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Establishment of a European Green and Sustainable Chemistry Award

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Preface

Green and sustainable chemistry is a new concept and scientific area with the aim of improving the eco-efficiency of chemical processes, products and services, and so achieve a sustainable, cleaner and healthier environment. This would at the same time improve the image of chemistry as a problem-solving science.

The European Environment Agency sees this project as part of its remit to stimulate the exchange of information on the best technologies available for preventing or reducing damage to the environment.

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Summary and conclusions

Green and sustainable chemistry is a new concept and research area first articulated in the early 1990s but which has gained wider currency only in the last few years. Green and sustainable chemistry is largely concerned with the development of processes and technologies which result in more efficient chemical reactions that generate little waste and less environmental emissions.

Most experiences have been obtained in the United States, where President Clinton announced the Presidential Green Chemistry Challenge in March 1995. The programme includes research grants, educational activities and annual green chemistry awards to highlight the topic and encourage companies and researchers to start activities.

This programme has in the few years of functioning resulted in a considerable reduction of emissions and of resource use in American industry. The research in green chemistry at American universities has also increased and new discoveries have been utilised. Furthermore, the programme has contributed to a better image of chemistry.

This success, and the competitive edge which American business has obtained, has inspired other countries in Europe and Asia to begin similar activities. In the UK, a Green Chemistry Network has been established. In Italy, Germany and Australia, similar activities are going on, including annual awards. Many international organisations, such as the Organisation for Economic Cooperation and Development (OECD), the International Union of Pure and Applied Chemistry (IUPAC), the European Chemical Industry Council (CEFIC) and the Federation of European Chemical Societies (FECS), have taken green and sustainable chemistry onto their agenda.

The European Environment Agency has taken the initiative to investigate the possibilities of establishing a European Green and Sustainable Chemistry Award. A small planning group of representatives of chemical societies, industry associations and the European Commission met three times during 1999 with the goal of discussing and developing such a programme.

There was a positive and constructive atmosphere at the meetings, and it was agreed that the European Green and Sustainable Chemistry Award will be for those who help achieve significant improvements in the eco-efficiency of chemical processes, products and services, and so achieve a sustainable, cleaner and healthier environment and a competitive advantage. Eco-efficiency is the efficiency with which ecological resources are used to meet human needs.

It was suggested to include the same three scientific focus areas as in the United States (and Australia):

- the use of alternative synthetic pathways;
- the use of alternative reaction conditions;
- the design of chemicals that are, for example, less toxic than current alternatives, or inherently safer with regard to accident potential.

It was suggested that there should be four awards: a business award, a small and medium-sized enterprise (SME) award, an academic award and an educational award. There should be no prize money, only a certificate and a trophy.

It was also suggested that the evaluation panel should be selected by an expert committee appointed by the Federation of European Chemical Societies. This committee, which will also have members from industry, should also be involved in the development and updating of selection criteria.

Funding is necessary to cover the cost of establishing and maintaining an award scheme. The amount is estimated to be at least EUR 30 000 annually but double this amount for the first year. It was assumed that the most likely sponsor would be the European Commission's Environment Directorate-General.

It is proposed that the three national organisations in the UK, Italy and Germany, which had offered to be the administrative body, decide as soon as possible between themselves which should be the principal contractor and eventual assistant contractors, and discuss how to cooperate and allocate the tasks of fundraising, etc.

The principal contractor will lead the work by drafting an application for funding, based on the proposal in this report, which should be sent to the European Commission's Environment Directorate-General — and later possibly to other sources of funding. The application should be supported by the EEA, FECS and CEFIC.

The sponsoring organisations will form the management board. It was also suggested to form an advisory group of members from national green and sustainable chemistry award bodies.

From the beginning, the plan has been that the first European Green and Sustainable Chemistry Award ceremony should be held on 27 August 2000 at the opening of the seventh FECS Conference on Chemistry and the Environment in Oporto, Portugal. In order to achieve this, the deadline for receiving any nomination should be around April 2000, otherwise the award ceremony would have to be postponed. Therefore, it is imperative that the funding and organisation are in place.

At present, this timetable is not realistic. However, it will not be difficult to select another relevant event when the award scheme is in place. The next (eighth) FECS Conference on Chemistry and the Environment will be held in Athens, Greece, from August to September 2002.

The official announcement of the award should be when the funding is in place, a guidance document for submitting nominations and selection criteria has been drafted, and the administrative body is functioning, and at least a year before the award ceremony.

A long delay in the development of a European award scheme will increase the risk that too many national awards will be established, which may confuse the picture, apparently decrease the need for a European award and, not least, contribute to the loss of the important European dimension. Nowadays, with more and more multinational companies, such an award needs to be international in order to contribute to the increased competitiveness of European business.

1. Background

A European Green and Sustainable Chemistry Award is intended to contribute to an improvement of the environmental quality in Europe and stimulate chemical innovations in European industry and business, and thereby help to improve the global competitiveness of the European industry and increase European employment.

Furthermore, a European Green and Sustainable Chemistry Award may stimulate education and the exchange of information on the best technologies available for preventing or reducing damage to the environment. Such an award may also promote the public image of chemistry by showing that chemistry may be able to help solve environmental problems and contribute to sustainable development.

The European award will be for those companies and individuals:

- who help to achieve significant improvements in the eco-efficiency of chemical processes, products and services, and by doing so contribute to making a more sustainable, cleaner and healthier environment and gain a competitive advantage;

- who promote the positive contribution of chemistry to a cleaner environment.

In the United States, a green chemistry award scheme has been successfully in place since 1996, and it has contributed to an increased competitiveness of American business. The award has been established through cooperation between the US Environmental Protection Agency (EPA), the American Chemical Society (ACS), the American industry and other organisations. Awards have been presented in five categories to nominated industries, SMEs, academics and research centres.

2. National and international green and sustainable chemistry activities

2.1. United States of America

2.1.1. The Presidential Green Chemistry Challenge[1]

President Clinton announced the Presidential Green Chemistry Challenge on 16 March 1995. This programme is one of the original 'Reinventing environmental regulations' initiatives to 'promote pollution prevention and industrial ecology through a new US EPA Design for the Environment (DfE) partnership with the chemical industry'.

The EPA's Office of Pollution Prevention and Toxics (OPPT) is leading this voluntary partnership programme with other EPA offices, federal agencies, members of the chemical industry, trade associations, scientific organisations and academia.

The green chemistry mission is 'to promote innovative chemical technologies that reduce or eliminate the use or generation of hazardous substances in the design, manufacture and use of chemical products'.

2.1.2. Definition of green chemistry

Green chemistry in the US Presidential Green Chemistry Challenge is defined as:

'The use of chemistry for source reduction or pollution prevention, the highest tier of the risk management hierarchy as described in the Pollution Prevention Act of 1990. More specifically, green chemistry is the design of chemical products and processes that are more environmentally benign.

Green chemistry encompasses all aspects and types of chemical processes that reduce negative impacts to human health and the environment relative to the current state of the art. By reducing or eliminating the use or generation of hazardous substances associated with a particular synthesis or process, chemists can greatly reduce risk to human health and the environment.'

Green chemistry involves a reduction in, or elimination of, the use or generation of hazardous substances, including feedstock, reagents, solvents, products and by-products, from a chemical process. The 12 principles of green chemistry are listed in Annex A.

2.1.3. Programme scope and objectives

The Presidential Green Chemistry Challenge recognises and promotes the research, development and implementation of innovative green chemical technologies that prevent pollution and that have broad industrial applications.

Through awards, education programmes and grants, the Presidential Green Chemistry Challenge recognises and promotes innovative technologies that

1 http://www.epa.gov/opptintr/greenchemistry/index.htm.

incorporate the principles of green chemistry into chemical design, manufacture and use, and that have been or can be utilised by industry for pollution prevention.

