Japan's Chemical Industry: From Post-War Recovery to Globalization

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The recent earthquake and tsunami in Japan had a devastating impact on the people and industry of this economic and cultural giant. This article reflects on the emergence of Japan's chemical industry in the half-century since World War II that led to its current position — from which it will begin a new recovery.

One-hundred years ago, Japan's chemical industry entered a period of dramatic growth. The Meiji era in the late 19th and early 20th centuries ushered in Japan's industrial revolution, and by the end of World War I, Japan had became a modern nation and a major industrial power.

Within 30 years, however, many of Japan's cities and industries were devastated by World War II. During the post-war period, Japan's chemical industry had to rebuild its lost infrastructure from scratch, contributing to the recovery of the entire country. After much struggle, the chemical industry has gained great prosperity — over the decades making course corrections to deal with oil crises, new environmental protection protocols, and climate change concerns.

Mitsubishi Chemical

◀ The Mitsubishi Gas Chemical Co. complex is located in Japan's Kashima coastal industrial zone, a region heavily impacted by the Mar. 11, 2011, earthquake and tsunami. At presstime, the company planned to begin producing ethylene again by late May, and to resume normal operation in late June. However, damage to port facilities may continue to hinder full recovery.

Post-war recovery and modernization (1945–1954)

In the immediate aftermath of World War II, Japan's first priority was to feed its people. The government called upon the domestic chemical industry to supply chemical fertilizers in large and stable quantities, and implemented policies aimed at increasing production. Accordingly, ammonium sulfate fertilizer plants were constructed across the country.

At the same time, the chemical industry was increasingly expected to supply synthetic dyes for clothes, and projects to increase the production of these dyes were implemented. On another front, vinyl chloride was attracting attention for its use in housing materials, and the chemical industry was charged with meeting domestic demand for this chemical and various synthetic resins.

Additionally, inspired by the production of new chemical products such as sweeteners, pharmaceuticals, and agricultural pesticides in other countries, Japan's chemical companies became more inclined to produce these products.

In the fields of electrochemistry and coal chemistry, caustic soda production was streamlined, a sealed electric furnace was developed for use in the carbide industry, and the coal-tar industry began using continuous processing equipment.

These developments in the inorganic and organic chemical fields allowed Japan's chemical industry to increase the

value of its shipments by 2.5 times over a five-year period during this decade. Such progress contributed to its rapid recovery ahead of other industries in post-war Japan.

Domestic production of petrochemicals (1955–1964)

As imports of petrochemical products from Europe and the U.S. increased, expectations for the domestic production of these products also increased, and Japan's chemical industry entered a period of technological innovation and modernization. This marked the end of the era of chemical fertilizers and the beginning of the era of petrochemicals.

To strengthen the strategic role of petrochemicals in its economy, the Japanese government established its first petrochemical project — the state-owned Japan Synthetic Rubber Co. In the synthetic fiber sector, major progress was made in the production of acryl fiber, the industrialization of acrylonitrile and polyester, the growth of nylon manufacturing, and the development of caprolactam and polypropylene. These synthetic chemicals became the mainstream materials of the fiber industry, with new markets for processed chemical products increasing in line with the rapid spread of synthetic fibers and with the shift from soaps to synthetic detergents.

Under a second petrochemical project implemented by the Japanese government, additional petrochemical plants were constructed and began operations. Steel-chemical complexes were also built, stimulating new forms of collaboration.

During this time, Japan's chemical industry was establishing its position as a core material industry, expanding its technology to incorporate alternative processes and raw materials for existing chemicals. Among the achievements: new technologies were developed for the use of alternative materials; the ammonia process for the production of caustic soda was replaced by the electrolytic method; manufacturing facilities for polyvinyl chloride (PVC) resin were expanded and the ethylene dichloride (EDC) route was introduced; and Japan Synthetic Alcohol Co. was established.

In parallel with the rapid growth of the chemical industry, adjunct industries also achieved substantial growth, including the engineering design and construction services sector and the plastic molding industry.

Becoming the world's second-largest chemical industry (1965–1970)

As the 1960s progressed, Japan's chemical industry faced the challenge of strengthening its international competitiveness.

Technological innovation and a trend toward upsizing led to increased production at ethylene and ammonia manufacturing plants. In line with this upsizing of facilities, the industry began importing naphtha for the diversification of raw materials. Many large plants were constructed in Japan during this period, including 15 petrochemical complexes.

Meanwhile, Japan's improving standard of living and an increasing demand for processed chemical products led to the emergence of new fine-chemical companies. In particular, the pharmaceutical industry achieved substantial growth, becoming the second-largest segment among Japan's chemistry-related industries, trailing only petrochemicals.

