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In cooperation with
Venice Office

Recommendation for Future Actions in Research and Developments

Workshop on Green and Sustainable Chemistry

Ca' Foscari University of Venice
June 8th, 2012

About the Workshop and this Document

The Sustainable Chemistry Issue Team has been active within the OECD Environment Health and Safety Programme since 1998 and has held many meetings in Germany and in Italy.

Although Italy has organized two meetings (Venice, 1998 and 2001) and has an excellent scientific and technological background in the field, the coordination among research, academy and industry, necessary to undertake actions among the leader countries of this area, has not yet been activated. At this end the University Ca' Foscari of Venice, in collaboration with the *Istituto Superiore di Sanità* (*ISS* – Italian Institute for Health) that co-ordinates in Italy the OECD activities in the framework of the Environment, Health and Safety Programme, has organized this Workshop aimed to the establishment of the Italian network on green and sustainable chemistry. The connection with EU achievements and with the recently instituted OECD Green Growth Knowledge Platform has been highlighted.

The first part of the Workshop has addressed European activities carried out in this field. OECD, EuCheMS, UNESCO have participated.

The second part, organised in collaboration with pertinent Italian ministries, universities, public research institutes and industries has highlighted the different point of views inherent to the sustainable development and in particular the state of art of the green and sustainable chemistry in Italy in connection with its international perspectives.

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1. Introduction

Contribution from Chemistry to Green Economy in the context of a Sustainable Development.

Sustainability aims to provide a lasting healthy both to people on earth and to future generations, whilst preserving the ecosystems and the existing animal species. Commonly, sustainable development is defined as a development that meets the requirements of human beings to preserve quality of life without affecting the ability of future generations to meet their own needs. In this sense, sustainability is an big challenge for science and technology where chemists play a crucial role by studying the nature and the human environment at molecular level and by developing new materials and by exploting those energy sources on which a sustainable future depend.

Green Economy is a new economic development model born in contrast to the existing black economic model based on fossil fuels. The Green Economy is based on ecological economics, which consider the impact of human activities on climate change and global warming. In the midst of the global economic crisis, the UNEP United Nations Environment Program called for a global Green New Deal according to which governments were encouraged to support their economic transformation into a greener economy. The Green Economy supports green and renewable energy as a replacement for fossil fuels and promotes energy conservation for efficient energy use. The green economy aims to create green jobs, ensure real, sustainable economic growth, while preventing environmental pollution, global warming, resource depletion, and environmental degradation.

Green growth is about maximizing economic growth and development while avoiding unsustainable pressures on the quality and quantity of natural assets. It is also about harnessing the growth potential that arises from transiting towards a green economy. (OECD Green Growth Strategy Synthesis Report, 2011).

The Green Growth paradigm emphasizes the search for an approach to economic development in which technology can provide solutions for decoupling from – increasing – pressures on the environment.

The Green Growth Knowledge Platform, which is a common initiative of the OECD, UNEP, the World Bank, and the Global Green Growth Institute to facilitate the creation, coordination, and dissemination of knowledge on green growth and the green economy, could provide a useful framework within which new partnerships for sustainable chemistry innovation could be developed.

Green and sustainable chemistry intends to develop technologies able to avoid or reduce the consumption of dangerous chemicals and pollutants in order to preserve the environment as well as human health. The research should be address to decrease resource consumption including energy and provides incentives for innovation to enterprises and scientists. In a globalized world this must include the development of long standing international collaborations.

This safer and green chemistry encompasses two different approaches that may be called the "bottom-up" and the "top-down":

The bottom-up approach deals with reactions and processes investigated on a lab scale in academies, that could be proposed for exploitation by industry through scaling up for future production (the most appropriate term would be **Green Chemistry**). In this context Green Chemistry is innovation at the molecular level.

The top-down approach instead, moves from the industrial needs in basic and applied research; that can be fulfilled through the collaboration with academic partners, and is directed to design safer alternatives for industrial products and processes (the most appropriate term would be **Sustainable Chemistry**).

Incidentally, the difference on meaning, capacity and connections between Green and Sustainable Chemistry is the same that occur among Pure and Applied Chemistry, respectively.

It should be mentioned that Green Chemistry has adopted several meaning in different geographical area. Thus, in Russia Green Chemistry mainly refers to decontamination, in Arabic countries is related to drought problems, in Anglo-Saxon regions to clean products and processes and in Latin countries is often associated to the development of a chemistry related to agriculture. These different meanings but common aims can well illustrate that chemistry is now recognized as a tool for attaining the purposes and the needs of a given and distinct community. Such a strategic and paradigmatic development was possible thanks to the scientific progress which has provided the humankind with means which now allow to embrace, together with the social objectives of science (answers to diseases, poverty, hunger problems), also ethical issues.

Most prominently, besides the intrinsic hazards of chemicals, the important issues for sustainable chemistry management are: water, climate, energy, waste, renewable resources and social aspects.