2.1.4. Research grants

Although the Presidential Green Chemistry Challenge programme does not provide an independent mechanism for green chemistry grants, it does support the EPA/NSF partnership for environmental research. The 'Technology for a sustainable environment' grant solicitation available through this partnership addresses the technological and environmental issues of design, synthesis, processing, production and use of products in continuous and discrete manufacturing industries.

The 'Technology for a sustainable environment' grant solicitation invites research proposals that advance the development and utilisation of innovative technologies and approaches directed at avoiding or minimising the use or generation of hazardous substances. Eligible applicants include academic and non-profit-making institutions located in the United States, and state or local governments. Award amounts typically range from USD 50 000 to USD 150 000 per award per year, and the award duration is approximately two to three years. These figures may vary annually.

2.1.5. Awards programme

The annual Presidential Green Chemistry Challenge awards programme recognises outstanding chemical technologies that incorporate green chemistry principles into chemical design, manufacture and use. The green chemistry award scheme has been successfully in place since 1996 and has contributed to an increased competitiveness of American business.

The awards programme invites nominations that describe the technical benefits of a green chemistry technology as well as human health and environmental benefits. The awards programme is open to all individuals, groups and organisations, both non-profit-making and profit-making, including academia and industry. An independent panel, selected by the American Chemical Society (ACS), judges nominations for the awards.

Awards have been presented annually in five categories to nominated industries, SMEs, individual academics and research centres. Presidential Green Chemistry Challenge awards recipients receive national public recognition for their outstanding accomplishments in the research, development and/or implementation of green chemical technologies. One award is made to each of the following five categories:

- a small business[2] for a project in any of the scope focus areas;
- an academic institution for a project in any of the scope focus areas;
- any sponsor for a project in focus area 1 (the use of alternative synthetic pathways for green chemistry);

[2] A small business is one with annual sales of less than USD 40 million, including all domestic and foreign sales by the company, its subsidiaries and its parent company.

- any sponsor for a project in focus area 2 (the use of alternative reaction conditions for green chemistry);

- any sponsor for a project in focus area 3 (the design of chemicals for green chemistry).

2.1.6. Green Chemistry Expert System

The Green Chemistry Expert System (GCES) allows users to build a green chemical process, design a green chemical, or survey the field of green chemistry. The system is equally useful for new and existing chemicals and their synthetic processes. It includes extensive documentation.

The GCES features are contained in five modules.

- The 'Synthetic methodology assessment for reduction techniques' (SMART) module quantifies and categorises the hazardous substances used in or generated by a chemical reaction, based on information entered by the user. Reactions can be modified in the SMART module and re-evaluated to optimise their green nature.

- The 'Green synthetic reactions' module provides technical information on green synthetic methods.

- The 'Designing safer chemicals' module includes guidance on how chemical substances can be modified to make them safer; it is organised by chemical class, properties and use.

- The 'Green solvents/reaction conditions' module contains technical information on green alternatives to traditional solvent systems. This module also allows users to search for green substitute solvents based on physico-chemical properties.

- The 'Green chemistry references' module allows the user to obtain additional information using a number of search strategies. The user may also add references to this module.

2.1.7. Stakeholders/partners

The award has been established through cooperation between the US Environmental Protection Agency, the American Chemical Society, the American industry and other stakeholders. The following is a list of the partners:

- American Chemical Society (ACS);
- American Petroleum Institute (API);
- BF Goodrich;
- Chemical Manufacturers' Association (CMA);
- Council for Chemical Research (CCR);
- Dow Chemical Company;
- Dow-Corning Corporation;
- E.I. DuPont de Nemours;

- Eastman Kodak Company;
- Environmental Commissioners of the States (ECOS);
- Gulf Coast Hazardous Substance Research Centre;
- Lamar University;
- Los Alamos National Laboratory (LANL);
- National Research Council (NRC);
- North Carolina Department of Environment and Natural Resources;
- Polaroid Corporation;
- Rochester Midland Corporation;
- Society of the Plastics Industry (SPI);
- Solutia;
- University of Massachusetts, Boston;
- US Department of Energy.

2.1.8. 1999 awards recipients

Alternative Synthetic Pathways Award
Lilly Research Laboratories
Practical application of a biocatalyst in pharmaceutical manufacturing

Alternative Solvents/Reaction Conditions Award
Nalco Chemical Company
The development and commercialisation of ULTIMER®: the first of a new family of water-soluble polymer dispersions

Designing Safer Chemicals Award
Dow AgroSciences LLC
Spinosad, a new natural product for insect control

Academic Award
Terrence J. Collins
Carnegie Mellon University
TAML™ oxidant activators: general activation of hydrogen peroxide for green oxidation technologies

Small Business Award
Biofine, Incorporated
Economic conversion of cellulosic biomass to chemicals

2.1.9. Green chemistry literature database

The EPA's 'Green chemistry' programme is compiling and organising journal articles into specific sub-topics for a literature database on the subject. Topic areas include alternative synthesis methods, catalysis, reaction conditions and alternative solvents. The goal of this database is to have a compilation of green chemistry literature, which is publicly accessible.

2.1.10. The role of the American Chemical Society[3]

As mentioned above, the American Chemical Society (ACS) is a partner of the Presidential Green Chemistry Challenge and selects the independent scientific panel which judges the nominations for awards. Furthermore, the ACS organises green chemistry symposia at its biannual national meetings, for example from 21 to 25 March 1999 in Anaheim, California, 22 to 26 August 1999 in New Orleans, Louisiana, and 26 to 30 March 2000 in San Francisco, California ('Green chemistry for reduction of greenhouse gas emissions'). It also organises a specific annual Green Chemistry and Engineering Conference in Washington DC, where the award ceremonies are held. The fourth conference will be held from 27 to 29 June 2000. The previous conferences were held in June 1997, and from 30 June to 2 July 1998 and 29 June to 1 July 1999.

2.1.11. Kenneth G. Hancock Memorial Scholarship in Green Chemistry[4]

An annual Kenneth G. Hancock Memorial Scholarship in Green Chemistry was announced in June 1997. The award was introduced in memory of one of the earliest US proponents of green chemistry and the 'environmentally benign chemical synthesis and processing' approach, Kenneth G. Hancock, former director of the Division of Chemistry at the National Science Foundation. The Kenneth G. Hancock Memorial Scholarship in Green Chemistry is an opportunity for undergraduate and graduate students to compete for a prestigious memorial scholarship in recognition of undergraduate and graduate studies and/or research in green chemistry. The scholarship is offered under the auspices of the American Chemical Society's Division of Environmental Chemistry, and is awarded in conjunction with the annual Presidential Green Chemistry Challenge awards ceremony at the annual Green Chemistry and Engineering Conference.

2.1.12. Gordon conferences[5]

Gordon conferences on green chemistry (previously 'Environmentally benign organic synthesis') are held annually. The fifth conference is to be held from 16 to 21 July 2000 in New London, Connecticut. Previous Gordon conferences were held in Henniker, New Hampshire (21 to 26 July 1996), Oxford, UK (17 to 22 August 1997), Meridan Hill, New Hampshire (16 to 21 August 1998) and in Oxford, UK (11 to 16 July 1999).

2.1.13. Green Chemistry Institute[6]

The Green Chemistry Institute at Los Alamos National Laboratory is a non-profit-making organisation dedicated to environmentally benign chemical synthesis and processing research and education. Its mission is to promote and foster green chemistry through information dissemination, chemical research, and conferences and symposia.

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3 http://www.acs.org/meetings/.

4 Anastas, P. T., Williamson, T. C., Hjeresen, D. and Breen, J. J., 'Promoting green chemistry initiatives', *Environ. Sci. Technol.*, 1999, 33(3):116A–119A.

5 http://www.grc.uri.edu/.

6 http://www.lanl.gov/greenchemistry/.

