THE INTEGRATION OF TOPICS ON HISTORY OF CHEMISTRY IN SECONDARY SCHOOL CURRICULA – A SYSTEMIC APPROACH

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The integration of topics on History of Chemistry in secondary school and University curricula, together with the correlated social and economic aspects of the implementation of chemical industries, in particular from the late nineteenth century up to our days, may be a powerful resource to help teachers contextualize different topics of Chemistry as a way of promoting better learning outcomes.

Complex areas like chemical equilibrium and Le Chatelier's Principle, catalysis and chemical kinetics, for example, are usually considered difficult by students that traditionally study them in artificial contexts and in a very formal way, often with long mathematical calculations, that make them extremely abstract and arid. Moreover the strategy used for the teaching of those concepts is linear, studying topic after topic often without any correlation.

The use of history of chemistry as background for a systemic approach for teaching and learning some of those chemistry topics helps students to develop an overall view of the interrelations of the concepts involved as well as of the development of the process of research in chemistry both as science and technology. The example of the synthesis of ammonia with all its technological challenges that culminated with the Haber process (Nobel Prize in 1918), is an extremely interesting example of the didactic possibilities the systemic approach proposed. This approach is represented in the following diagram (Fig. 1), where the main concepts relevant in the process are shown.

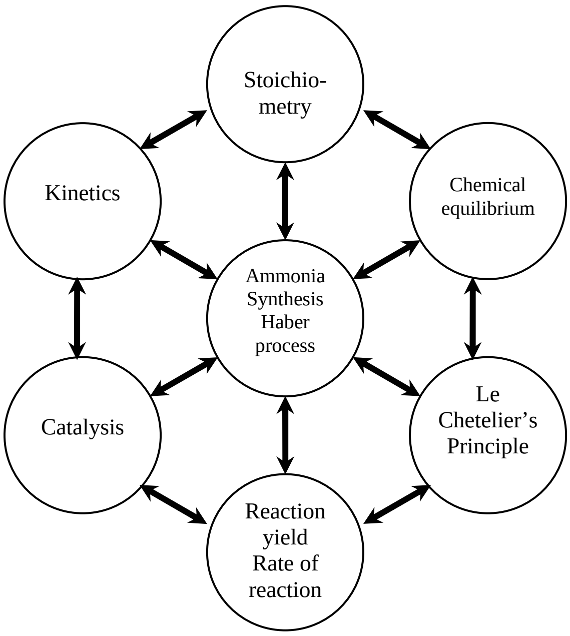

Figure1- The ammonia synthesis – Haber process

All the concepts included in the diagram are fundamental (and interconnected) for the determination of the rate and yield of the reaction, that are crucial in the industrial production of ammonia. The history of the ideas and processes involved, as they were proposed and developed by chemists like Le Chetelier, Thénard or Haber, also gives the human perspective of the evolution of science and technology.

It is important to point that we can widen the scope of this example. If we want to go further and allow students to get a better perspective of the impact of chemistry and chemical technology, a possible contextualization of the topics referred is related to the study of the changes in agriculture that occurred along the last 150 years in relation with fertilizers and later with the synthesis of ammonia. Focusing this study in a national (or regional) perspective may help to increase the interest of students, in the line of the proposed UNESCO strategies for education for sustainable development.

As a national example that can be used as context, by the beginning of the 20th century in Portugal, the change in the agricultural processes started with the introduction of synthetic chemical fertilizers, following the trend already shown in more developed countries. Several known Portuguese chemists engaged in the popularization of the principles of the so called “scientific agriculture” that substituted the traditional small scale familiar agriculture, using biological fertilizers, by a larger scale production with the massive use of chemicals, in particular nitrates and phosphates as fertilizers. Conferences and booklets produced by these scientists are interesting sources of information about this process of modernization of agriculture.