Chemists not only in industry but all over the world view sustainable chemistry as a growing, profitable area in the future. But besides the prediction of an excellent future and high economic potential, there are some hurdles that sustainable chemistry has to over-come.

Therefore, according to ethical issues, it is necessary to address the sustainable use of chemicals by means of a global approach. The fragmentation of regulations, systems and indicators used in the management of sustainable chemistry must be overcome. Nonetheless, different approaches for different situations and regions are needed to bring sustainable chemistry into the market. There is not one unique direction for chemistry to create sustainability. Although the focus may appear broad and therefore weak, *vice versa*, so many areas of interest represent the actual power of green and sustainable chemistry, as shown by the worldwide debate which demonstrates how alive and growing is the attention on this topic.

Another important step in the history of green and sustainable chemistry has been realised by the introduction of Registration, Evaluation and Authorisation of Chemicals Regulation (REACH), which was formally adopted on the 18th of December 2006 by the European Council of Environment Ministers. This new regulation aims to improve the protection of human health and the environment through improved assessment of chemical substances. This Regulation gives greater responsibility to industry as manufacturers and importers and ultimately calls for progressive substitution of the most dangerous chemicals by greener alternatives.

Indicators for sustainability of chemicals and products, production and uses have to be developed based on a common understanding of all stakeholders. The measurement of these indicators can be already done by various instruments, but the lack of data and its dissemination makes the task complex. The difficulty to obtain sufficient data is even intensified by the challenge to deal with confidential business information. Additionally, this scenario comprises a composite combination of various parameters and notions. Therefore, data collection and communication between all stakeholders is crucial for success.

The aim of the Venice 2012 Workshop on Green and Sustainable Chemistry was therefore to generate a common platform among the different partners; the subsequent decisions and recommendations will be offered to the institutional bodies responsible to take decisions and command.

In this prospect, the Working Group constituted in this Venice Workshop intends to bring toghter institutions and industries with the aim to propose competitive green and sustainable projects. Such projects could be financed either by direct commitments or by taking part in the Italian or Europeans research grants applications, i.e. Italian Ministries, 7PQ and Horizon 2020.

This document is intended as a starting point for the Green and Sustainable Chemistry platform and for future collaborations and proposals.

2. History

In 1991, the USEPA Office of Pollution Prevention and Toxics launched a program called "Alternative Synthetic Pathways for Pollution Prevention." In 1993, the program was expanded to include other topics, such as greener solvents and safer chemicals, and was renamed "Green Chemistry".

In August 1996 International Union of Pure and Applied Chemistry (IUPAC) began its involvement in the Green Chemistry field by the foundation of the Working Party on Synthetic Pathways and Processes in Green Chemistry. In September 1997 the First International Conference on "Challenging Perspectives on Green Chemistry" was held in Venice. Since then IUPAC has been actively involved in several projects related to Green Chemistry.

In 1998 upon an USEPA proposal, the Organization for Economic Co-operation and Development (OECD), instituted a Directive Committee for the development of sustainable chemistry and finalised a programme called "Sustainable Chemistry" that included chemistry aimed at pollution prevention and better industrial performance. The activity commenced with a survey of the Steering Group [USA, Italy, Japan, Germany, Belgium, Canada, Mexico, Sweden, UK, and Business and Industry Advisory Committee to the OECD (BIAC)] on programs and initiatives on Green Chemistry launched worldwide by governments, industries and academia. The USA and Japan were nominated co-leaders in the field of research and development while Italy was appointed leader of the Educational Act. In consideration of the survey results, the policy and programmatic aspects of the sustainable chemistry activity were discussed at the Venice Workshop (October 1998) in the presence of representatives from government, industry and academia of 22 countries, and subsequently endorsed by the OECD's **Joint Meeting of the Chemicals Committee** and the **Working Party on Chemicals, Pesticides and Biotechnology**, Paris (June 6, 1999). As a result of this meeting the following **seven research areas** in green/sustainable chemistry were identified:

Use of Alternative Feedstocks: the use of feedstocks, which are renewable rather than depleting and less toxic to human health and the environment.

Use of Innocuous Reagents: the use of reagents that are inherently less hazardous and are catalytic whenever feasible.

Employing Natural Processes: use of biosynthesis, biocatalysis, and biotech-based chemical transformations for efficiency and selectivity.

Use of Alternative Solvents: the design and utilization of solvents, which have reduced potential for detriment to the environment and serve as alternatives to currently used volatile organic solvents, chlorinated solvents, and solvents which damage the natural environment.

Design of Safer Chemicals: use of molecular structure design - and consideration of the principles of toxicity and mechanism of action - to minimize the intrinsic toxicity of the product while maintaining its efficiency of function.

Developing Alternative Reaction Conditions: the design of reaction conditions and catalysts that increase the selectivity of the product and allow for dematerialization of the product separation process.

Minimizing Energy Consumption: the design of chemical transformations that reduce the required energy input in terms of both mechanical and thermal inputs and the associated environmental impacts of excessive energy usage.