2.2. United Kingdom

2.2.1. Royal Society of Chemistry

In the United Kingdom, there is a tremendous amount of support for green chemistry, especially among the 46 000 members of the Royal Society of Chemistry (RSC). Green chemistry is expressed as 'cleaner, cheaper and smarter chemistry'. It is a set of principles that reduces or eliminates the use or generation of hazardous substances in the design, manufacture and application of chemical products. Green chemistry includes, for example, clean synthesis, atom efficiency, replacement of stoichiometric reagents, new solvents and reaction media, water-based processes and products, replacement of hazardous reagents, intensive processing, novel separations, alternative feedstock and waste minimisation.

At the next RSC annual conference in Manchester from 16 to 20 April 2000, there will be a special symposium 'Towards sustainability', which will include, on 19 April, a poster session on green chemistry networking.[7] The RSC is also organising a green chemistry conference 'Sustainable products and processes', to be held in Swansea from 3 to 6 April 2001.

2.2.2. UK green chemistry awards

A UK green chemistry awards programme has recently been announced. The awards are sponsored by the Royal Society of Chemistry, Salters' Company, the Jerwood Charitable Foundation, the Department of Trade and Industry (DTI) and the Department of the Environment, Transport and the Regions (DETR).

There are three awards.

- *The Jerwood–Salters' Environment Award*
  This annual award of GBP 10 000 will be given to a young academic, preferably working in collaboration with industry. Salters' Company, with the generous financial support of the Jerwood Charitable Foundation, sponsors this award.

- *Two annual awards*
  These comprise a trophy and certificate awarded to UK companies for technology, products or services. At least one of the companies will be a small and medium-sized enterprise (SME).

Submissions should be received by 31 May 2000. All qualifying entries will be judged by an expert panel appointed by the Royal Society of Chemistry and Salters' Company. Winners will be notified by the end of September 2000.

2.2.3. UK Green Chemistry Network[8]

The Royal Society of Chemistry has launched a national UK Green Chemistry Network (GCN) located at York University. The director is Professor James Clark and the network manager is Mike Lancaster. The GCN began its work in May 1998. A technical advisory panel consisting of trade associations, professional organisations, government departments and funding bodies has been established.

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7 http://www.rsc.org/lap/confs/ac2000/acsust.htm/.

8 www.chemsoc.org/gcn/.

This network will promote awareness and facilitate education, training, technology transfer and practice of the green chemistry concept in UK industry, academia and schools. This will be achieved by:

- establishing a database on green chemistry linked to overseas networks via the RSC web site;
- organising technology transfer brokerage;
- providing links to other organisations and government departments;
- organising conferences, workshops and training courses, for instance a Green Chemistry Network symposium on 24 May 2000 at the University of Leicester;
- providing educational material for universities and schools;
- providing newsletters and books with close links to the new *Green Chemistry* and *Environmental Monitoring* journals;
- providing prizes and awards for companies and university researchers.

A satellite network has been established in Hungary.

2.2.4. Green Chemistry journal[9]

The Royal Society of Chemistry publishes an international scientific journal entitled *Green Chemistry* with six issues annually. The first issue was published in February 1999 and the fifth in December 1999.

2.3. Italy

2.3.1. INCA

Italy is among the pioneers in green/sustainable chemistry in Europe.[10] The Inter-University Consortium on Chemistry for the Environment (INCA)[11] established in 1993 is a non-profit-making organisation for research in environmental chemistry. INCA consists of some 30 Italian universities, and the director is Professor Pietro Tundo of the Università Ca' Foscari di Venezia.

2.3.2. Chemistry for the environment

Green chemistry or 'chemistry for the environment', as it is called, plays an important part in the activities of INCA. The Italian (INCA) definition of 'green chemistry' (translated into English) is:

'Green chemistry/chemistry for the environment is the use of chemistry for pollutant source reduction; the definition encompasses therefore all aspects and chemical processes that reduce impact on human health and on the environment. Its goal is to improve quality of life and the competitiveness of industry by developing alternative syntheses for important industrial chemicals. To this end,

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9 www.rsc.org/greenchem/.

10 Tundo, P. and Breen, J. J., 'Venice: a centre for green chemistry on the continent', *Today's Chemist at Work*, 1999, 8(2):52–59.

11 http://helios.unive.it/inca/.

significant challenges are available for chemists to design new syntheses that are less polluting, and to gain detailed understanding of the scientific facts and of the technical base needed to support sustainable development and environmental protection.'

INCA organised an international scientific conference 'Green chemistry: challenging perspectives' in October 1997, in Venice, and an IUPAC/OECD workshop on sustainable chemistry in Venice from 15 to 17 October 1998.

2.3.3. Summer schools

Postgraduate summer schools in green chemistry were organised by INCA in Venice from 29 August to 6 September 1998 and 6 to 12 September 1999. A third is planned for 2 to 9 September 2000. In all, 45 graduate students and 16 teachers from 13 countries attended the first of these. The European Commission's Research Directorate-General funds the summer schools via the 'Training and mobility of researchers' programme.

2.3.4. Italian green chemistry award

In 1998, INCA launched an Italian green chemistry award ('Chemistry for the Environment Award') for Italian companies only. It was announced with 29 January 1999 as the deadline for nominations. In its first year, the award attracted 50 nominations, which were judged on scientific merit and on economic and environmental impact. Awards were presented in March 1999 in three categories: (1) processes; (2) products; and (3) recycling. INCA recognised the following three companies in 1999:

1. Lonza Intermediates and Additives SA for its process 'optimisation of the oxidation of *o*-xylene to phthalic anhydride by the selective transformation of reaction intermediates';

2. Mapei SpA for its development of 'very low VOC-emitting adhesives';

3. Solvay, Italia for its process 'recovery of residues from fume purification plants and their reutilisation as feedstock'.

The next deadline is 21 January 2000, and the award ceremony will be at the green chemistry symposium in Rome on 29 February at the next annual meeting of INCA, which will be held in Rome on 28 and 29 February 2000.

2.4. Germany

2.4.1. German Chemical Society[12]

In Germany, the Gesellschaft Deutsche Chemiker (GDCh) decided in 1997 to introduce a new annual award in sustainable chemistry called the Wöhler-Preis 'Ressourcenschonende Prozesse'. No more information is available.

2.4.2. Representative task force

The GDCh has established a Task Force on Sustainable Chemistry ('Nachhaltigkeit in der Chemie') with every important scientific, industrial and governmental partner from the field of chemistry and chemical technology, including the following:

[12] http://www.gdch.de.

- VCI Verband der Chemischen Industrie (Chemical Producers' Association);
- BMBF Ministry of Research and Technology;
- BMU Ministry of the Environment;
- UBA Federal Environmental Agency;
- IG BCE trade union for chemistry;
- GDCh FECS/ECCC members;
- DECHEMA FECS/ECCC members;
- DBG FECS/ECCC members;
- BAA Federal Agency for Occupational Safety and Protection.

2.4.3. Seminar on sustainable chemistry[13]

A status seminar on sustainable chemistry ('Nachhaltigkeit in der Chemie und ihren Produkten') was held in Bonn on 13 and 14 April 1999. The seminar was organised by the Ministry of Education and Research in cooperation with 10 other partners, including the GDCh.

2.4.4. Divisional working group

The GDCh Division on Environmental Chemistry and Ecotoxicology has recently formed a Working Group on Environmentally Benign Chemistry ('Ressourcen- und umweltschönende Synthesen'). Professor E. Bayer of the University of Tübingen chairs the working group. The group organised its first symposium 'Nachhaltigkeit in der Chemie und ihren Produkten' in Tübingen on 24 August 1999.[14] The next symposium will be in September 2000 in Oldenburg.

2.4.5. Haltermann Innovation Prize[15]

The chemical company HaltermannAscot GmbH located in Hamburg, Germany, endowed the Haltermann Innovation Prize in 1998 on the occasion of the 100th anniversary of the company's foundation. The purpose of the prize is to provide recognition and encouragement to postgraduates in scientific disciplines and to research scientists. The prize is awarded every two years.

