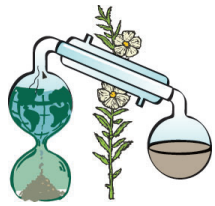
Editorial

Sustainable Chemistry: Signal for Innovation or only Slogan?



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Introduction

'Sustainable Chemistry' is the title of a series of papers in ESPR starting with the current September issue.

The term 'sustainability' was introduced in the public debate in 1992 by the UNCED (UN Conference on Environment and Development) in Rio de Janeiro, Brazil. There, all countries committed themselves to the overarching goal of 'sustainable development' in conjunction with the meaning of the Brundtland report "*….development that meets the needs of the present without compromising the ability of future generations to meet their own needs*" [1]. This was the starting point for an ongoing discussion on the concrete meaning of the term 'sustainability'.

'Sustainability' is a rather unwieldy term. Politicians, industrial organisations and non-governmental groups claim it for their different interests and targets, and use it as an argument in political conflicts without explaining why their action can be regarded as 'sustainable'. Politicians like to constitute and consult expert committees advising them in long-term perspectives and tendencies [2]; however, often enough they fail to integrate this advice in their daily work. Some NGOs representing environmental or consumers' interests occasionally reveal a very narrow view on ecological aspects and human health because they ignore the fact that 'sustainable development' cannot be realized without the economic actors in our society. Finally, though industry generally admits sustainability, it asserts that ecological and social aspects of sustainable development are overestimated, while the economic side is neglected.

The aim of this series on 'sustainable chemistry'

It is not the aim of this series to contribute to the ongoing controversial debate on the term 'sustainability'. On the contrary, we would like to explore the beneficial potential of 'sustainability in chemistry' for the sake of chemical safety including future chemical production, processes and products. We would like to investigate the obstacles to hinder the implementation of innovative and sustainable solutions.

How can chemists contribute to sustainable chemistry?

The discussion, can chemists contribute to 'sustainable development', and in which way, is rather young. Most chemists did not hear anything about this issue at the university; sustainability topics obviously did not exist in research and the curricula. 'Life without chemistry is not possible'; 'only with chemistry can mankind prosper' – these were the slogans 20 years ago which demonstrated an unbroken belief in the growth and wealth achieved by chemistry. In the late seventies (Seveso) and eighties, this faith was shaken; many people now perceived chemistry as a threat to the environment and human health. Many chemists were perplexed about this change in the public image and perception. Today, the controversies of the last two decades have generated a more differentiated thinking necessary to minimize the risks posed by chemicals and chemical processes.

The chemical industry has achieved significant improvements with regard to the reduction of direct emissions and waste. This is a result from the high technical level which has been developed in the meantime, under consideration of the saving of energy and raw material. The most hazardous chemicals like PCBs and other POPs are banned [3]. Sustainability targets, however, continue to play only a subordinate role in the development of new chemicals and chemical processes. New chemicals should fulfil their function in an optimised manner; but the proportion of new chemicals which are classified as dangerous is not lower than that of existing chemicals. When developing new processes or products, criteria like low resource demand, low waste, low toxicity are mostly of minor importance. Sustainability is still waiting to become a main goal worthwhile being conquered.

Sustainable chemistry as an innovative new branch of chemical science

Some people believe that chemistry is a mature science which can look back on a very proud tradition. New approaches demonstrate that chemistry is still an exciting science with challenging problems. Renewable raw materials are discovered as an alternative feedstock for chemical production; it is not only that they have the advantage of being CO_2-neutral, they also result in new interesting applications [4]. The importance of heterogeneous catalysis and biotechnology in designing chemical processes has been growing in the last decade [5]. Many syntheses are now planned, taking into account atom economy and structure-activity relationships [6]. While the debate on chlorine chemistry in the past was not always helpful, it nevertheless guided the development of new substances and products to the target of compatibility to the envi-

ronment and human health. These examples demonstrate that chemistry has the capacity to move toward sustainability and may provide innovative solutions for further development.

This progress is accompanied by the development of harmonized guidelines for risk assessment, plans and measures to manage and reduce the risks, and economic models which facilitate the identification and implementation of sustainable solutions. Compared with the eighties and nineties, debates about 'substances of the month' have become rare events. With regard to sustainability, it is important to stress that the 'persistence of chemicals' is a central criterion in chemical assessment: 'Short-range chemicals', which do not remain in the environment for longer periods and are not distributed over long ranges, will protect future generations from unknown risks [7]. The German Federal Institute for Occupational Health and Safety (BAuA) developed a scheme to categorize chemicals in respect to their inherent safety at work-places which is based on classification and labelling. This scheme aims at a hierarchy of management options and a high proportion of chemicals which are inherently safe and can be used by small and medium enterprises without detailed technical safety measures [8]. Moreover, it has become more and more common to reflect the entire lifecycle of products from 'cradle to grave' and to identify sustainable solutions together with all actors of the supply chain. This approach, for example, is realized by the so-called product panels in Denmark [9]. In addition, economic models like 'chemical leasing' help to reduce the use of chemicals and, hence, to minimize costs, thereby creating a win-win situation [10].

How can sustainable chemistry be promoted and implemented?

Looking at the other side of the Atlantic ocean, we recognize that under the term 'Green Chemistry' an innovative branch of chemistry has grown from a Cinderella to a well-supported and acknowledged part of chemistry. In 1998, Anastas and Warner published 12 principles of Green Chemistry which are widely accepted as a basis of describing green and sustainable chemistry [11]. In 2004, the Senate and House of Representatives of the USA approved the support of research and development of green chemistry in 2005 to 2007 with $38.5 Mio, defining the subject as "chemistry and chemical engineering to design chemical products and processes that reduce or eliminate the use or generation of hazardous substances". In Europe, a comparable support is still lacking. In the USA, the main focus is on innovative research and education in order to implement a new thinking of scientists in research, industry and authorities hoping that, in this way, green chemistry will spread out by itself. This implies that insufficient research and understanding of the actors are the main obstacles which are to be overcome to enter a glorious green chemistry era.