Despite being issued in 1998, these areas of research are still current as they vividly represent the main lines of development of green and sustainable chemistry.

The Venice Workshop on Green and Sustainable Chemistry envisages that also Minimization of effluents and wastes from processes, should be an area endorsed by OECD.

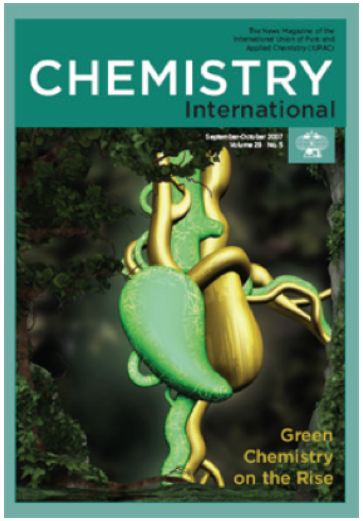


Figure 1. A heart representing the concept of Circular Economy: a heart that recycle the waste into new useful green products. This image taken from the cover of Chemistry International the newsmagazine of the International Union of Pure and Applied Chemistry (IUPAC).

3. Green and Sustainable Chemistry Education

Education is of critical relevance to effectively incorporate green chemistry into chemical product and process designs. For green chemistry to enter widespread practice, chemists must be educated about green chemistry during their academic and professional training. The chemical industry has discovered that when their professional chemists are knowledgeable about pollution prevention concepts they are able to identify and implement effective pollution prevention technologies.

Many Summer Schools, Seminaries, Workshops, Courses, Curricula are dedicated to Green and Sustainable Chemistry around the world. Notable to be cited is the event which maybe was the first global meeting on the subject: the IUPAC Workshop on Green Chemistry Education held in Venice on 12-14 September 2001, in collaboration with OECD (see Appendix 1).

Figure 2. Tenth Edition of the Summer school on Green Chemistry (Ca' Dolfin, Ca' Foscari University, Venezia, 2008).

4. Needs and requirements

Key challenges for chemistry science and technology are the improvement of current knowledge dissemination of new acquisitions in the fields of chemical processes relevant to biodiversity, the carbon cycle and in particular CO_2, the nitrogen cycle, land use, freshwater, environmental pollution due to human activity, air quality and aerosols, ocean acidification, and the ozone layer. These concepts must be communicated by scientists so that public might clearly understand their relevance. Sustainable development is a great and multidisciplinary challenge that needs new mechanisms to fund required research.

Achieving public recognition that chemistry is a crucial part of the solutions to living within safe operating spaces for human development is crucial. Chemists also have to work with all stakeholders to ensure technologies can be used in safe and sustainable ways. This has implications for the way chemistry is taught and communicated to society as a whole, and how chemistry research is structured and integrated within Universities. Chemistry will have a key enabling role both in understanding the impact of human development on our future and the development of sustainable solutions for this future.

The research will need to focus on:

- New molecular transformations based on renewable feedstocks and that minimise waste;
- Reduced energy intensiveness of existing processes;
- Separation, sequestration and use of CO_2;
- New and improved routes to energy production;
- Toxicology and eco-toxicology to enable understanding of the fate and effects of chemicals introduced into the environment as a result of human activity;

These researches to be effective and fruitful will require new partnerships between the sciences, technologies, and industry and also new funding despite the financial constraint. An example is the SusChem technology platform in Europe (EU, EuCheMS and Industry). This innovation is mandatory for the introduction of new business ideas, processes and products in a sustainable manner.

The interest of the Italian Industries on Green and Sustainable Chemistry can be identified in two main areas: 1. Biomass for fuels and 2. Biomass from chemicals.

The participants of the Venice Workshop on Green and Sustainable Chemistry agree with the research priorities outlined by the Italian Association for Industrial Research, AIRI. In particular, the proposed following topics incorporate both AIRI areas of interest as well as subjects rised during the Working Group discussion.

These topics, to be pursued as a priority instance and that reflect the two main areas above outlined, and that do not exclude the Topics on Sustainable Chemistry already endorsed by OECD on June 6th 1999, are:

Tecnologie da risorse rinnovabili (*Technologies from renewable*)

- Processi di bioraffineria (Biorefinery processes)
- Feedstock alternativi per energia e per prodotti chimici (Alternative feedstock for Energy and chemicals)
- Bioetanolo (Bioethanol)
- Tecnologia per biochemical di II generazione (Technologies for II generation biochemicals)
- Tecnologia per la produzione e l'utilizzo di biopolimeri per il settore pneumatici (Technology for the production and the use of biopolymers for tyres)
- Biobased materials for interior in vehicles (cars, train, buses, airplanes)

Tecnologie per l'ambiente e la sostenibilità (*Technologies for the Environment and the Sustainability*)

- Sostituzione delle sostanze "very high concern" (Substitution of very high concern substances)
- Tecnologia di recupero di materiali polimerici da pneumatici usati (Technology for recovering polymeric materials from used tyres)
- Sustainable product design by taking into account the entire Life Cycle.

