaries and cultural differences.

Dr. Dennis L. Hjeresen
Senior Program Manager
Environmental Management Programs
Los Alamos National Laboratory
Los Alamos, NM 87545
(505) 665-7251/FAX 5-8118
e-mail: dennish@lanl.gov

Dr. Joseph Breen
The Green Chemistry Institute
1650 Research Boulevard, Rockville, MD 20850
301-294-2854/FAX 301-294-2829
breenj1@westat.com

CASE STUDIES IN GREEN CHEMISTRY AT LOS ALAMOS NATIONAL LABORATORY

Dr. Dennis L. Hjeresen

Los Alamos National Laboratory, with support from the U.S. Environmental Protection Agency (Office of Pollution Prevention and Toxics) and the Department of Energy (Office of Industrial Technologies), has an ongoing research program on alternative industrial processes that can eliminate waste and conserve energy. The poster highlights three projects that exemplify the Green Chemistry approach. All three projects utilize dense phase carbon dioxide (CO_2) or other fluids as alternative solvents or as alternative reaction media. CO_2 has the following benefits in these applications:

- It is a non-flammable, non-toxic, inexhaustible solvent.
- It does not deplete the ozone or pollute the ground water.
- It helps industry comply with federal and state environmental regulations because the process minimizes hazardous wastes and emissions.
- It reduces costs by lowering energy consumption, run times, and labor costs.

Specific projects discussed include:

- A materials modification method for cement and fly-ash,
- A technology for conventional solvent replacement in several semiconductor processing operations, including the cleaning of silicon wafers, metal deposition, etching, photoresist removal, and waste treatment,
- Dimethylether: A dense phase fluid as an alternative polar solvent

Dr. Dennis L. Hjeresen
Senior Program Manager
Environmental Management Programs
Los Alamos National Laboratory
Los Alamos, NM 87545
(505) 665-7251/FAX 5-8118
e-mail: dennish@lanl.gov

A Research Project on Catalytic Chemistry for Sustainable Chemistry in Academia: Catalytic Chemistry of Unique Reaction Fields

Masakazu Iwamoto
Hokkaido University

Makoto Misono
University of Tokyo

The accomplishments of a four-year research project, which was initiated to establish new catalytic chemistry and technology which can meet the severe conditions required to solve environmental issues related to “catalytic processes for sustainable chemistry” and novel catalysts for emission control, will be presented. The project has been supported by the Ministry of Education and includes more than a hundred researchers in academia.

New catalyst materials, new reaction routes and new concepts for catalyst design based on atom-level design, multi-functionality, etc. are the underlying elements of the project. The project comprises the following sub-projects:

1) design of catalysts at atomic/molecular level,
2) principles of combination of multi-functions (membrane reactor, photocatalysis, etc.),
3) new catalyst materials (porous materials, super solid acid and bases, etc.),
4) molecular dynamics and molecular chemical engineering,
5) environmental catalysis (HDS, NO_x, catalytic combustion, etc.).

The progress has been publicized in symposia and newsletters twice a year. 1998 is the last year for which the achievements of the project have been summarized. It is expected that they will be applied in various ways to practical uses in the near future.

The Flemish BAT Centre: BAT for the Production of Paint, Varnish and Printing Ink

Joeri Van Deynze, Peter Vercaemst, Pieter Van den Steen, Roger Dijkmans and Anne Jacobs

In the Flemish region of Belgium, the environmental permit conditions and/or the permit conditions that eventually appear in the permit should be based on Best Available Techniques (BAT). “Best” means “best for the environment as a whole”, “Available” means “no longer experimental, and economically achievable by the enterprises concerned”, and “Techniques” means “technologies and organisational measures”. This definition of BAT is derived from, and hence similar to, the BAT definition used in European directive 96/61/EC, also called the IPPC directive.

To assist the Flemish authorities in defining BAT for specific sectors, and to inform the competent authorities and the industry of developments in BAT, the Flemish Institute for Technological Research (VITO) has been asked to write BAT documents on various industrial sectors. BAT documents contain technical and economic information on available techniques that may improve the environmental performance of processes used in these sectors (candidate BAT). The BAT selected from the list of candidate BAT are used as a basis for suggestions to the Flemish authorities for updating the environmental permit conditions per sector. The BAT centre also takes part in the Technical Working Groups that function in the framework of IPPC.

BAT information is distributed to Flemish authorities (regional and local) and industry. The following means are used: i) printed form, ii) the Internet (http://www.vito.be/emis) and iii) oral presentations.

One of the sectors studied is the manufacturing of paint, varnish and printing ink. This process consists of mixing pigments, binders, additives, water and/or organic solvents. The process may cause considerable emissions of volatile organic compounds (VOCs). Dust and odour may also be a problem. The suggested BAT consist of a number of measures which allow the production of paint, varnish and printing ink in an environmentally friendly way and without requiring unreasonable costs. The BAT are: process adjustments (input of pigments in the mix reservoir beneath the liquid level, transport of raw materials through pipes) and end-of-pipe techniques (dust filters, filter installations for removal of VOCs from the exhausted air). The BAT selection was carried out on the basis of socio-economic studies, cost calculations, foreign BAT reports, and discussions with industry experts, suppliers, and specialists from (semi) public institutes.

The BAT have proven valuable because they allow suggestions of new permit conditions (e.g. imposing a maximum VOCs loss of 30 or 50 g per kg VOCs used). A more generalised use of BAT can reduce the VOCs emission in this sector by about 32% without compromising the economical health of this sector.