The use of synthetic fertilizers was made possible by the production in large scale of ammonia that is an essential chemical for their synthesis. The Haber process was the key factor of the development of the Portuguese chemical industry associated to this production. It is interesting to mention that the process used nowadays, in most plants all over the world, for the production of ammonia is still basically very similar to the originally proposed by Haber, about one century ago.

As mentioned above, the study of the original Haber process involves the understanding of the complex concepts previously referred, namely chemical equilibrium, catalysis and chemical kinetics. Le Chatelier’s Principle in its different formulations is also a fundamental piece of knowledge that can be studied in the context of the process. The contributions of outstanding chemists like Ostwald, Nernst or Vant’Hoff and the study of controversies about the different formulations of the Le Chatelier’s Principle may also be studied in depth in this context, in particular in more advanced classes.

All this systemic study may be considered a “cluster” that is the basis for the knowledge about the industrial production of ammonia, which is in the centre of the new diagram represented below (Fig. 2). This diagram translates the relationships among the industrial production of ammonia by the Haber process (studied before) and the impacts, positive and negative in the environment, considered in a holistic perspective. The diagram includes the socio-economic consequences of the process that have to be considered, as this transformation of agriculture is closely linked to the development of chemical industry that started producing fertilizers in large scale, and to the demographic changes that this implied. Furthermore, in a perspective of sustainable development it has to be stressed that the initial good results of the new techniques contributed to the establishment of new practices. Slowly, however, the increase in production began to be smaller and that led farmers to use bigger amounts of fertilizers in an attempt to compensate the decrease in production. These fertilizers, used very often in excess, contaminate ground waters that frequently show high concentrations in particular of nitrates that make them, in some cases, unsuitable for human use. And so, in the diagram, the environmental consequences (in the traditional restricted meaning related to pollution) also are included.

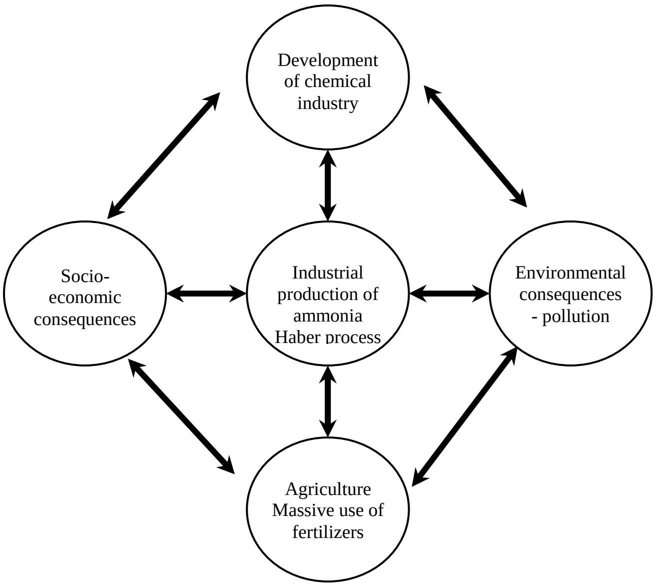

Figure 2 – Industrial production of ammonia

This is an example, among many others, where the use of History of Chemistry, in particular the study of the evolution of chemistry concepts and related chemical technology, can contribute to motivate students to study difficult topics, by showing its impact in the evolution of society along the time. It can be of great value if it is intended to give students a global view of chemistry and its importance for the sustainable development of our world, and not only the simple knowledge of a set of unrelated chemistry concepts.

Bibliography:

Fahmy,A.M. and Lagowski, J.J.; J. Chem. Educ., **80,** (9), 1078-83, 2003.

Knight, D.M., *Ideas in Chemistry: A History of Science*, Rutgers University Press, 1995

Lister, T. (comp.), *Cutting Edge Chemistry*, Royal Society of Chemistry, London, 2000.

Partington, J.R., *História de la Química*, Espasa-Calpe, Madrid, 1945.

Shortland, M. e Warwick, Eds. *Teaching the History of Science*, Basil Blackwell, Oxford, 1989.