Patents, Public Policy, and Petrochemical Processes in the Post-World War II Era

John Kenly Smith, Jr.

History Department
Lehigh University

> ...I think [petroleum intermediates] poses one of the great problems before our company today. Should we get into it at all; if so, how deeply? What are our advantages or disadvantages opposite the many others who are already interested in that field among both chemical manufacturers and petroleum manufacturers?
> –W.S. Carpenter, Jr., Du Pont President, to C.H. Greenewalt, August 16, 1946 [Carpenter, 1946].

> It is now timely to consider the problem of "what went wrong" in the petrochemical industry at some point along its development path.
> –Peter Spitz [Spitz, 1988, p. 537].

The above quotations document the evolving situation in petrochemical technology – chemicals made from oil and natural gas – from the perspective of the DuPont Company at the end of World War II and from a longtime industry participant and observer four decades later. Note that both observers use the word "problem" in connection with the petrochemical industry. For both the main source of the problem was competition that lowered prices and undermined profits. What Carpenter feared would happen and what Spitz laments was that petrochemical technology became a marketable product that was available to all at attractive prices. This certainly was not the situation in 1946. This paper traces the development of the market for petrochemical technology and the role that public policy regarding patents and anti-trust played in the process.

In the beginning petrochemicals appeared to be contested terrain between two powerful and concentrated industries – chemicals and petroleum. In the 1930s DuPont officials were aware that a few oil companies were beginning to produce chemicals from by-product refinery gases, but told themselves that this was not really a major new trend signaling an invasion of their domain by the large and powerful oil industry [Beadle, 1936]. The potentially disruptive alliance between Standard Oil of New Jersey and the German chemical juggernaut IG Farben to exploit IG technology in the United States had not produced much in the wake of their 1930 agreements. Standard, it

BUSINESS AND ECONOMIC HISTORY, Volume Twenty-seven, no. 2, Winter 1998.
 ISSN 0894-6825.

turned out, was mainly interested in controlling IG technology for turning coal into synthetic crude oil, something it hoped would never happen in the United States. Standard did, however, hope to use the German technology to improve the yield of gasoline from crude oil [Stocking, 1947, chapter 11]. IG used this agreement as part of a larger campaign to get access to a wide range of American chemical technologies. The Germans proved to be very adept at trading patents and promises for real American processes. In 1935, the Ethyl Corporation, a joint venture between Standard and General Motors, provided IG Farben with patents, know-how, and engineering assistance to build a tetraethyl lead gasoline additive plant in Germany. Ethyl's manufacturing agent, DuPont, objected to this technology transfer, warning of its importance in military aviation fuel [Stocking, 1947, pp. 476-7]. This deal would come back to haunt Ethyl a few years later when Germany launched it blitzkrieg powered by leaded gasoline.

The demands and dislocations of World War II established the basic parameters around which the petrochemical industry would expand in the post-war decades. The war greatly accelerated the deployment of petrochemical processes, the development of products made from petrochemicals, and the geographical relocation of the chemical industry to oil- and gas-producing regions, notably the Gulf Coast region of Texas [Spitz, 1988, chapter 3].[1] Before the war, petrochemical production had been limited by a lack of end products that could be made from them. The most notable example of success was Union Carbide's use of natural gas to make ethylene glycol, a new radiator coolant antifreeze [Spitz, 1988, chapter 2]. During the war the need to produce large quantities of synthetic materials to replace unavailable or scarce ones, especially rubber, metals, and leather, generated a significant demand for petroleum-based chemicals. The most important wartime project, both strategically and technologically, was the synthetic rubber program. Japanese expansion into southeast Asia in 1942 severed the United States from almost all its supply of natural rubber. The U.S. government organized and funded a $600 million project to make a rubber substitute from a polymer of butadiene and styrene. Most of the butadiene plants were built and operated by oil companies using petroleum derived feedstocks, while chemical companies, notably Dow and Monsanto, made styrene from ethylene and benzene, the latter still recovered from the coking of coal. As the war ended, the future of synthetic rubber and the plants to make it were uncertain – final disposition would not occur until 1955 – but the future of synthetic polymers made from petrochemicals looked bright [Herbert, 1985, chapter 11]. A technical breakthrough in oil refining, platforming, at the independent petroleum process company, Universal Oil Products (UOP) in 1947, dramatically improved the quality of gasoline and allowed the production of benzene and related chemicals from petroleum. Of

[1] This latter factor would give an important advantage to smaller companies such as Dow, who could build integrated petrochemical complexes to produce a variety of products. Larger companies, such as DuPont, had already made major investments in plants dispersed around the country, many inherited from earlier enterprises.

course, UOP could profit from this technology only by widely licensing the process to the oil companies [Spitz, 1988, pp. 176-83].

