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Energy Quarterly

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MATERIALS FOR ENERGY BLOG
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Images incorporated to create the energy puzzle concept used under license from Shutterstock.com. Energy Sector Analysis image: A derrick drilling in the Eagle Ford Shale in South Texas.

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MRSBulletin

Future loves history

The 100th anniversary of the industrialization of ammonia synthesis was celebrated in 2013. The headline of this editorial happens to be the subtitle of a symposium I recently attended. Near the end of the 19th century, securing an active nitrogen source for fertilizers in agriculture was critical because of the explosive population growth that exhausted active natural nitrogen resources. Chemist Fritz Haber of Karlsruhe University succeeded in the artificial synthesis of ammonia under high pressure (~100 atm) and high temperature (600–1000°C) using osmium as the catalyst. Chemical engineers thought it impossible to achieve industrial production using such severe conditions, except for a young researcher, Carl Bosch, who later became the president of BASF. His team achieved this by overcoming many technical difficulties, including hydrogen embrittlement of metals. Alwin Mittasch explored alternatives to the rare and expensive osmium by the systematic screening of thousands of candidate materials, eventually finding that Swedish magnetite worked as an efficient catalyst. This is a brief history of the so-called Haber–Bosch (HB)-process, which is now producing 1.7 hundred million tons/year of ammonia.

The invention of the HB-process is recorded in history as a monumental landmark. To my shame, I only belatedly realized this after hearing talks by several pioneers. The HB-process was realized by the successful transfer of a university research breakthrough to industry. The big ammonia synthesis industry and a new science frontier of high pressure reactions were established. To overcome a critical issue, a fundamental science breakthrough jump-started the engineering, and eventually new frontiers opened in basic science and engineering.

The energy issue is an urgent problem we have to resolve. A crucial breakthrough is strongly demanded in fundamental science such as the discovery of a new superconducting material with higher T_c and less anisotropy, or a solar cell material with higher efficiency and stability than currently available. Fortunately, advancements in materials exploration and materials design, "materials genome" and "inverse materials design," are in progress. I hope these approaches would be very helpful for the needed crucial breakthrough for energy and possibly the birth of a new field of materials science.

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