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Editorial

Catalysts inspired by life

Biosynthetic processes take place throughout our world with astonishingly high precision and rapidity to create biological systems, trees, and even such complex products as our own living bodies. Though each of the chemical reactions involved in creating something as complex as a tree is thermodynamically possible, there is nearly zero possibility of creating complex biomaterials without the use of enzymes. Breaking down those biomaterials is somewhat easier – even fire can accomplish that – but still it is enzymes that make most biodegradation possible throughout the world. An enzyme acts as a catalyst, accelerating and often helping to direct the path of a reaction that would not otherwise take place fast enough or which might otherwise tend to take a different reaction path from what is needed.

But enzymes are not the only kinds of catalysts. The present issue of *Biofuel Research Journal*, for instance, has an article that shows how zeolites can help direct the reactions of vapors of pine wood pyrolysis. Catalysts made by humans often follow our ancient tradition of alchemy: selecting or modifying minerals or metal ores in the hopes of obtaining something valuable. In his book *The Alchemy of Air*, Thomas Hager describes how the chemical engineers/inventors Fritz Haber and Carl Bosch managed to convert gaseous nitrogen into ammonia. The key was to use an impure iron wire, along with incredibly high pressure and high temperature. It is estimated that one-half of all the nitrogen atoms presently incorporated into your own body, right now, are a direct result of the Haber-Bosch process. Yes, nitrogen also can be "fixed" by biological processes, but not at a rate that would support the current human population, and humanity had to discover another catalyst in order to sustain the growth of civilization.

Another aspect of the Haber-Bosch story that is worth bearing in mind is that their invention was strongly motivated by an urgent situation. Soils around the world in the late 1800s and early 1900s were becoming depleted. Crops were failing. People were going hungry. The nitrogen-rich fertilizer collected from guano droppings accumulated over centuries on little islands off the coast of Chile was running out. While it has been said that "necessity if the mother of invention," perhaps it is more accurate to say that "necessity is the catalyst of invention". From outward appearances, one might be tempted to draw a sharp distinction between the urgent need for nitrogen fertilizer in the early 1900s and the relative abundance and current relatively low prices of crude petroleum. The important historical lesson is that guano-derived natural fertilizer was abundant and relatively easy to collect, almost up to the moment when the resources had been completely depleted.

Advances in petroleum extraction have bought some time relative to the ultimate depletion of accessible crude oil reserves. Petroleum companies express optimism about the extent of available supplies, but a parallel optimism undoubtedly prevailed in the world until guano-based fertilizer was being scraped from the last remnants on the most obscure of the Chilean islands. With each passing year the available crude petroleum is not only further down, but also further off to the side from where oil rigs can be positioned. So the costs of extraction ultimately will have to rise. And as if that is not bad enough, the continued burning of fossil fuels is enriching the carbon dioxide in the world's atmosphere. These increases in CO_2 are sufficient to explain a recent unprecedented rapid rise in average temperatures, a melting of polar ice, and higher instances of severe weather. These changes in our world's ecosystem cannot escape people's attention – especially the attention of those whose lives are focused on science and engineering. The good news is that such scientists and engineers may be catalyzed by the situation so that they help invent sustainable, bio-based alternatives to the use of fossil fuels.

Maybe humanity's current challenge involves advancing beyond "alchemy" and returning to biology as a main arena for catalysis. Such an approach is represented by the article in this issue dealing with biogenic hydrogen production. Just as in the case of the inorganic catalysts discovered by Haber and Bosch, it takes a great deal of patience and many unsuccessful attempts in order to come up with high-performing enzymes, which may be regarded as biocatalysts. Many factors may degrade or inhibit the activity of a catalyst. As emphasized in the review article "Green biodiesel production," we can expect catalysts to take center stage as humanity grapples with the challenge of sustainability in this increasingly crowded and often hungry world. These catalysts will take many forms – from transition metal complexes, to enzymes, to pieces of rusty wire. But without progress in the field of catalysis there is no way that all of us will be able to survive on this planet.

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