Materiali funzionali per l'industria manifatturiera (*Materials for the manufacturing industry*)

- Nanotecnologia per formulati cementizi per edilizia (Nanotechnology for cement formulates for construction)
- Nanomamateriali per la catalisi di processi chimici (Nanomaterials for the catalysis of chemical processes)
- Tecnologie per imballaggi alimentari (Technologies for food packaging)
- Solventi, addittivi, formulanti (Solvents, additives and formulates)
- Materiali per edilizia di origine vegetale (Building materials from vegetables)

Information, education and training actions are suggested by the Working Group as Accompanying Measures at National and European level. Such actions should be extensive, persuaded and thoughtful.

Green Chemistry should be taught in every chemistry course including in the secondary schools.

5. Metrics, Indicators and decision support tools

Good indicators, tools and monitoring systems are missing in many regions and especially on a global scale, but new concepts are gaining the attention of international and national organizations, such the consideration of "Planet boundaries", in terms of identifying the carrying capacity of of the ecosphere to cope with anthropogenic pressures (e.g. nitrogen accumulation). Indicators would have the potential to define sustainability in distinct areas and decision support tools could provide assistance in its implementation. Environmental management systems like ISO 14001 combine tools and indicators since they contain guidelines and recommendations as well as environmental performance indicators. Monitoring systems could make comprehensive evaluation possible and have the additional benefit to show where changes lead to financial benefits.

The OECD has recognized the need for work in this area and is launching work on tools and approaches to support decision-making for the substitution of harmful chemicals, which will be overseen by an Ad Hoc Group that has been established for this purpose.

Good monitoring systems and indicators are needed for the measurement of sustainability in chemistry and for minimizing the use and release of chemicals. Additionally, they have to be specialised and adapted to different types of business. Measurement and quantification of sustainability is possible, but since it applies to many aspects, a bottom up approach is needed in addition to management initiatives. Additionally, the scope and application has to be defined and the data availability from enterprises needs to increase significantly. For implementation of existing tools and instruments an easy to use and comprehensive data system is needed

Regulatory programs and global harmonisation of chemicals management systems are of great importance to foster green and sustainable chemistry. Still, existing instruments and conventions should (first) become fully implemented on a global scale. In order to develop a coherent framework for sustainable assessment aspects like an agreed basis/start level, the right tools (out of the many already existing), financial effort and commitment, sufficient amount and quality of data and the potential of a system to be universally adoptable as well as social aspects (especially in DC/CEiT4) are needed.

A policy-induced management change is a key driver to create liability for the enterprises.

Together with enterprises, politics are needed as front runners and creators of a market for sustainable products (and to rule out unsustainable products that are unwanted by society). Nonetheless, consumer habits must change also towards increased sustainability.

It is noteworthy that industry is rapidly moving toward compounds and products which meet the consumer appreciation also from a sustainable point of view; accordingly, surfactants, perfumery, solvents, etc. are advertized with a green label. Also synthetic pathways used in their preparation are publicized as "Proven green syntheses " which constitute an added value for the consumer.

Other drivers for more sustainability are innovations that reduce energy and resource demand, the commitment of all stakeholders (consumers, enterprises and politics) to achieve resource efficiency as well as increased value adding through less resource consumption and manufacturing of long-life products in contrast to more sales.

6. Financing

Public policies are required to promote green and sustainable chemistry. In fact, the market is not spontaneously leading towards green and sustainable chemistry because the perception dominates that imposing new standards on chemical industry would damage competitiveness.

Actually, this is a short term view of the market performance: *vice versa* negative environmental costs reduce the market value of an average chemical firm because experience shows instead that an appropriate regulation eventually supports competitiveness.

The question is how regulation for a green chemistry should be defined. Also in this case experience shows that regulation is founded basically on a "command and control" approach to dangerous chemicals; a crucial role at this regard is risk assessment: in Europe, Registration, Evaluation and Authorization of Chemicals (REACH) will play a fundamental function.

There is an unanimous request for an active policy to promote a chemistry green and sustainable oriented.

Some aspects of this policy are costless. For example:
1. Favor procedures for a better protection of intellectual property rights in the area of green chemistry;
2. Green oriented public procurement;
3. Give trade reform a greener orientation at an international level.

Other aspects are costly. For example:
1. Subsidies to R&D in green chemistry, particularly in SMEs;
2. Supporting programs of international technological cooperation.

The financial support to these costly measures could be achieved from two main sources:
1. reducing perverse subsidies to traditional polluting chemical processes and products,
2. imposing traditional polluting chemical processes and products a price (charge) possibly connected to the value of the environmental damage seems necessary.

It should be also mentioned that a not expensive and easy way to promote Green Chemistry is to grant awards to young researchers in the field.

Moreover, command and control should be integrated to an increased use of price incentives.

