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Guest editorial: Agenda 21 as a guide for green chemistry research and a sustainable future†

Terry Collins asked in his recent editorial (*Green Chem.*, 2003, **5**, G51) two important questions: 'How should education change to better promote a **sustainable future**?' and 'How should research change to better promote a **sustainable future**?' I can fully subscribe to the answers and the conclusions given by Terry, as I am sure will most readers of this journal. Then, rethinking the editorial, I thought that it would be useful to tackle these questions from another perspective. To give an answer, we must have a thorough and very precise understanding of what **sustainable development** may be, considering its ecological, economical and social dimensions. In principle, this is quite simple; in practice it is much more difficult.

Sustainable development is being understood as the implementation of the Rio Declaration and Agenda 21 including its ongoing advancement such as the Johannesburg Declaration and Plan of Implementation of the World Summit on Sustainable Development in 2002. Thus, chemistry will best promote sustainable development by being devoted to the implementation of the Rio process. The 27 principles of the Rio Declaration were made concrete in Agenda 21, the comprehensive plan of action for the 21st century that was adopted by more than 170 governments in Rio. Agenda 21 'addresses the pressing problems of today and also aims at preparing the world for the challenges of the next century. It reflects a global consensus and political commitment at the highest level on development and environmental cooperation.' (Chapter 1.3). The 'pressing problems' were developed most precisely and flexibly in 40 chapters. 'The programme areas that constitute Agenda 21 are described in terms of the basis for action, objectives, activities and means of implementation. **Agenda 21 is a dynamic programme** … It could evolve over time in the light of changing needs and circumstances.' (Chapter 1.6).

The fact that the Rio process marks the very beginning of a new global partnership for sustainable development is most important. In the 11 years since Rio we have all come to understand the fragility of this process on the one hand and the importance and the necessity of continuing it on the other. There is no alternative for mankind. The Rio process must become irreversible.

The 'Conservation and management of resources for development' constitutes the main focus of interest outlined in 14 chapters of Agenda 21. The sciences have to make considerable contributions if this aim is to be achieved. Chapter 35, 'Science for Sustainable Development', 'focuses on the role and the use of the sciences in supporting the prudent management of the environment and development for the daily survival and future development of humanity… The sciences should continue to play an increasing role in providing for an improvement in the efficiency of resource utilization and in finding new development practices, resources, and alternatives. There is a need for the sciences constantly to reassess and promote less intensive trends in resource utilization, including less intensive utilization of energy in industry, agriculture, and transportation. Thus, the sciences are increasingly being understood as an essential component in the search for feasible pathways towards sustainable development.' If this statement is right—and I have no doubt that it is—then the sciences may have to change and focus on contributing to the solution of the pressing problems outlined. This, however, means nothing less than requesting scientists to develop their basic and applied research topics from the immense catalogue of unsolved problems that stand in the way of the sustainable development outlined in Agenda 21. This also applies to chemistry and chemical research topics thus developed. They clearly will be appropriately termed 'green chemistry' or 'sustainable chemistry' and should all become important topics of discussion in this journal.

As examples of what I mean, I will briefly outline several of these unsolved problems and the possible contribution of chemistry with respect to the important Chapter 4 'Changing Consumption Patterns'. This chapter focuses on 'unsustainable patterns of production and consumption' and 'national policies and strategies to encourage changes in unsustainable consumption patterns'.

The encouragement of the environmentally sound and sustainable use of natural resources is one aim of this chapter. At present, the proportion of renewable raw materials in the feedstock consumption of the chemical industry in the industrialized countries runs to less than 10%. It is assumed that this percentage will increase considerably. In 2020, 25% of the production of organic chemical products is expected to come from renewable feedstocks. In the long term, renewables are the only workable solution, and their processing by catalytic and other methods will make it possible to replace oil as civilization's basic feedstock. Here it should be pointed out that the selective catalytic transformation of the complex molecules of biomass presents a very great challenge to chemists. Most products obtained from renewable raw materials are at present not competitive with petrochemical products, a circumstance that will change rapidly when oil resources diminish and the oil price rises. Therefore, it is high time to expand basic research on the chemical transformation of renewable feedstocks to