The Haltermann Innovation Prize is awarded primarily to postgraduates studying for doctorates and candidates for positions as lecturers in the chemistry and engineering faculties at universities and polytechnics in Belgium, Denmark, Germany, Sweden and the UK. Scientists at other research institutions and in private industry are also entitled to enter for the prize. The prize money amounts to a total of EUR 25 000. It is divided between three different categories.

The Haltermann Innovation Prize is awarded for chemical–technical developments in the area of product- and process-integrated environmental protection. Special emphasis is placed here on processes for substance separation and environmentally sound products based on renewable raw materials. A vital criterion in assessment of the entries is the technical and scientific progress made as regards sustainable development.

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[13] *GDCh Mitteilungsblatt*, 1999, 5(3):7–9.

[14] *GDCh Mitteilungsblatt*, 1999, 5(3):15–16.

[15] http://www.haltermann.com/.

Projects that have been completed in 1999 as well as the interim results of work that has not yet been completed can be entered. The deadline for submission is 29 February 2000.

The jury for the evaluation of nominations is as follows:

- Peter von Foerster, Board Chairman, Industrieverband Hamburg e.V. (Chairman);
- Arnold Alscher, Director, HaltermannAscot GmbH;
- Professor Ulrich Förstner, Hamburg-Harburg Technical University;
- Maximilian Gege, Board Member, BAUM e.V;
- Krista Sager, Hamburg Senator for Science and Research;
- Professor Walter Kaminsky, Hamburg University;
- Professor Hansjörg Sinn, Hamburg University;
- Professor Thomas Willner, Hamburg-Bergedorf Polytechnic.

The prizes will be presented at a public award ceremony held by HaltermannAscot GmbH in Hamburg in the summer of 2000. Summaries of all the entries will also be documented and published.

2.4.6. Braunschweig Prize[16]

The City of Braunschweig and the Technical University of Braunschweig award research for sustainable ('nachhaltige') development with a prize of DEM 100 000 every second year. The first international award was given on 24 September 1999 to Michael Georgieff of the University of Ulm for using the noble gas xenon as anaesthesia administered intravenously.

2.5. Czech Republic

Green chemistry activities are going on in the Czech Republic. The Czech Chemical Society has established a green chemistry web site (http://www.csch.cz/green.htm).

2.6. Japan

The Japan Chemical Innovation Institute[17] in Tokyo is involved in research and development of 'green and sustainable chemistry' (the term used in Japan). Their definition is 'science and technology aiming to reduce adverse effects and/or increase positive contributions to human health and the environment by chemicals in every stage of the life cycle of the raw materials, production, utilisation, etc.' An alliance for a green and sustainable Japan will be formed in the spring of 2000. The motto is 'green chemistry will make our dreams come true in the 21st century'.

A new 'Sunshine' programme involving 12 organisations (academics, industry, institutes and government) and 67 individuals will be established. It will evaluate

[16] http://www.braunschweigpreis.de.

[17] http://www.jcii.or.jp/.

green and sustainable chemistry methods, promote research and inform and educate.[18]

A green chemistry workshop was held on 26 and 27 November 1999.

2.7. China

Green chemistry is an issue in China. The second International Workshop on Green Chemistry in China was conducted from 23 to 27 May 1999 at Chengdu/Sichuan University. Zhu Qingshi is the founder of the green chemistry movement in China. There were approximately 75 participants in the workshop part of the meeting. Some interesting areas of advance in China include numerous alternatives for the tanning industry, which ranks behind only pulp and paper processing in severity of water pollution.

2.8. Australia

2.8.1. Green chemistry awards

In 1999, the Royal Australian Chemical Institute (RACI)[19] inaugurated Green Chemistry Challenge Awards to recognise and promote fundamental and innovative chemical methods in Australia that accomplish pollution prevention through source reduction, and that have broad applicability in industry, and to recognise contributions to education in green chemistry. The Australian awards and their details are very much inspired by the US experience. The Green Chemistry Challenge Awards are open to all individuals, groups and organisations, both non-profit-making and profit-making, including academia and industry. The first Green Chemistry Challenge Award 1999 went to Dr Chris Strauss of RACI.

2.8.2. Definition of green chemistry

Green chemistry in Australia involves a reduction in or elimination of the use or generation of hazardous materials, including feedstock, reagents, solvents, products and by-products, from a chemical process. It encompasses all aspects and types of chemical processes, including synthesis, catalysis, analysis, monitoring, separations and reaction conditions that reduce impacts on human health and the environment relative to the current state of the art.

2.8.3. Award categories

Awards may be made in the following three areas:

- projects from any of the small business sectors[20] in any of the scope focus areas;
- an academic or government institution for a project in any of the scope focus areas;
- green chemistry education.

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18 M. Kitajima, JCII, lecture at Sustech 10, 1 December 1999.

19 http://www.raci.org.au/RACI/awards.html.

20 A small business is defined here as one with annual sales of less than USD 10 million, including all domestic and foreign sales by the company, its subsidiaries and its parent company.

2.8.4. Nomination

The nominated green chemistry technology must have reached a significant milestone within the past five years in Australia (for example been researched, demonstrated, implemented, applied, patented, etc.). Nominated green chemistry technologies should be an example of one or more of the following three focus areas:

- the use of alternative synthetic pathways;
- the use of alternative reaction conditions;
- the design of alternative chemicals.

Self-nominations are allowed and expected. Nominations must be submitted on a typed, single-spaced report that is no longer than eight pages. Submissions longer than eight pages will not be accepted.

2.8.5. Selection criteria

Judgment of green chemistry technologies nominated for an award will be based on whether they meet the following criteria (where applicable):

- the nominated chemistry technology must fall within the scope of the programme and at least one of the focus areas;
- the nominated chemistry technology should offer human health and/or environmental benefits;
- the nominated chemistry technology should be generally applicable to a large and broad-based segment of chemical manufacturers, users, or society at large;
- the nominated technology should offer at least the following:
  - a realistic approach to green chemistry,
  - a remedy to a real environmental management problem,
  - features that can be transferred readily to other facilities, locations and industry sectors;
- the nominated chemistry technology should be innovative and of scientific merit. The technology should, for example, be original (i.e. never employed before) and scientifically valid.

2.8.6. Judging entries

A panel of technical experts selected by the Royal Australian Chemical Institute will judge the entries. These experts might include members of the scientific, industrial, governmental, educational and environmental communities.

To ensure fairness, judges will compare entries only with others in the same award category. Judges may request verification of any chemistry described or claims made in entries that are selected as finalists. The judges will select the chemistry projects/contributions that best meet the selection criteria as award recipients. The judging panel will look for as much detail (non-proprietary) as possible about the nominated technology.

An award based on contribution to green chemistry education will be evaluated on the basis of innovation, impact, community involvement, etc.

The evaluation of the new technology's impact will include considerations of the health and environmental effects throughout the technology's life cycle with recognition of the necessity for incremental improvements.

2.9. International organisations

2.9.1. European Commission

The fifth framework research programme includes sustainable chemistry. In the 'Growth work programme 2000', sustainable chemistry is included in Section 5.3 of *Generic activity 1A: materials and their technologies for production and transformation.* RTD in this area is focused on generic chemical issues, advanced polymers, and fine or speciality chemicals and solid state chemistry. The overall aim is to achieve a sustainable chemistry based on clean processing and synthesis routes and efficient use of resources, including the use of renewable raw materials, for example for the production of organic chemicals. Research is also needed aiming towards higher added value and safer materials (e.g. 'smart', multifunctional, packaging materials). RTD tasks should include functional materials for chemical engineering, including catalysts and materials for separation technologies. They should also cover formulation engineering, new synthesis routes and alternative reaction media, supra molecular chemistry and chemistry for new materials, including colloidal systems and nano-structured materials.

The European Commission's Research Directorate-General, via the 'Training and mobility of researchers' programme, funds the postgraduate green chemistry summer schools held in Venice and organised by INCA (see Section 2.3.3).