Such economic measures should go along with Society's environmental responsibility, as this is a powerful driver of this change of strategy. So, more entrepreneurs should be convinced of the medium term advantage of a green chemistry choice.

At this regard, education for final consumers will play a pivotal role.

Venice, June 8th, 2012

APPENDIXES

This document incorporates five Appendixes that signify the growing interest of the scientific community on Green Chemistry, beginning from the OECD involvement in the area from which the present Workshop originates and wants to represent the continuation.

They are:

Appendix 1: Summary of the work done by OECD in the years 1998 - 2001.

Appendix 2: Worldwide Awards for Green Chemistry Research granted by governments, academia and industry.

Appendix 3: A few Recent IUPAC works related to Green and Sustainable Chemistry at international level as well as in **the European region.**

Appendix 4: The European Roadmap on Chemical Sciences recently published by European Association on Chemical and Molecular Sciences.

Appendix 5: Priorities on Green and Sustainable Chemistry on the Veneto Region.

Appendix 1

OECD and its Sustainable Chemistry Program (1998-2001).
(from: IUPAC Workshop on Green Chemistry Education, ISBN 88 88214 00 5, p. 25-29.
Link: http://www.unive.it/media/allegato/DIP/SAmbInfStat/Eventi/SciAmb/GreenSustainableChemistry/IUPAC-OECD.pdf)

In the framework of the "Risk management Programme" within the Organisation for Economic Co-operation and Development (OECD), a new activity called "Sustainable Chemistry" was endorsed by the member countries (Paris, February 1998), with an aim to encourage the development of chemical products and processes (and to recommend the related actions) which are at the same time environmentally friendly and economically viable.
The activity started with a survey of the Steering Group [USA, Italy, Japan, Germany, Belgium, Canada, Mexico, Sweden, UK, and Business and Industry Advisor Committee to the OECD (BIAC)] on programs and initiatives on Green/Sustainable Chemistry launched worldwide by governments, industries and academies.
In consideration of the results of the survey, the policy and programmatic aspects of the Sustainable Chemistry activity were discussed at the Venice Workshop (October 1998) in the presence of representatives from governments,
industries and academies from 22 countries and approved at the OECD meeting in Paris (6 June, 1999).
This Workshop was hosted by the Interuniversity 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 for Pure and Applied Chemistry (IUPAC) and BIAC.
The workshop focused on the policy/programmatic aspects of Sustainable Chemistry initiatives, with a mandate to:

- identify the types of Sustainable Chemistry activities already under way, supported in part by the results of an OECD-wide survey;
- identify effective techniques and approaches in the field of Sustainable Chemistry (including educational approaches), considering problems and highlighting solutions;
- identify activities that could further the development and use of Sustainable Chemistry.

During the Workshop the United States Environmental Protection Agency presented a report summarising survey responses and identifying trends across Member countries. It was evident from the response to the survey and from the lectures and interventions made during the workshop that considerable interest and enthusiasm exist among governments, industry, NGOs and academia both for Sustainable Chemistry's basic concepts and for practical developments.
Further, many stated that it was imperative to integrate Sustainable Chemistry thinking into the fields of chemistry and environmental sciences, and throughout the vast array of industrial sectors that they affect.

Seven Recommendations, suggested at the Venice Workshop, were endorsed by the following OECD Joint Meeting, held in Paris in September 1999:

1. The existing OECD Steering Group that was formed to organize the workshop should remain intact and take on the new responsibility of overseeing the implementation of these recommendations;
2. OECD should publish the proceedings for this workshop;
3. OECD should encourage Member countries to undertake Sustainable Chemistry research and facilitate the development of effective research activities in institutions and other organizations;
4. OECD should begin an activity that establishes an international programme for rewarding and recognizing work in the area of Sustainable Chemistry and provides guidance to countries interested in establishing national programmes;
5. OECD should establish an information exchange activity on Sustainable Chemistry to promote the development and functioning of the international Sustainable Chemistry community;
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;
7. OECD should promote the incorporation of Sustainable Chemistry concepts into chemical education and provide support material to do so.

Recommendations 1 and 2 were approved at the Fourth Meeting of the Working Party on Risk Management and require no further planning or discussion. The Task Descriptions section included a prioritisation of recommendations
3-7 and the brief descriptions of the tasks needed to implement each recommendation. The detailed description of recommendation 7, which specifically regards education, is presented below. It should again be noted that many recommendations were considered at the October 1998 Workshop and that recommendations 3-7 were considered of the highest priority. Recommendations 3, 4, and 7 were considered programmatic activities, whereas recommendations 5 and 6 were considered organisational and communication activities that would support and sustain the programmatic activities.
The Steering Group estimated that the tasks identified can be completed within a time period of 48 months. The US and Italy co-lead this initiative, and several Member countries on the Steering Group have led specific tasks. The Recommendation 7 relates specifically to Education, and Italy was chosen to lead this task.