Environmental and resource challenges (1971–1979)

Japan's economy as a whole had achieved stable growth by the 1970s, but the rapidly growing chemical industry was about to undergo structural changes.

Following the aggravation of worldwide pollution problems, developed countries began to strengthen their environmental regulations, and chemical companies across the globe gave priority to complying with these regulations. The production of caustic soda without using mercury is one example of such efforts.

The chemical industry was thus moving toward attributing more importance to the protection of the environment than to economic growth. Amid this situation, the industry faced two major oil crises.

The oil crises of the 1970s delivered a serious warning to the petrochemical industry, which had been depending on oil resources as a cheap and available feedstock. To help deal with soaring oil prices, the chemical industry began to construct larger facilities to foster more-efficient use of resources and energy. It also implemented measures to improve existing facilities and develop new technologies for the diversification of raw material resources, rather than simply continuing to pursue constant growth. As a result, the chemical industry became the first industry in Japan to address social concerns — including environmental, safety, security,

Table 1. Japan's chemical industry was the world's second largest for some four decades, until it was surpassed by China's rapidly growing chemical industry in 2008. *(1)*

Rank	Country	Shipments, US$ billions
1	United States	689.3
2	China	549.3
3	Japan	298.0*
4	Germany	263.2
5	France	158.9
6	South Korea	133.2
7	Brazil	126.7
8	United Kingdom	123.4
9	Italy	122.9
10	India	98.2

* Excludes plastic and rubber products

and pollution problems; the proper disposal and reuse of waste plastic; safety and environmental impacts of synthetic detergents; and safety measures for agricultural pesticides.

Under these circumstances, safety problems related to chemicals such as polychlorinated biphenyls (PCBs) began to be recognized as societal problems. Japan banned the production, use and import of PCBs in 1972.

Structural improvement (1980–1990)

In the wake of the oil crises and slower economic growth of the 1970s, some core production facilities of the chemical industry were facing obsolescence, such as small-scale plants making petrochemicals, fertilizers, and sodas. The industry began downsizing. In response to the increasing sophistication and diversification of market needs, the industry promoted the development of information technologies and the streamlining of production processes.

In addition, as new chemical manufacturing companies in developing nations entered the world market, the Japanese chemical industry began to relocate some production processes to developing countries to reduce costs associated with raw materials, distribution, and labor. Moreover, it implemented measures to help domestic chemical companies substantially increase exports and expand their business activities and investments in foreign countries. At the same time, Japan's chemical industry revitalized its materials sector with process innovations, such as a vapor-phase reactor for the production of linear low-density polyethylene (LLDPE) and other engineered plastics. The industry also pressed forward with research and development on new technologies, strengthening the processed-chemicals sector and adding more value to chemical products.

The era of globalization (1991–2010)

The impact of globalization, along with the Southeast Asia financial crisis of 1997, brought much change to the business environment surrounding Japan's chemical industry. Many foreign companies in Japan changed their import-export policies and business operations; such western chemical majors as Dow Chemical and DuPont were beginning domestic operations in Japan, and chemical companies began to be regulated by global standards as well as by the Product Liability Act of Japan (1994).

In this era, East Asia and Southeast Asia became growth centers for the chemical industry, and the Asian chemical industry overall emerged as one of the three major chemical industries in the world.

Most prominently, China's chemical industry has shown phenomenal growth since the beginning of the 21st century (*CEP*, Feb. 2011, p. 16). Although Japanese chemical companies made efforts to keep up with their Chinese competitors, the size of the Chinese chemical industry (in terms of shipment value) surpassed that of the Japanese chemical industry in 2008 (Table 1) *(1)*.

Nevertheless, the chemical sector plays an important role among Japan's manufacturing industries, and has contributed greatly to Japan's economy. According to a 2008 census of manufacturers performed by Japan's Ministry of Economy, Trade and Industry, the value of Japan's chemical industry shipments in 2008 (including plastic and rubber products) was 43.7 trillion yen — equivalent to US$533 billion (based on a May 2011 conversion rate of approximately 82 yen per U.S. dollar). This makes the chemical industry Japan's second largest, behind only the automobile and transportation vehicle industry (which in 2008 had shipments totaling 63.8 trillion yen [US$778 billion]).

Japan's chemical industry today is characterized by a wide range of companies — in contrast to the chemical industries in Europe, the U.S., and many emerging economies, where a small number of major companies dominate the industry. Because of this, no Japanese companies ranked among the top ten chemical companies in the world as of 2009; Japan's largest chemical company, Mitsubishi Chemical, ranked 14th (Table 2) *(2)*.