2.9.2. Organisation for Economic Cooperation and Development

In February 1998, the Organisation for Economic Cooperation and Development (OECD) decided to start work on 'sustainable chemistry' — their expression for green chemistry. It is defined as the design, manufacture and use of environmentally benign chemical products and processes that prevent pollution, produce less hazardous waste and reduce environmental and human health risks. One of the activities initiated was an OECD-wide survey of ongoing activities in sustainable chemistry.

Furthermore, the Business and Industry Advisory Committee to the OECD organised, together with the IUPAC and INCA, a workshop on sustainable chemistry in Venice, Italy, from 15 to 17 October 1998.[21] There were 75 participants from 16 member countries. The following are some recommendations from the workshop:

- Member States should be encouraged to initiate and support research in sustainable chemistry;

- the OECD should establish an international sustainable chemistry award and provide guidance to countries interested in establishing national award programmes;

[21] Reports from IUPAC-sponsored symposia, *Chemistry International,* 1999, 21(1):17–22.

- the OECD should establish an information exchange activity on sustainable chemistry to promote the development and functioning of an international sustainable chemistry community;

- the OECD should promote the incorporation of sustainable chemistry concepts into chemical education.

An OECD steering group was formed to continue the work. The OECD published the proceedings of the workshop in 1999. A press release was circulated on 29 October 1998.[22]

2.9.3. International Union of Pure and Applied Chemistry

The International Union of Pure and Applied Chemistry (IUPAC) is the global society of chemists.

The IUPAC has worked together with the OECD and INCA concerning the sustainable chemistry workshop in Venice in October 1998. The IUPAC news magazine *Chemistry International* has published a report from the workshop on sustainable chemistry.

During the 13th IUPAC Conference on Physical Organic Chemistry (25 to 29 August 1996, Inchon, Korea), the IUPAC formed a working party of Commission III.2 on synthetic pathways and processes in green chemistry, later called the Working Group on Sustainable Chemistry. A constitutional meeting was held on 27 May 1998 in Washington DC. The chairman is Pietro Tundo of INCA. Working party meetings were held on 17 and 18 October 1998 after the OECD symposium and on 8 August 1999 during the IUPAC 1999 congress in Berlin.

The definition of sustainable chemistry adopted by the IUPAC working party is 'the invention, design and application of chemical products and processes to reduce or eliminate the use and generation of hazardous substances'.

In 2000, the IUPAC will publish a White Paper containing 25 submissions on sustainable chemistry which will be edited by Tundo and Black.

The IUPAC is sponsoring the Chemrawn[23] XIVth World Conference 'Toward environmentally benign processes and products' to be held in Boulder, Colorado, from 9 to 13 July 2001.

2.9.4. Federation of European Chemical Societies

The Federation of European Chemical Societies (FECS)[24] is a voluntary association, the object of which is to promote cooperation in Europe between those non-profit-making scientific and technical societies in the field of chemistry. FECS was founded in 1970 and has about 50 member societies in 35 countries,[25] together representing some 200 000 individual chemists in academia, industry and

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22 http://www.oecd.org//news and events/release/nw98-103a.htm/.

23 CHEMical Research Applied to World Needs.

24 http://www.chemsoc.org/gateway/fesc.htm/.

25 The member countries are: Albania, Austria, Belgium, Bulgaria, Croatia, Cyprus, the Czech Republic, Denmark, Estonia, Finland, the Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Ireland, Israel, Italy, Latvia, Lithuania, Luxembourg, the Netherlands, Norway, Poland, Portugal, Romania, Russia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey, Ukraine and the United Kingdom.

government in Europe. The secretariat is hosted partly by the Royal Society of Chemistry in London and the Hungarian Chemical Society in Budapest. The present chairman is Reto Battaglia from Switzerland.

FECS is organised in six divisions, four working parties and the European Communities Chemistry Council (ECCC). The Division on Chemistry and the Environment[26] with 32 members from 29 countries is responsible for green and sustainable chemistry issues. In 1999, the division formed a Subcommittee on Green and Sustainable Chemistry with members from various academic centres and industry.

In relation to the European award, the subcommittee should be involved in the development and update of evaluation criteria and annually select the group of experts who should evaluate the proposals and pre-select the winners. FECS, in general, will be responsible for publishing information about the award and promoting it among chemists in Europe.

2.9.5. European Chemical Industry Council[27]

The European Chemical Industry Council (CEFIC) in Brussels is a member of AllChemE and of the planning group for the European Green and Sustainable Chemistry Award. CEFIC supports the concept of sustainable development and has an annual Science Education Award for schools; the scope of the award can include sustainable chemistry.

In 1994, CEFIC established a collaborative research and development programme in sustainable technologies for the process industries called 'Sustech'. CEFIC will provide a forum for sustainable/green chemistry under the Sustech umbrella in which all interested partners can formulate joint actions aimed at developing and implementing new synthetic chemistry.

CEFIC organised the Colloquium on Sustainable Chemistry on 1 December 1999 during its Sustech 10 symposium in Brussels, Belgium.

2.9.6. Alliance for Chemical Sciences and Technologies in Europe

The Alliance for Chemical Sciences and Technologies in Europe (AllChemE) was formed in 1995 and promotes chemistry and chemical technologies in Europe. It coordinates activities of mutual interest to the partners. The member organisations are FECS, EFCE (European Federation of Chemical Engineering), CEFIC, COST Chemistry and CERC3 (Chairmen of European Research Councils Chemistry Committees). AllChemE has green/sustainable chemistry on its agenda and sees the potential for green/sustainable chemistry as a concept which might help the image of chemistry, particularly among young people. AllChemE has delegated the work on a European award to FECS.

2.9.7. European Chemistry Thematic Network[28]

The European Chemistry Thematic Network (ECTN) consists of about 90 universities from 24 countries. The network has existed since 1996 and is funded by the European Commission's Socrates/Erasmus programmes. Green chemistry forms a part of the work and reports of the Working Group on Chemistry and the Environment and the Working Group on the Image of Chemistry.

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26 http://www.scientificjournals.com/espr/fecs/committee.htm.

27 http://www.cefic.be/.

28 http://www.cpe.fr/ECTN/.

2.9.8. Other European environmental awards

There are many European environmental awards, for instance:

- awards for European information sources, by the European Information Association;
- BCE Awards (UK); [29]
- Distinguished Service in Environmental Planning;
- European Award for Environmentally Sound Office Building;
- European Sustainable City Award;
- German Environment Award, by the German Federal Environment Foundation;
- SME European Quality Award;
- St Francis Prize for the Environment (Italy);
- 'The Blue Flag', by the Foundation for Environmental Education of Europe (EC support);
- European Environment Award, biannual;
- 'The Princes' Award' by the EEA.

[29] bce@ortg.demon.co.uk.

3. Proposal for a European Green and Sustainable Chemistry Award

3.1. Planning group

In order to investigate the possibilities for establishing a European Green and Sustainable Chemistry Award, a planning group was formed of representatives of the EEA, FECS member societies and the European Commission services, as well as industry representatives. Another potential stakeholder, the European Environment Bureau, was invited but declined. The planning group has held three meetings so far:

- on 7 and 8 January 1999 at the European Environment Agency, Copenhagen, Denmark;
- on 23 March 1999 at CEFIC, Brussels, Belgium;
- on 12 May 1999 at CEFIC, Brussels, Belgium.

A final meeting was planned for December 1999 but was postponed until further notice.

The following individuals participated in the meetings of the planning group:

- Domingo Jimenez-Beltran, EEA (1)
- David Gee, EEA, Meeting Chairman, Project Manager (1, 2, 3)
- Allan Astrup Jensen, FECS, Meeting Secretary (1, 2, 3)
- Sirpa Herve, FECS (1, 2, 3)
- Luciano Morselli, FECS (1)
- Evelyn McEwan, FECS (2)
- John Brophy, RSC/GCN (1, 2)
- James H. Clark, RSC/GCN (1)
- Mike Lancaster, RSC/GCN (2, 3)
- Pietro Tundo, INCA (2)
- Andrea Scozzafava, INCA (3)
- David Bricknell, CEFIC (2, 3)
- Guy J. Martens, UNICE (2)
- Horst König, BASF (1)
- Willi Meier, EFCE (2)
- Gerald Petit, European Commission, Industry Directorate-General (2)
- Marco Morettini, European Commission, Environment Directorate-General (2)
- Maria Douka, European Commission, Research Directorate-General (2)
- Gerard Riviere, European Commission, COST Chemistry (2, 3)

The meetings discussed various aspects of the proposal, such as terminology, boundaries, timetable, selection criteria and administrative and economic aspects. The following proposal is based on the outcomes of these planning meetings.