According to the decision made by OECD:

RECOMMENDATION 7 (Sustainable Chemistry Education):

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

1. Priority of recommendation: Medium priority activity
2. Outcome:
   a) to have background information available to engage appropriate communities involved in undertaking Sustainable Chemistry education activities;
   b) to have information on specific resources available to facilitate the implementation of these activities.
3. Description of the tasks needed to implement recommendation:
   a) identify and begin engaging education communities as well as industrial and governmental interests on the mechanisms that are available or that need to be created to effectively incorporate Sustainable Chemistry into the education system.
   b) develop a background document that explains the need for and benefits of Sustainable Chemistry education.
   c) develop a resource guide of existing Sustainable Chemistry educational materials/ tools
   d) identify and develop new educational materials/tools.
4. Schedule: Begin: Mid 1999. Anticipated completion: Mid 2003

On February 29 - March 1, 2000 an in informal Meeting was held in Rome between USA - Italy - Japan in order to propose future actions according to the lines endorsed by OECD.
It was suggest to organise a Workshop on R&D sustainable chemistry in Tokyo on October 2000 and to organise a second survey specifically devoted to R&D. In such a Meeting also a few aspects on education were considered
and discussed.

The second survey was sent to the Member governments, industry, and academia to collect information on the on-going research and to identify the organisations willing to be actively engaged in the Sustainable Chemistry activities. In total, 70 responses were received from 13 countries and one international organisation. The survey indicated that a number of organisations had undertaken work (or were in the process of doing so) on R&D in the context of Sustainable Chemistry, many were interested in the co-operative research at the fundamental or pre-competitive level, and many anticipated value in the establishment of an information exchange network to promote more co-operation.
The results of this survey were used as a basis for discussion at the second Workshop on Sustainable Chemistry held in Tokyo (11-12 October 2000), hosted by the Japanese Ministry of International Trade and Industry and cosponsored by the governments of Japan and the US in co-operation with the Japan Chemical Innovation Institute. One of the main objectives of the Workshop was to develop a guidance that could assist Member countries and others to develop the effective R&D programmes.
With regard to the Education, at the end of the Workshop on R&D held in Tokyo the initiative to organise a specific Workshop related to education was encouraged.

The OECD Joint Meeting of the Chemical Committee held in Paris October 7-10, 2000, expressed appreciation for the proposal a Workshop on Green Chemistry Education and suggested that, as IUPAC has a specific interest in educational matters and works on education, it should take the lead in this meeting, in collaboration and consultation with the Secretariat and Issue Team. Accordingly, Italy gave its availability to organise in Venice that a Workshop

Appendix 2:

Award for Green Chemistry Research (a short selection)

Green Chemistry research is supported by several awards that incentivise innovation and excellence in the Green Chemistry field. Some examples are:

The Presidential Green Chemistry Challenge. In the USA, The Presidential Green Chemistry Challenge was established by President Clinton in 1995 to recognise and promote fundamental and innovative chemical methods that accomplish pollution prevention through reduction at source and that have broad applicability in industry. The Presidential Green Chemistry Challenge Awards Program was established to recognise technologies that incorporate the principles of green chemistry into chemical design, manufacture and use. The evaluation of the new technology's impact include consideration of the health and environmental effects throughout the technology's lifecycle with recognition that incremental improvements are necessary. Five categories are envisaged: 1. Alternative synthetic pathways; 2. Alternative reaction conditions; 3. Design of safer chemicals; 4. Small business; 5. Academic investigator

Award for Green Products and Processes. This award was presented by INCA to Italian Companies that excelled in developing green processes and products. Examples of companies that have received the award are: Enichem, Polimeri Europa, Ausimont, Ilva Polimeri, Lamberti, Lonza Group, Mapei and Valagro.

The European Sustainable Chemistry Award . In 2010, EuCheMS, with the backing of the European Environment Agency (EEA) and the support of SusChem (European Platform for Sustainable Chemistry) and CEFIC (European Chemical Industry Association), launched the European Sustainable Chemistry Award. This Award (a prize of €10,000) was presented during the 3rd EuCheMS Chemistry Congress, on 29 August – 2 September 2010 in Nürnberg, Germany.

The Institution of Chemical Engineers Award. The IChemE awards is given for Innovation and Excellence in the Green chemical technology and sustainability area.

*Green and Sustainable Chemistry Network Award (Japan).*The Green & Sustainable Chemistry Network was established in March, 2000 to promote research and development for the Environment and Human Health and Safety through the innovation of Chemistry. One of the activities, GSCN established in 2001 was the "GSC Awards". GSC Awards are to be granted to individuals, groups or companies who greatly contributed to promote GSC through their research, development and their industrialization in the fields of development of industrial technologies, reduction of environmental bourdon (such as carbon dioxide, waste, landfill, harmful by-products etc.) and of establishing new philosophies/methodologies in research. The achievements are awarded either by the Minister of Economy, Trade and Industry, or by the Minister of the Environment, or by the Minister of Education, Sports, Culture, Science and technology, depending on their application.