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achieve substitution processes and products as was pointed out by the German Chemical Society on the occasion of the world summit in Johannesburg (http://www.gdch.de). However, chemistry is changing very slowly. Obviously, chemical companies are comfortable with petrochemicals and are reluctant to process alternative renewable feedstocks such as plant oils and carbohydrates, which may not be suited to the usual petrochemical processing. This presents a serious general structural flaw in chemical education. Chemists learn from the very beginning to think in terms of petrochemical product lines. It is difficult for us to develop alternative thinking in terms of renewable feedstock product lines that have not been available up to now and have to be invented. While most chemists continue to prefer simple petrochemical molecules as feedstocks to develop catalysts and reactions, the growing trend among the newly forming green chemistry community to develop green catalysts, green solvents, and green reactions around renewable source materials is particularly important in the field. We need to a certain extent to substitute current curricular material that teaches today's students classical thinking in terms of petrochemical products with material that advances their ability to think about a future chemical industry based on renewable feedstocks. For the students, this will lessen the inevitable challenge of transforming their skills to suit the processing of feedstocks that will become more and more biomass-based. The classical approach that holds hegemony today is possibly not preparing them even remotely adequately for this challenge.

There is another problem tenuously connected with this old thinking. The competition between the cultivation of food and renewable raw materials for the limited available agricultural area could lead to problems, because food demand and consumption will also increase dramatically. The world population will rise from the present 6 billion people to about 9 billion by the year 2050. For that reason, the United Nations programs to combat desertification (Agenda 21, Chapter 12; see also 'United Nations Convention to Combat Desertification') and deforestation (Agenda 21, Chapter 11, see also Statement of Principles for a Global Consensus on the Management, Conservation and Sustainable Development of all Types of Forests, Rio Conference, 1992) are most important. Unfortunately, the implementation of these programs has not advanced much, mainly because the industrialized countries have not been interested. Obviously, the implementation of these programs has to be greatly intensified, both to stop desertification and deforestation, and also to regenerate agricultural areas by 'combating land degradation through, *inter alia*, intensified soil conservation, afforestation and reforestation activities' (Agenda 21, Chapter 12.4b). The sciences and especially chemistry could make enormous contributions to these programs, which may also help to stabilize a favourable global climate. However, are the sciences, and in particular is chemistry, prepared to make the necessary contributions? We have already lost much time by not rising to the research challenges of sustainable development that have been available for study in the forty chapters of Agenda 21 for 11 years now, and we will lose much more if we continue to not refer to Agenda 21 in establishing our national and international research project priorities.

During the Christmas period, when I was writing this editorial, a European and an American mission arrived on the planet Mars, one most successfully, the other much less so. Obviously, it may be fascinating for some people, and, I confess, also for me, to know whether molecules of water or of any organic compound may be found on this planet. However, beside the fact that mankind will have available thousands of years to answer this interesting question, assuming that sustainable development of human civilization on this earth can be established, it could be thought that this kind of research at this time is contra-sustainable. In other words, 2 billion euros—the approximate cost of these two missions to Mars—is now not available for sustainability-related research, *e.g.* to reverse desertification and deforestation, which is clearly an important step on the road to sustainable development.

Recently, energy ministers from around the world signed the first international framework for R&D on the capture and storage of CO_2 emissions (*Chem. Eng. News*, June 30, 2003, 19). Will that be a step towards sustainable development? Consulting Agenda 21 and also the documents of last year's world summit in Johannesburg reveals, remarkably, that CO_2 sequestration and R&D on this topic have not been on the agenda for sustainable development. One might think that this first international framework is just a program for the industrialized and some industrializing countries to continue their unsustainable practices, as strikingly characterized in chapter 4 of Agenda 21. Perhaps this framework could be oriented in the direction of sustainable development if it could be successfully coupled to the UN program to combat desertification and deforestation, because the most efficient system of CO_2 sequestration, validated over millions of years, is the terrestrial biosphere. However most probably these billions of dollars and euros spent on capturing and storing CO_2 will be wasted and will be lost to research contributing to sustainable development, as have been many more billions of dollars and euros in the years since Rio.

Terry Collins emphasized in his editorial that 'our responsibility translates into a duty to alert civilization to move away from the dependence that is undermining it.' There is no time like the present to be doing this!

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