In 1946 the president of the DuPont Company, Walter S. Carpenter, Jr., interestingly characterized petrochemicals as a "problem" instead of as an opportunity for DuPont. At this point the future evolution of the industry was unclear for a number of reasons. The chemical industry had prospered using sophisticated processing to transform cheap, widely available raw materials into much more valuable products. Synthetics were the latest and most rapidly growing segment of the industry [Spitz, 1988, chapter 6]. The industry had limited interest in backward integration because its suppliers were much less profitable, especially in terms of investment turnover and return on investment [Development Department, 1966]. The prospect, however, of the oligopolistic oil industry controlling the raw materials for chemical production was unsettling.

For the petroleum industry, chemical production would complicate an already complex business. Because most oil companies were fully integrated, they engaged in a wide variety of activities. First and foremost was the discovery and development of oil fields. Once found and recovered, oil had to be transported, processed, distributed and sold [Development Department, 1966].

Historically, the industry tended to share refining technology, especially after the patent battles between Burton and the Dubbs over thermal cracking of crude oil in the early 1920s. Also, with relatively weak in-house research capability the oil industry relied on outside sources for new technology [Spitz, 1988, chapter 6]. The cost of new technology would be lower if oil companies chose not to compete in this arena. With limited experience in process innovation, the oil companies could not easily move into petrochemicals, which would move them into new markets involving new customers anyway. While the oil and chemical companies eyed one-another somewhat suspiciously, a few entrepreneurial firms, such as Scientific Design, founded by chemical engineers Ralph Landau, Harry Rehnberg, and Bob Egbert saw an opportunity to develop processes and construct plants for producing chemicals from petroleum. With limited capital and no intention of building large plants, the engineering firms depended on working closely with their clients to develop new processes. Its first process, ethylene oxide, was developed from pilot to full scale facility by Petrochemicals Ltd, which had received an exclusive license for Great Britain. Scientific Design had licensed the fully developed process over one hundred times by the 1980s. The development of a successful business strategy for selling technology to an industry with massive R&D establishments posed a real challenge for the new engineering firms [Spitz, 1988, pp. 318-30; Landau].

A real danger for the engineering firms was threat of the loss of control over their process technologies. How could they package their technology so that customers would know what they were getting, yet still have to pay for it to get it? Part of this was made possible by the maturation of the discipline of chemical engineering, which developed a generalized vocabulary that permitted discussion of processes without divulging proprietary aspects of them. Another key aspect for both seller and buyer was patent protection. Strong patents were essential to making chemical processes a salable commodity [Arora, 1997]. Yet, strong process patents were difficult to construct, especially when compared to product patents.

To be most effective a patent should claim specific things as examples of more generalized invention. For example, with synthetic fibers, DuPont tried to patent them globally based on early experiments that yielded no commercially viable specimens. After the discovery of nylon, DuPont claimed a very broad array of compounds for use as synthetic fibers because it was recognized that polyamides represented a distinct group of polymers, some of which yielded fibers with outstanding properties. In 1940 when British chemists discovered a polyester fiber that had commercially viable properties, DuPont's early patent claiming polyester fibers did not dominate the new discovery because the new invention was demonstrated to be a fundamentally different type of polyester [Hounshell, 1988, pp. 237-46, 407-14].

The problems of effectively patenting products pale in comparison with patenting processes. Some of the chemical engineering entrepreneurs developed processes by working around claims in other patents [Spitz, 1988, p. 315]. Probably the most patentable part of a process is the catalyst used in the chemical reaction. Yet, because there is no general theory of catalytic action, it is difficult to extend claims beyond the specific invention. This, of course, opens the door for competitors to find similar yet legally differentiable substitutes [Spitz, 1988, pp. 331-8].