It was decided that the geographical area covered by the award should not only be the European Union but greater Europe, corresponding to the member countries of the Federation of European Chemical Societies (FECS) and the European Environment Agency (EEA).[30]

3.2. Definition of green and sustainable chemistry

One of the first problems to solve was the name of the proposed European award. It was instantly clear that the word 'green' had a politically loaded meaning, particularly in German-speaking countries. Therefore, some members of the planning group suggested using 'sustainable chemistry' instead, as done by the OECD and IUPAC. However, it was neither possible nor realistic to propose changing the term 'green chemistry' in English-speaking countries, where it has been used for many years with a certain specific content.

As a compromise, the name of the award in English became 'the European Green and Sustainable Chemistry Award'. In countries with other native languages, trade associations and national chemical societies will be free to translate the term into some other specific name which they prefer, for example 'Nachhaltige Chemie' in German and 'La Chimica per l'Ambiente' in Italian.

It was agreed that the European Green and Sustainable Chemistry Award will be for those who help achieve significant improvements in the eco-efficiency of chemical processes, products and services, and by doing so contribute to making a more sustainable, cleaner and healthier environment and gain a competitive advantage. Eco-efficiency is the efficiency with which ecological resources are used to meet human needs.[31]

3.3. Scientific focus areas

Green chemistry projects can be categorised into one or more of the following three focus areas:

- the use of alternative synthetic pathways for green chemistry, such as catalysis/biocatalysis, natural processes (such as photochemistry and biomimetic synthesis), or alternative feedstock that are more innocuous and renewable (e.g. biomass);

- the use of alternative reaction conditions for green chemistry, such as use of solvents that have a reduced impact on human health and the environment, or increased selectivity and reduced wastes and emissions;

- the design of chemicals that are, for example, less toxic than current alternatives, or inherently safer with regard to hazardous properties.

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30 Albania, Austria, Belgium, Bulgaria, Croatia, Cyprus, the Czech Republic, Denmark, Estonia, Finland, the Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Latvia, Liechtenstein, Lithuania, Luxembourg, Malta, the Netherlands, Norway, Poland, Portugal, Romania, Russia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey, Ukraine and the United Kingdom.

31 *Eco-efficiency*, OECD, 1998.

3.4. Suggested award categories

It is proposed to give one award for each of the following categories:

- a business award for a company of any size for a project in any of the focus areas;
- a small and medium-sized enterprise (SME)[32] award for a project in any of the focus areas;
- an academic institution award for a project in any of the focus areas;
- an educational award for a project in any of the focus areas.

3.5. Selection criteria

The selection criteria have to be developed and refined on basis of the following principles.

1. The nominated green chemistry project must fall within the scope of the award and at least one of the focus areas.
2. The nominated green chemistry projects should offer human health and/or environmental benefits. The technology may, for example:
    - reduce toxicity (acute or chronic), illness or injury, flammability, or explosion potential;
    - reduce emissions or other releases;
    - reduce transport of hazardous substances; or
    - reduce use of hazardous substances in reaction processes;
    - improve usage of natural resources, such as renewable feedstock;
    - enhance biodiversity.
3. The nominated green chemistry projects should be generally applicable to a large and broad-based segment of chemical manufacturers, users, or society at large. The nominated technology must offer at least the following:
    - a realistic approach to green chemistry;
    - a remedy to a real environmental management problem; or
    - features that can be transferred readily to other facilities, locations and industry sectors.
4. The nominated green chemistry projects should be innovative and of scientific merit. The technology should be, for example:
    - recent and original (i.e. never employed before); and

32 An SME is a business employing less than 250 people.

- scientifically valid. (That is, can the nominated technology or strategy stand up to scientific scrutiny through peer review? Has the mechanism of action been thoroughly elucidated through sound scientific research?)

FECS will, via its Division on Chemistry and the Environment's Subcommittee on Green and Sustainable Chemistry, draft the initial evaluation criteria and update these criteria regularly.

3.6. Management, administration and stakeholders

3.6.1. Management board

The establishment of a European Green and Sustainable Chemistry Award requires scientific, technical and/or economic sponsorship from different organisations such as the European Commission's Environment Directorate-General, the European Environment Agency (EEA), the Federation of European Chemical Societies (FECS) and the European Chemical Industry Council (CEFIC). The management board will consist of representatives of sponsoring organisations; it should elect a chairman and meet at least once a year. The management board will have the final responsibility for the award scheme, including strategy, budget, approval and revision of criteria, and appointment of the administrative body.

3.6.2. Administrative body

The administrative body will be responsible for the announcement of the award, production of the winners' certificates, the contacts with stakeholders and the organisation of meetings, including the award ceremony, and secretariat for the management board, the advisory group and the evaluation panel. The administrative body will be reimbursed for the costs of carrying out the administration of the award according to the budget. In addition, the administrative body will have the main responsibility for the marketing plan, the home page and the production of printed matter, for example leaflets. Each participating society, trade association and government body will be expected to market the award within its own membership and areas of influence.

The Royal Society of Chemistry's Green Chemistry Network (CGN) at York University, UK, INCA in Italy, and the German Chemical Society have all the abilities to take over the task and have all informally offered to be part of the administrative body. It may also be decided that the administrative body should be the European Commission or a body chosen by it, for example an organisation which is already administering other environmental awards.

3.6.3. Advisory group

The European Green and Sustainable Chemistry Award should, now and in the future, complement related national awards and build on their experience. In order to ensure coordination, the administrative body should be assisted by a small advisory group with members from other active European national green chemistry centres and networks, for example those existing in the UK (GCN), Italy (INCA), Germany (GDCh), the Czech Republic and Hungary. In the future, it is foreseen that green chemistry centres will be formed in other European countries.

3.6.4. Evaluation procedure

The nominations for the award will be preliminarily screened, reviewed and classified according to the established criteria by the administrative body, before forwarding to the evaluation panel.

The evaluation panel will base its evaluations on the criteria and will look for as much detail (non-proprietary) as possible about the green chemistry technology. Specifics of the chemistry will assist the evaluation panel in evaluating a nomination and will enhance the prospects of a nomination winning. Such specifics include comparisons to an existing technology, toxicity data, quantities of hazardous substances being reduced or eliminated, degree of implementation in commerce, and other technical, human health, environmental and economic benefits.

3.6.5. Selection of the evaluation panel

The evaluation panel will comprise recognised experts in synthetic and industrial chemistry and technologies, in green/sustainable chemistry and in environmental chemistry and toxicology. The experts should be selected from industry, academia and governmental agencies. At least one judge should be from outside the 'green'/environmental field.

FECS will, via its Division on Chemistry and the Environment's Subcommittee on Green and Sustainable Chemistry, be responsible for the annual selection and appointment of up to 12 representative members of the evaluation panel. Each nomination should initially be evaluated in detail by at least three experts of different scientific background before it is discussed in plenum.

3.6.6. Other supporters and stakeholders

In addition to the board members and advisory group organisations, other organisations may support the European Green and Sustainable Chemistry Award, for instance the European Commission's Industry, Research, and Enterprise Directorates-General, AllChemE, EFCE, IUPAC, OECD, SETAC,[33] APME,[34] EPE,[35] WBCSD,[36] individual companies, trade associations representing companies with an interest in chemistry, European universities, etc.