RACI Green Chemistry Challenge Award. The Royal Australian Chemical Institute Green Chemistry Challenge awards recognise and promote fundamental and innovative chemical methods in Australia that accomplish pollution prevention through reduction at source and that have broad applicability in industry. They also recognise contributions to education in Green Chemistry. The Green Chemistry Challenge Awards are open to all individuals, groups and organisations, both non-profit and for profit, including academia, and industry.

Appendix 3:

A few recent works related to Green and Sustainable Chemistry by the International Union of Pure and Applied Chemistry (IUPAC)

International Conferences on Green Chemistry.

The 2012 conference will be held in Iguaçu, Brazil, in August; it will be the 4th in this recently established Series focusing on broad topics such as benign synthesis/process, green chemistry for energy/production, chemicals from renewable resources, green engineering, education in green chemistry, and engineering and policy.

Synthetic pathways and processes in green chemistry.

IUPAC Symposium in-Print PAC, 2000, 72, No. 7, 1207-1228. An introductory overview gives a detailed account of the role and interest of IUPAC in promoting this initiative with an interpretation of the meaning of the term "green chemistry" and an account of the historical emergence of the concept.

IUPAC White Book on Chlorine.

A contribution to the debate on the effect of chlorine and chlorine-containing compounds on the environment.

Chlorine-free Synthesis for Green chemistry.

PAC Special Issue March 2012. This PAC issue deals with the following topics: chlorine-free reagents, chlorine-free catalysts, phosgene replacement, chlorine-free solvents, thionyl chloride substitution, and metrics for chlorine-free reactions.

Books Series on Green Chemistry

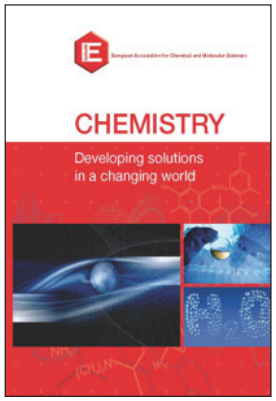
Green. Chemistry in Africa; Green Chemistry in Latin America; Green Chemistry in the Arab Regions Green Chemistry in Russia.

Global Climate Change.

A monograph for Secondary Schools was translated from Italian into English, Greek, Romanian, Portuguese, Spanish and Russian.

Appendix 4:

European Association for Chemical and Molecular Sciences (EuCheMS) Roadmap



Europe is facing economic and social challenges unmatched since the end of World War II. They should however also be seen as opportunities. Within the Europe 2020 strategy, the European Union is well positioned to promote and foster the revolutionary changes. As president Barosso underlined in his May 9 speech, re-launching growth and job creation requires financial stability as well as "structural reforms and targeted investment".
In this respect, looking from European green/sustainable chemistry point of view, the following is being considered:

- Green chemistry in a context of industrial revolution
- Green chemistry and Horizon 2020
- Green chemistry and environment
- Green chemistry and job opportunities

The Mission Growth conference (European Commission, Enterprise and Industry) articulated in more detail relevant challenges that Europe is facing. It was concluded, amongst other, that the new industrial revolution, boosted by technological developments, should lead towards the gradual introduction of substitutes of hydrocarbons as our main source of energy, and towards more efficient and sustainable use of resources that will become increasingly scarce. Green technologies are big opportunity for European firms, as the global market for green technologies is expected to double or triple by 2020. Moreover, "Scientific support for growth, jobs and sustainability: the example of eco-industries" conference (European Commission, Joint Research Centre), emphasized the unique role eco-industries can play in Europe's economic recovery and sustainable future.
Complementary, Horizon 2020, the EU Framework programme for research and innovation (2014-2020), to which the European Association for Chemical and Molecular Sciences (EuCheMS) provided an input via its roadmap "Chemistry – developing solutions in a changing world", includes green chemistry, green economy and related topics in an explicit way, which shows the importance it is being given for the coming years.
While this year's Green week was dedicated to water, the European Commission defined in its communication "Towards a job-rich recovery" a set of key employment actions for the green economy, namely (i) promote a mainstreaming of green employment into national job plans, (ii) strengthen green skills intelligence, (iii) promote greater use of EU financial instruments for smart green investments and (iv) build partnership between labour market actors.

Some further reading

1. ***Chemistry – developing solutions in a changing world***, www.euchems.eu
2. Conference ***Mission growth***, http://ec.europa.eu/enterprise/policies/innovation/policy/conference-mission-growth_en.htm
3. **Horizon 2020**, http://ec.europa.eu/research/horizon2020/index_en.cfm
4. **European forum for science and industry**, http://ec.europa.eu/dgs/jrc/index.cfm?id=6660
5. ***Every drop counts***, Green week 2012, http://www.greenweek-2012.eu/

Appendix 5:

Nowadays, both in emerging and developed countries Governments call for the development of new sustainable industrial processes. Looking to shared rules, Green and Sustainable Chemistry represents a powerful tool for a new model of development, in particular in the field of energy, water, wastes, and raw material.

