Chemistry´s Contribution to China´s Present and Future

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It is easy to see that China´s chemical industry has contributed to the environmental problems of the country. Examples include air pollution, water pollution and toxic substances in food and many other materials. As a consequence, local opposition to new chemical projects has been increasing, and industry regulation has already been tightened.

But it is sometimes overlooked that the chemical industry also has the potential to be a major positive force in China´s future development. Indeed, if properly directed, chemistry can help solve many of China´s most pressing issues. Chemistry can improve food security, help alleviate poverty, improve the health of the population, increase sustainability, enhance environmental protection and reduce resource intensity of the economy. This paper examines some of these items in the hope of contributing to a more balanced attitude towards chemistry.

In food production, chemistry has made major contributions. While in 1970 China´s rice production was 113 million tons, it reached 204 million tons in 2012 while the area used for rice production actually decreased. But rice yield per hectare about doubled from 3.4 tons per hectare to 6.8 hectare. The widespread application of NPK fertilizer produced by the chemical industry was the most important factor in this increase. Other factors depending on the chemical industry were the supply of secondary and micronutrients and the better crop protection via pesticides. By now, the application of some of these chemicals has actually overshot, for example for certain pesticides. However, the chemical industry will keep a strong role in maintaining and possibly further increasing food supply. New, more environmentally friendly pesticides need to be developed, with a particular focus on avoiding resistance which develops after long-term application. At the same time, fertilizer usage needs to become more targeted – for example, in the US methods to determine specific fertilizer requirements of the soil based on chemical analysis are much more widespread. In China, companies such as ALS and SGS now also offer this service. This represents another field for chemical knowledge to improve yields of China´s farmers and at the same time reduce both their costs and the damaging runoff from excess fertilizer. And even simple plastic sheets used to cover fields and thus to make them grow faster (the original “greenhouse effect”) are an example of chemical materials benefiting China´s food production.

Food usually is stored before it is consumed. Chemical substances - preservatives – are widely used to prevent spoilage of food during this period. Admittedly these preservatives do not always have a very good reputation, but at least for some substances, this is ill-deserved. For example, Vitamin C as a food ingredient as used not only as a vitamin but also as a preservative. More importantly, the alternative to preservatives produced by the chemical industry would be substantially increased amounts of wastes food.The focus of new developments in preservatives now is on low dosage and harmless break down products.

Chemical products are also used to make food healthier and more nutritious. China is the biggest global vitamin producer, and the appreciation of China´s food consumers for fortified foods is increasing rapidly. Despite having a thoroughly bad reputation, food containing products of the chemical industry may thus contribute to the improvement of China´s health.

Of course, active pharmaceutical ingredients produced by the chemical industry do so on a much larger scale. Life expectancy in China has doubled from 37 years in 1949 (when the People´s Republic was founded) to 75 years in 2010. One reason is the massive decrease in deaths from infectious diseases such as tuberculosis, which can be treated fairly

easily with chemical substances such as isoniazid. The decrease of such deaths shifts mortality to diseases that are currently not so easily treated, such as cancer and heart disease – however, even for those, treatments based on chemically synthesized substances have some degree of success and are likely to improve further.

Access to an improved water source and improved sanitation both have improved significantly in China along with economic growth. According to UNICEF estimates, between 1990 and 2008 more than 450 million Chinese gained access to an improved water source, reaching 89% of the population, while access to improved sanitation was 55% in 2008. Some of these improvements were achieved due to the use of basic chemicals such as chlorine and hydrogen peroxide as well as more sophisticated water treatment chemicals. Another trend is towards using membranes made from specialty polymers for water treatment (and also for desalination). However, water treatment is an area in which China still lags behind Western countries. The current level of water pollution will still require substantial further efforts, which makes the chemical segment of water treatment a promising one. Treatment of industrially used water also allows the reuse of water and thus reduces the overall water consumption – as many of China´s provinces suffer from low water resources, this is highly relevant. Even more indirect is chemistry´s contribution to saving water in water-saving agricultural techniques such as drip irrigation, which only delivers water to individual plants and thus almost eliminates evaporation. While sprinkler systems are around 75-85% efficient, drip systems typically are 90% or higher.Simple PVC and PE plastic pipes, basic products of the chemical industry, make this technology possible.

China passed the US as the world´s biggest energy user in 2010, and its energy usage still increases by about 4-5% per year. China will require even more energy than now to further increase the standard of living of its population. However, China already imports a large share of its oil needs, and in any case global oil resources are limited. Chemistry can also make contributions to alleviate China´s energy problems – both directly (by adding to China´s energy supply) and indirectly (by reducing the amount of energy needed per unit of GDP). Producing oil and chemicals from coal is an example for the first approach. Currently there are many coal chemicals projects in different stages of progress, and they all aim at converting coal that due to its remote location is not very suitable for utilization into more easily transportable energy sources and chemical raw materials. But alternative energy such as solar and wind also rely heavily on the chemical industry, be it to provide the materials for solar cells or for blades of wind turbines. Reduced energy consumption in transportation can be promotedby strong, light-weight materials such as engineering plastics and composite materials that can replace metals in cars and airplanes and thus reduce their weight and subsequently their fuel needs. Needless to say, chemistry also drives forward the search for efficient energy storage, e.g., in new types of batteries which are a key component of electric cars.

The shift to more sustainable raw materials sources will also require support by specific chemicals. For example, bio based value chains may lead to new monomers which then can be converted by chemical reaction into new bio based plastic materials. Many recycling processes rely on chemicals, for example, for the de-inking of paper. The resource intensity of current products can also be reduced much further, benefiting from chemical progress. Future cars will be more durable and have longer lifetimes due to better corrosion protection. 3D-printing based on chemical materials is an additive process that potentially reduces material usage.

As for China´s environmental issues, though some of them have indeed been caused by the chemical industry, the same industry will also play an important role in improving the environmental situation. The key will be the integration of environmental considerations into chemical production processes. It is much more efficient to avoid pollution of, e.g., a river in the first place by reducing byproducts of a chemical reaction in the first place rather than to clean up the river later. This approach – pushed along by regulation – has led to huge environmental improvements in European countries and also holds much promise for China. For many chemical processes, the key will be to shift from stoichiometric to catalytic processes to reduce material consumption and subsequent waste. Of course, the chemical industry also supplies many of the materials necessary to deal with existing pollution, e.g., in the shape of polymeric filter materials for power plants.

China has made huge progress reducing poverty and increasing the living standard of the population. Chemistry will be a major driver in keeping up this momentum. It is to be hoped that this will be a major motivation both for companies and for individuals to become and remain part of the industry. While much criticism of China´s chemical industry is justified, it would be a huge loss if this led to neglecting the benefits chemistry can offer China. ■