3.6.7. Prizes, trophy and logo

The winners will receive the honour, a trophy and a certificate, but no prize money. The Swedish artist, Jonas Torstensson, has been suggested as the producer of the trophy. He has already produced nice trophies made in recycled glass, for example 'the Bangemann Challenge' trophy. At present, the exact price of any trophy is not known, but the expenses can be estimated at about EUR 6 000 for the first year and EUR 2 000 for the following years.

It would be relevant to ask a designer to produce a logo for the award, which possibly could reflect the physical form of the trophy.

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[33] Society for Environmental Toxicology and Chemistry.

[34] Association of Plastic Manufacturers in Europe.

[35] European Partners for the Environment.

[36] World Business Council for Sustainable Development.

3.6.8. Award ceremony

The presenter of the award to the winners should be a high-level person in Europe, preferably the President of the European Commission, the Environment Commissioner or the Executive Director of the EEA. The award ceremony should be visible and could be held in connection with a related scientific event, for example the FECS Chemistry and the Environment Conference.

3.6.9. Dissemination of information

The announcement of the award should be by means of press releases, a printed leaflet and own home page information. The sponsoring organisations should help with the dissemination of information and announcement, for example by home page links.

The award's own home page should contain general information about it, announcements, links to related home pages and a one-page summary of all the nominations evaluated. All summaries could also be published and disseminated via the EEA 'EnviroWindows' public accessible database placed on the EEA home page.[37]

In addition, the summaries of the award winners' projects could be published in a printed publication, for example in a monograph and/or in the international journals *Green Chemistry* and *Environmental Science and Pollution Research* (ESPR).

[37] www.eea.eu.int.

4. The future

4.1. Funding

In order to establish the European Green and Sustainable Chemistry Award, some sources of funding have to be identified beforehand for the cost of trophies, prizes, announcements and administration.

The most likely sources of funding will be the European Commission, with contributions from some of the larger national chemical societies. (The funding of this study and related meetings and other expenses has come from the EEA, but no funding will be available for its further development.) It is not thought appropriate that the chemical industry itself should be asked to sponsor an award directed towards its own members.

4.2. Draft budget

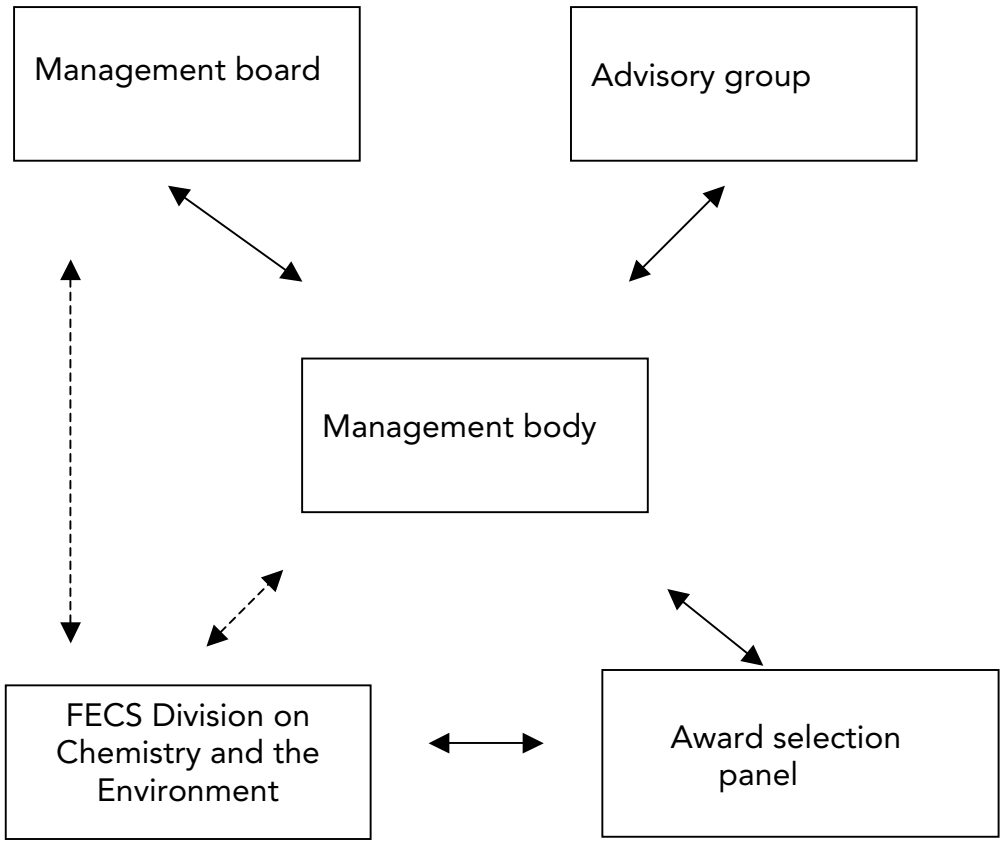
The following draft budget is suggested for the first year of operation.

	EUR
Trophy	
Design	2 000
Mould and test production	2 000
Award, 4 x 500	2 000
Subtotal	6 000
Administration	
Pre-selection/screening of nominations	1 000
Mailing	1 000
Organisation of meetings	2 000
Travel expenses for the administrator and board members, 4 x 1 500	6 000
Final check	1 000
Certificates	2 000
Economy/accounting	2 000
Subtotal	15 000
Marketing	
General information and contacts	2 000
Leaflet production	5 000
Posters	2 000
Home page mastering	2 000
Announcements	10 000
Award ceremony	2 000
Logo development	1 000
Subtotal	24 000
Criteria development and updates	10 000
Subtotal	10 000
Evaluation panel	
Travel expenses, panel meetings, 12 x 1 500	18 000
Subtotal	18 000
Total expenses (EUR)	**73 000**

Excluding parts of the marketing expenses would decrease this budget.

The budget for the second and following years may be considerably lower, because the development costs of the trophy etc. will have been paid in the first year.

4.3. Proposed structure of award organisation



4.4. Application

It is proposed that the three national organisations in the UK, Italy and Germany, which had offered to be the administrative body, decide as soon as possible between themselves which should be the principal contractor and eventual assistant contractors, and discuss how to cooperate and allocate the tasks of fundraising, etc.

The principal contractor will lead the work by drafting an application for funding, based on the proposal in this report, which should be sent to the European Commission's Environment Directorate-General — and later possibly to other sources of funding. The application should be supported by the EEA, FECS and CEFIC.

4.5. Announcement and timetable

At the CEFIC Colloquium on Sustainable Chemistry on 1 December 1999, the intended European Green and Sustainable Chemistry Award was preliminarily announced to a broader circle. The original plan was that the award should be presented for the first time on 27 August 2000 at the opening of the seventh FECS Conference on Chemistry and the Environment to be held in the city of Oporto,

Portugal. In order to achieve this, the deadline for receiving any nomination should be around April 2000.

At present, this timetable is not realistic. However, it will not be difficult to select another relevant event, when the award scheme is in place. The next (eighth) FECS Conference on Chemistry and the Environment will be in Athens, Greece, from August to September 2002.

The official announcement of the award should be when the funding is in place, a guidance document for submitting nominations and selection criteria has been drafted and the administrative body is functioning, and at least a year before the award ceremony.

A long delay in the development of a European award scheme will increase the risk that too many national awards will be established, which may confuse the picture, apparently decrease the need for a European award and, not least, contribute to the loss of the important European dimension. Nowadays, with more and more multinational companies, such an award needs to be international in order to contribute to the increased competitiveness of European business.

Annex A: The 12 principles of green chemistry[38]

1. Prevention
It is better to prevent waste than to treat or clean it up after it has been created.

2. Atom economy
Synthetic methods should be designed to maximise the incorporation of all materials used in the process into the final product.

3. Less hazardous chemical synthesis
Wherever practicable, synthetic methods should be designed to use and generate substances that possess little or no toxicity to people or the environment.