Chemical Industries: Threats and Opportunities in Veneto

Threats:

90 % of the industries in Veneto are small-medium sized firms (PMI), which are exposed at several financial risks (i.e. lack of competitiveness). Integration and/or reconversion processes could represent new opportunities which, however, need a wider, innovative and more incisive participation of the Institutions (Confindustria, Academics, Politics).
The initiative "*Green Shift-The Green Choice-Success Factors for re-positioning Manufacturing PMI firms*", promoted by Confindustria and Commerce Chamber of Padua, represents a good example in which the local PMI are progressively helped in the identification of more sustainable new business, opportunities, and technologies.

Opportunities:

Due to its constant price increase, Energy is a crucial factor for Veneto, both in terms of local production capacity and as a negative factor of competitiveness.
The Energy produced by biomasses and raw materials could be an interesting area to be developed, which is associated to several additional effects such as the recovering/re-converting of exhausted industrial areas and activities, the profitable management of wide marginal lands, and the territory safeguard and stabilization.
All Institutions (Confindustria/Federchimica/Technological Parks/Academics) should act in coordination to provide public funds which are necessary to support such projects.

Looking for a reference scenario

At Country/Regional level a consistent macro project describing new models of sustainability should be set as soon as possible and an Industrial Policy has (and could) to follow just later. In such a macro project the Green and Sustainable Chemistry should play a key role in defining new scenarios for a more sustainable industrial development.

Università
Ca'Foscari
Venezia

Ministero degli Affari Esteri

Consiglio Nazionale delle Ricerche

In cooperation with
Venice Office
United Nations Educational, Scientific and Cultural Organization

Green and Sustainable Chemistry

Ca' Foscari University of Venice June 8th, 2012

In collaboration with
Department of Environmental Sciences, Informatics and Statistics
Department of Molecular Sciences and Nanosystems

Steering Committee
Dr. **Gabriele Aquilina** Head of the Italian Delegation to the Joint Meeting - OECD / EHS Programme, Istituto Superiore di Sanità, Rome, Italy
Prof. **Pietro Tundo** Italian Delegate to the Joint Meeting - OECD / EHS Programme, Ca' Foscari University of Venice
Drssa **Lucilla Alagna** Italian Delegate to the Joint Meeting - OECD / EHS Programme, Science Expert DGMO Ministry of Foreign Affairs
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Prof. **Pietro Tundo** Department of Environmental Science, Informatics and Statistics, Ca' Foscari University
Dr. **Fabio Aricò** Department of Environmental Science, Informatics and Statistics, Ca' Foscari University
Dr. **Andrea Vavasori** Department of Molecular Science and Nanosystems, Ca' Foscari University

Workshop:

9.00-13.00 Ca' Foscari - Aula Baratto

9.00 **Welcome and Opening Remarks**
Ca' Foscari University, Rector Prof. **Carlo Carraro**
Minister of Enviroment, Dr. **Corrado Clini**
The National Research Council, as Deputy for the President, Dr. **Sesto Viticoli**

Green/sustainable chemistry in Europe

Chair: Dr. **Gabriele Aquilina**, National Health Institute (Istituto Superiore di Sanità), ISS
9.45 OECD, Environmental Directorate, Paris, Dr. **Peter Börkey**
10.15 UNESCO-BRESCE, Dr. **Mario Scalet**
10.30 EuCheMS , Brussels Secretary General, Dr. **Nineta Majcen**
10.45 Ca' Foscari University, Prof. **Ignazio Musu**

11.00 Coffee break

Green/sustainable chemistry in Research and Industry

Chair: Prof. **Pietro Tundo**, Ca' Foscari University of Venice
11.15 Mossi & Ghisolfi, Ing. **Guido Ghisolfi**
11.30 ENI-Versalis, Dr. **Gianni Girotti** e Ing. **Sergio Lombardini**
11.45 Confindustria Veneto, Dr. **Massimo D'Onofrio**
12.00 University of Perugia, Prof. **Luigi Vaccaro**

State of the Art in Italy

Chair: Dr.ssa **Lucilla Alagna**, Ministry of Foreign Affairs; DGMO, Rome
12.15 Coordinator of the Department of Chemical Science and Materials Technologies, CNR, Dr. **Luigi Ambrosio**
12.30 Emilia-Romagna Region, Head of Unit & ECHA, Dr.ssa **Silvia Grandi**
12.45 National Council of Chemists - Rome, Prof. **Sergio Facchetti**

13.00 Lunch time

14.00-16.30, Auditorium Santa Margherita

14.00 **Ca' Foscari University on Green, Sustainable Chemistry and Green Growth; Departments Contributions**

14.30 **Discussion and endorsement of the Position Paper**
Participants:
University, CNR, Ministry of Environment, ISS, EuCheMS, OECD, UNESCO-BRESCE, ENI-Versalis, Mossi & Ghisolfi, National Council of Chemists, MAE and Confindustria Veneto

16.30 Conclusions

The Workshop will be held in English