The irony in the petrochemical industry is that process patents proved to be adequate for developing a well-defined market for buying and selling processes. The obvious question is: why should someone pay for something that can be obtained for free? Theft of processes is difficult to document, since companies can hide plant technology from competitors. I would also argue that in the negotiating of the sale of a process the buyer should be able to glean enough information to be able to duplicate the process without a license. Part of the answer is expedience. It appears that the incentive for the buyer to go along with the deal is the prospect of getting the technology in place cheaper than if he did it himself. One ramification of this is the relatively bargain prices at which processes are licensed [Spitz, 1988, pp. 540-3]. Patenting was probably also necessary to protect oneself from competing claims by others, so secrecy was not a viable option. In addition, with the professionalization of chemical engineering, a new process was an important professional achievement, so secrecy would lead to morale problems, or more threateningly, to skilled people jumping to one's competitors [Spitz, 1988, pp. 316-7].

As they gained experience the engineering firms developed one critical advantage over their clients. In the postwar period the scale of individual plants increased dramatically. For example, from 1952 to 1970 the output of a typical new vinyl chloride monomer plant increased from 30 million pounds per year to one billion pounds per year, a more than 30-fold increase [Spitz, 1988, p. 395]. Because of all the problems caused by scaling-up, the engineering firms could leverage their experience from one generation of plants to the next.

Even if a handful of engineering firms were able to successfully sell petrochemical processes, this might not have made a major impact on the industry as long as the firms in the industry decided to keep their plant processes proprietary. However, this turned out generally not to be the case. A few important exceptions were Dow and DuPont, which did keep some processes proprietary [Spitz, 1988, p. 547]. The oil and chemical companies entered into the market for petrochemical processes, selling them at the same bargain prices as did the engineering firms. In the period from 1951 to 1971, chemical and oil companies generated one-third and one-quarter of new process developments, respectively. Specialized engineering firms accounted for 18 percent; the remainder were supplied by foreign firms and a few from other industries [Mansfield, 1977, chapter 3]. Although the incentive for marketing processes may have come from the engineering firms, obviously the chemical and oil companies decided to participate in this market.

There are several explanations for this. Using the personal computer paradigm, the rate of process change was seen to be so rapid that the useful life of a given process was very short, leading firms to attempt to maximize its value by widespread licensing. One analysis shows that it took competitors nearly six years to respond to an innovative process [Stobaugh, 1988]. It is uncertain whether this time frame is short enough to encourage immediate licensing of processes.

Finally, I believe that the strict anti-trust climate of the postwar era strongly encouraged companies to license their technology instead of keeping it proprietary. After World War II the U.S. Justice Department decided to attack the gentlemanly club-like atmosphere of the prewar industry both domestically and internationally [Arora, 1997, p. 397; Hounshell, 1988, pp. 346-7]. Revelation of the chemical industries participation in international cartels, especially its entanglements with IG Farben, were a source of ongoing embarrassment. One source of collusive behavior was the tangled web of patents that surrounded the burst of innovation of the 1930s. The bartering of patent rights had been the legal basis of the cartelization of the industry before the war [Smith, 1992]. Compulsory licensing of patents, it was argued, could end this type of control over innovation by a few large companies. On the domestic front, less-than-competitive attitudes reflected the fact that chemical companies were each others' best customers [Smith, 1994]. By dramatically reducing the diversity of chemical raw materials and intermediates, petrochemicals promised to decouple companies from each other, allowing a more sincere form of competition to occur.

The rapid growth of the chemical industry – usually over twice the rate of growth of GNP – in the postwar decades reinforced the licensing of chemical technology. One of the most unusual cases is that of DuPont actively recruiting a competitor, Chemstrand – a joint venture of Monsanto and American Viscose – to set up in the nylon business [Hounshell, 1988, p. 347]. One reason for doing this was to avoid future anti-trust problems, but business concerns were also involved. DuPont did not want to have to invest most of its capital into the rapidly expanding nylon business. DuPont had other new products that might turn out to be new nylons. In the more general field of petrochemical intermediates, because they were transforming the very basis of the industry, no firm wanted to be responsible for the huge capital investment required to finance this growth.