4. Designing safer chemicals
Chemical products should be designed to effect their desired function while minimising their toxicity.

5. Safer solvents and auxiliaries
The use of auxiliary substances (e.g. solvents or separation agents) should be made unnecessary whenever possible and innocuous when used.

6. Design for energy efficiency
Energy requirements of chemical processes should be recognised for their environmental and economic impacts and should be minimised. If possible, synthetic methods should be conducted at ambient temperature and pressure.

7. Use of renewable feedstock
A raw material or feedstock should be renewable rather than depleting whenever technically and economically practicable.

8. Reduce derivatives
Unnecessary derivatisation (use of blocking groups, protection/de-protection and temporary modification of physical/chemical processes) should be minimised or avoided, if possible, because such steps require additional reagents and can generate waste.

9. Catalysis
Catalytic reagents (as selective as possible) are superior to stoichiometric reagents.

10. Design for degradation
Chemical products should be designed so that at the end of their function they break down into innocuous degradation products and do not persist in the environment.

11. Real-time analysis for pollution prevention
Analytical methodologies need to be further developed to allow for real-time, in-process monitoring and control prior to the formation of hazardous substances.

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[38] *Sources:* US Environmental Protection Agency and American Chemical Society.

12. Inherently safer chemistry for accident prevention

Substances and the form of a substance used in a chemical process should be chosen to minimise the potential for chemical accidents, including releases, explosions and fires.

Annex B: Examples of green chemistry approaches based on summaries of US Presidential Green Chemistry Challenge award winners' projects

Resource conservation

The vast majority of the synthetic organic chemicals in production derive from non-renewable resources. Such resources should be used as sparingly as possible and all waste streams should be minimised. This requires employment of reactions that produces minimal by-products, either through the intrinsic stoichiometry of a reaction or as a result of minimising competing undesirable reactions, i.e. making reactions more selective. Consideration of how much of the reactants end up in the product is called 'atom economy'. Professor Barry M. Trost of Stanford University has developed the 'atom economy' concept (Academic Award (a) 1998).

It is possible to convert waste biomass to animal feed, chemicals and fuels by a family of technologies developed by Professor Mark Holtzapple of the Department of Chemical Engineering of Texas A&M University (Academic Award 1996). Lime-treated agricultural residues (e.g. straw and bagasse) may be used directly as an animal feedstuff and thus substitute grain production. Alternatively, the lime-treated biomass can be fed to a large anaerobic fermenter in which rumen micro-organisms convert the biomass into volatile fatty acid salts such as calcium acetate, calcium propionate and calcium butyrate. These fatty acid salts may serve as feedstock for the production of many different organic chemicals (acids, aldehydes, alcohols, etc.), and thus save non-renewable resources, and the alcohols formed may be used as fuels and thereby reduce the contribution of fuels to global warming.

Alternative synthetic pathways

The production of 4-aminodiphenylamine, a key intermediate in the production of rubber antioxidants, is traditionally based on the chlorination of benzene. A new process developed by Flexsys America utilises the base-promoted, direct coupling of aniline and nitrobenzene (Alternative Synthetic Pathways Award 1998). This process does not involve chlorine, and it generates 74 % less organic waste, 99 % less inorganic waste and 97 % less wastewater.

The BHC Company has developed a new synthetic process to manufacture Ibuprofen, a well-known anti-inflammatory painkiller, and minimise waste (Alternative Synthetic Pathways Award 1997). The new process involves only three catalytic steps, with approximately 80 % atom utilisation, and it replaces technology with six stoichiometric steps and less than 40 % atom utilisation. Anhydrous hydrogen fluoride is used as catalyst, and it is completely recovered.

Catalysis

Disodium iminodiacetate is a key intermediate in the production of the herbicide Roundup®. The production of this chemical requires quite toxic and volatile intermediates such as ammonia, formaldehyde, hydrogen cyanide and hydrochloric acid. Furthermore, this process is exothermic and generates potential unstable intermediates. In order to substitute this process, the Monsanto Company has developed an alternative process that relies on the copper-catalysed dehydrogenation of diethanolamine (Alternative Synthetic Pathways Award 1996). The raw materials have low volatility and are less toxic than those of other processes. Furthermore, the process is safer to operate and generates less waste.

An example of an environmentally benign synthesis is the use of genetically manipulated microbes as synthetic catalysts for synthesis of the important basic chemicals, adipic acid and catechol, from renewable glucose as starting material and water as the reaction medium. This environmentally friendly method was developed by Dr Karen M. Draths and Professor John W. Frost of Michigan State University (Academic Award (b) 1998) and replaces methods using non-renewable benzene and nitric acid as starting materials and which release nitrous oxide to the atmosphere.

Alternative solvents/reaction conditions

The Dow Chemical Company has developed and implemented commercially the use of 100 % carbon dioxide as an environmentally friendly blowing agent for the polystyrene foam packaging market and in this way replaced the ozone layer damaging chlorofluorocarbons (CFCs) and hydrochlorofluorocarbons (HCFCs) (Alternative Solvents/Reaction Conditions Award 1996).

The company Imation has developed an imaging system called Dry View™ (Alternative Solvents/Reaction Conditions Award 1997). This photothermography technology uses no wet chemistry, creates no effluent and requires no additional post-process steps such as drying. In this way, the new system eliminates a large amount of hazardous wastewater from the photographic developing process.

Argonne National Laboratory has developed a novel process based on selective membranes that permits low-cost synthesis of high-purity ethyl lactate and other lactate esters from carbohydrate feedstock (Alternative Solvents/Reaction Conditions Award 1998). The process requires little energy input, is highly efficient and selective, and eliminates the large volumes of salt waste produced by conventional processes. The innovation will enable the replacement of toxic solvents, expand the use of renewable carbohydrate feedstock and reduce emissions.

The much-used halone gases for fire extinguishment are hazardous for the stratospheric ozone layer. Pyrocool Technologies Inc. has developed an environmentally responsible fire extinguisher and cooling agent based on a formulation of several highly biodegradable surfactants added to water (Small Business Award 1998).

Legacy Systems Incorporated has developed Coldstrip™, a revolutionary organic removal and wet cleaning technology for photoresists to be used in the semiconductor and other industries (Small Business Award 1997). The active agent is ozone in chilled water generated directly, and there is no waste. This

process eliminates the use of 'Piranha solution' containing sulphuric acid and hydrogen peroxide, and water consumption is considerably reduced.

Polyacrylic acid is an important anionic polymer which is used in many industrial applications and which ends up as non-biodegradable waste. An economically viable, effective and biodegradable alternative is thermal polyaspartate (TPA). The Donlar Corporation has invented two highly efficient almost waste-free processes to manufacture TPA (Small Business Award 1996).

Designing safer chemicals

Liquid carbon dioxide may be an environmentally friendly solvent for polymers etc. and thus be a substitute for toxic organic solvents. In order to be able to dissolve most chemicals, certain surfactants have to be added to the carbon dioxide. Such surfactants have been designed and used by Professor Joseph M. DeSimone of the University of North Carolina and North Carolina State University (Academic Award 1997).

Conventional biocides, used to control the growth of bacteria, algae and fungi in industrial cooling systems, oilfields, and ship surface and process applications, are highly toxic to humans and aquatic life and often persist in the environment, leading to long-term damage. The company Albright and Wilson Americas has developed a new class of environmentally benign, low-toxic biocides based on tetrakis(hydroxymethyl)phosphonium sulphate (THPS) (Designing Safer Chemicals Award 1997).

The Rohm and Haas Company has designed a new marine antifoulant Sea-Nine™ based on 4,5-dichloro-2-octyl-4-isothiazolin-3-one which degrades rapidly in sea water without bioaccumulation and which is 300 times less toxic than the tributyltin oxide (TBTO) it may substitute (Designing Safer Chemicals Award 1996).

The Rohm and Haas Company has invented and commercialised a new safer chemical family of insecticides (CONFIRM™) based on diacylhydrazines (Designing Safer Chemicals Award 1998).