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Table 2. In 2009, no Japanese chemical company was among the world's ten largest, but ten Japanese chemical companies placed in the top 50. *(2)*

Rank	Company	Shipments, US$ billions
1	BASF (Germany)	55.8
2	Dow Chemical (U.S.)	44.9
3	Sinopec (China)	31.3
4	Ineos Group (England)	28.6
5	ExxonMobil (U.S.)	26.8
6	DuPont (U.S.)	26.0
7	Formosa Plastics (Taiwan)	25.4
8	Royal Dutch/Shell (Netherlands)	24.6
9	SABIC (Saudi Arabia)	23.1
10	Total (France)	20.5
14	Mitsubishi Chemical	16.7
17	Sumitomo Chemical	13.1
18	Mitsui Chemical	12.9
20	Toray Industries	12.5
26	Shin-Etsu Chemical	9.8
28	Asahi Kasei	9.5
33	Dainippon Ink and Chemical	8.1
39	Tosho	6.7
45	Showa Denko	5.5
50	Hitachi Chemical	4.9

In Japan, many chemical companies have been achieving growth by capitalizing on their unique and proprietary technologies — such as Mitsui Chemical's bimodal slurry-phase process to produce high-molecular-weight, high-density polyethylene (HMW-HDPE) for ultrathin films, and its hybrid (bulk loop/gas) process for high-yield, high-stereospecificity catalyst to produce polypropylene homopolymer and random/impact copolymers. Other companies are achieving growth through technological collaborations, both horizontal (Mitsui Petrochemicals and Mitsui Toatsu Chemicals), and vertical (Mitsubishi Chemical and Mitsubishi Rayon).

Future prospects for Japan's chemical industry

Today, Japan's chemical industry contributes to the country's economic growth by supplying fertilizers, synthetic fibers, and other chemical products, while developing and providing new materials that are essential for the development of the automobile, housing, electricity, and electronics industries. With worldwide trade liberalization, and the entry into the world market of new chemical manufacturing companies from developing nations, Japanese firms are no longer expected to domestically manufacture all of the products to be supplied to the domestic market.

Under these circumstances, in what direction is Japan's chemical industry expected to move in the next decade?

According to the Japan Chemical Industry Association (JCIA), the trade organization that represents Japan in the International Council of Chemical Associations (ICCA), environmental stewardship — particularly regarding climate change — and chemical safety are foundations of the chemical industry's current mission. The JCIA plays a prominent role in the ICCA, serving as chair-organization of ICCA's Energy and Climate Change (E&CC) Leadership Group.

The E&CC recently conducted a quantitative carbon lifecycle analysis to determine how the chemical industry — through products and technologies that it provides to other industries — can help reduce greenhouse gas (GHG) emissions. The study (*CEP*, Aug. 2009, pp. 10–11) found that the products of the chemical industry can help to increase the ratio of GHG emissions saved to GHG emissions generated to more than 4 to 1 by 2030 *(3)*. With Japan emitting about 1.2 billion tons of CO_2 annually, the potential reduction in emissions is indeed great. The E&CC's report also suggests that chemical products can contribute to energy conservation, for example, through new, lighter-weight materials, as well as to the development of new energy sources.

Environmental stewardship and chemical safety are foundations of the chemical industry's current mission.

Risk assessment of new chemicals and materials is crucial. It can cost a Japanese company more than 10 million yen to have the safety of a product assessed by a third-party organization, as required by the European Union's Registration, Evaluation, Authorization and Restriction of Chemical Substances (REACH) regulation. Moreover, if the safety assessment reveals problems, the R&D money invested in the new material might not be recovered, products that are already in use might need to be recalled, or the business might be discontinued. To avoid such risks, Japan's chemical industry advocates that companies perform risk assessments as early as possible, which also permits informed decision-making about the future direction of a company's R&D.

In the area of chemical safety management, the JCIA has launched the Japan Challenge Program — in which Japan's government and industry are collaborating to gather safety information on chemicals. The chemical industry will also expand the scope of its activities by participating in joint research led by the Japanese government, and in a new product stewardship initiative.

Looking ahead

In reflecting on the history and progress of Japan's chemical industry, it is clear that the industry has made immeasurable social contributions. The achievements of the industry's forerunners helped to establish modern Japan's significant place in the world economy. Today, it is important that Japan's chemical industry recognizes the importance of doing both "what can be done only now" and "what should be done right now," so that future generations will appreciate the industry's activities. CEP

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