In spite of its importance to both the oil and chemicals industries both regarded petrochemicals as secondary to their major strategies, producing high value-added chemicals and gasoline, respectively. In the mid-1960s DuPont was still trying to decide whether it should integrate backward into petrochemicals or continue to buy feedstocks from others. A DuPont report stated that petroleum and natural gas provided the base for over 80 percent of the organic chemicals produced in the United States, but chemical demand represented only 4 percent of the raw materials handled by the petroleum industry. Even though the chemical sales of petroleum companies doubled between 1960 and 1964, this accounted for less then 10 percent of all chemical sales. DuPont acknowledged that the petroleum industry remained a large supplier and competitor but that backward integration into oil would put the company into a highly competitive business that produced commodity products. Rather than investing in less profitable oil companies, DuPont should continue its traditional strategy of introducing high value-added products [Development Department, 1966]. Though the fact that DuPont was seriously thinking of investing in an oil company indicates that the faith in the nylon paradigm may have been weakening.

By 1960, a market for petrochemical and polymer plants was well established. There was forward integration in the process industry, especially with regard to the oil companies who moved into plastics manufacture. The development of turn-key technology reached the point that barriers to entry in petrochemical and polymer markets were greatly lowered. The oil and chemical companies had lost control of a technology that ultimately contributed to the deconcentration of the industry and the inability to control prices. Competition reared its ugly head and profit margins and prices began to fall. Even important new products such as high density polyethylene and polypropylene rapidly became competitive commodities. With both of these products, supply quite frequently ran ahead of demand. By 1961 *Fortune* magazine writer Perrin Stryker published a piece entitled, "Chemicals: The Ball is Over" [Stryker, 1961].

Industry leaders began to be nostalgic about the era of proprietary and profitable new products. In the 1960s DuPont launched a heroic and expensive effort to produce new nylons. When that failed to distance DuPont from its competitors, it reluctantly began to look for other opportunities, including buying an oil company [Hounshell, 1988, chapter 22]. But petrochemical markets were even more competitive than traditional product ones. Earlier by making process technology widely available, the industry lowered the cost of all chemical products and encouraged rapid – sometimes dizzying – rates of growth. When product markets began to falter, petrochemicals got the blame for ruining the industry. Industry participants and analysts such as Peter Spitz looked back on the heyday of petrochemical process development and licensing with some regrets. The prewar regime of closely held technology appeared to be a more orderly and sustainable industrial model [Spitz, 1988, chapter 13]. The unusual place of petrochemicals between two large industries and the public policy of the United States government combined to create a unique outcome.

References

Arora, Ashish, "Patents, Licensing, and Market Structure in the Chemical Industry," *Research Policy*, 26 (1997), 391-403.

Beadle, W.S., "Chemical Manufacture by Oil Companies," January 13, 1936, Papers of Willis Harrington, Accession 1813, Hagley Museum and Library, Wilmington, Delaware.

Carpenter, W.S., to C.H. Greenewalt, August 16, 1946, Records of the E.I. du Pont de Nemours and Co., Series II, Part 2, Box 829, Hagley Museum and Library, Wilmington, Delaware.

Development Department to the Executive Committee, "The Petroleum Industry," February 24, 1966, Accession 1850, Hagley Museum and Library, Wilmington, Delaware.

Herbert, Vernon, and Attilio Bisio, *Synthetic Rubber: A Project That Had to Succeed* (Westport, CT, 1985).

Hounshell, David A., and John Kenly Smith, Jr., *Science and Corporate Strategy: DuPont R&D, 1902-1980* (New York, 1988).

Landau, Ralph, and Nathan Rosenberg, "Successful Commercialization in the Chemical Process Industries," typescript.

Mansfield, Edwin, et al, *The Production and Application of New Industrial Technology* (New York, 1977).

Smith, John Kenly, Jr., "National Goals, Industry Structure, and Corporate Strategies: Chemical Cartels Between the Wars," in Akira Kudo and Terushi Hara, eds., *International Cartels in Business History* (Tokyo, 1992)

———, "The End of the Chemical Century? Organizational Capabilities and Industry Evolution," *Business and Economic History*, 23 (Fall 1994), 152-61.

Spitz, Peter H., *Petrochemicals: The Rise of an Industry* (New York, 1988).

Stocking, George W. and Myron W. Watkins, *Cartels in Action* (New York, 1947).

Stryker, Perrin, "Chemicals: The Ball is Over," *Fortune*, October 1961, 125-7, 207-18.