Certainly, sustainable chemistry will not succeed without both enhanced research grants and a modern, problem-oriented education in academia. Particularly with regard to chemical processing, sustainable solutions are economically favourable. However, they often need higher starting investments which tend to be avoided, whereas time-to-market aspects are more decisive. 'Quick and dirty' approaches are in conflict with sound, but time-consuming and integrated solutions. Therefore, smooth steps may be more successful than radical changes.

The reduction of research capacities in chemical industry and low readiness for cooperating with other disciplines are further reasons for the slow speed in implementation. An effective information network throughout the supply chain and liability requirements may be important drivers. It will be necessary to identify further impediments when speeding up the implementation of sustainability in chemistry.

Indispensable for the promotion of sustainable innovation in chemistry will be an ambitious legal and regulatory framework which functions as a target-setter and not as an obstacle. With regard to chemical processing, the IPPC-Directive 96/61/EC of the EU is a successful example for a legislation and related rules which does not prescribe definite abatement measures, but is based on information exchange with flexible mechanisms for the implementation of further technological development. The narrow ridge between impeding innovation by high administrative requirements, and too weak demands regarding environmental safety and human health, has to be recognized when discussing the question of substituting hazardous substances. A legal framework should favour and facilitate non-hazardous substances and set definite criteria and data requirements for these alternatives in order to prevent inadequate solutions [12]. It will be one of the crucial requirements in designing REACH as the new European chemical legislation is to be both demanding and encouraging. It is clear that the claim of 'lowering the legal requirements means promoting innovation' is far too simple. Several examples demonstrate that high legal requirements induced the development and distribution of better alternatives.

Starting point for a dialogue on sustainable chemistry

To move toward sustainable chemistry, all actors need a common understanding of the capacity 'sustainable'. Despite the activities of several international fora like OECD and OSPAR, such a common understanding has not yet been achieved. Therefore, an intensive discussion between experts of different disciplines is one of the main tasks for the near future in order to identify criteria for sustainable chemicals, products and processes. The OECD-supported workshop [13], held in Dessau (Germany) in January 2004, was a promising start into a dialogue for a common understanding. 150 experts from 14 countries exchanged their views and presented interesting new insights. The German Federal Environmental Agency (UBA), as the organizer, was called to continue working on this issue and to develop a network for information exchange. This series of articles in ESPR will be an important part of this further work. The dialogue can only be successful when all affected sectors, academia, authorities, industry and public interest groups, as well as representatives of different disciplines, will participate in this process. The door to a sustainable chemistry is only open a crack. However, it should be pushed open widely.

To this end, and as announced in the July-issue of ESPR (No. 4, p. 8A, 2004), a series on the following topics will be published in several issues of ESPR:

- Principles and Perspectives
- Sustainable Chemicals
- Sustainable Production and Processing
- Sustainable Products
- Implementation of Sustainable Chemistry

We will appreciate interesting contributions to this series.

The editors would like to make an introduction

The editors of this series have different responsibilities in the Federal Environmental Agency in Berlin and, thus, cover different aspects in the sustainable chemistry issue. Klaus Günter Steinhäuser, Petra Greiner and Steffi Richter are members of the Division 'Chemical and Biological Safety' dealing with the safety and sustainability of chemicals. Jutta Penning and Michael Angrick belong to the Division ' Environmentally Compatible Technologies – Processes and Products ' and take responsibility for the sustainable production and processing in chemical industries, and in the downstream processing of chemicals in different branches.

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[13] UBA/OECD (2004): Report on the International Workshop on 'Sustainable Chemistry – Integrated Management of Chemicals, Products and Processes', 27 to 29 January 2004, Dessau < http://www.sustainable-chemistry.com>

[Ref. 13] The workshop was held by the Federal Environmental Agency (UBA) in cooperation with the OECD and the Federal Institute of Occupational Health (BAuA). The aim of this workshop was to provide representatives and experts from authorities, research and university institutes, environmental NGOs and industry of OECD countries a forum to discuss steps forward to be made for development of sustainable chemistry.

Documentation of the Workshop
<http://www.sustainable-chemistry.com/agenda.html>

Tuesday, 27 January 2004
Opening and Introduction into the Program
Session I:
Principles and Perspectives of Sustainable Chemistry
Session II
Sustainable Chemicals – We know what we produce – but do we know enough about Risks and Hazards?
Session II A:
Sustainable Chemicals and Environment
Session II B:
Sustainable Chemicals and Occupational Health

Wednesday, 28 January 2004
Session II A:
Sustainable Chemicals and Environment (continuing from the day before)
Working Group: Criteria and possible Indicators for Environment
Working Group: Instruments I
Session II B:
Sustainable Chemicals and Occupational Health (continuing from the day before)
Working Group: Criteria and possible Indicators for Occupational Health
Working Group: Instruments II
Session III:
Sustainable Production and Processing – We know what we do – but do we know what we could do?
2 Working Groups: 1: Criteria and possible Indicators, 2: Instruments for Implementation
Session IV
Sustainable Products – Do we use what we need and do we need what we use?
Working Group: Criteria and possible Indicators

Thursday, 29 January 2004
Session III:
2 Working Groups (continuing from the day before): 1: Criteria and possible Indicators 2: Instruments for Implementation
Session IV:
Working Group: Instruments
Session V:
Implementation – We know the target, but how to reach it?