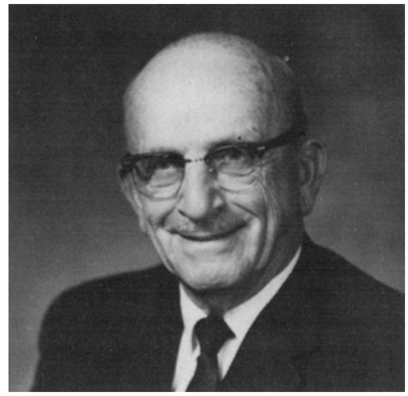
A tribute to Ralph H. Potts



The late Ralph H. Potts was one of the truly ingenious pioneers in the oleochemicals industry. He spent almost all of his working career with Armour and its successor firms in the Chicago area, and therefore some of his co-workers at Armak arranged to have a special symposium in his honor during the AOCS 74th annual meeting this past May in Chicago. The following two papers provide two views of Ralph Potts. The first, by Richard Reck of Armak, offers a personal glimpse. The second, by Norman O.V. Sonntag, reviews the technical contributions Ralph Potts made to the oleochemicals industry.

History of a Pioneer in Chemistry

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Ralph H. Potts, born in Pennsylvania in 1900, was graduated from Lehigh University in 1922 with a chemical engineering degree. In 1922 chemical engineers were rather new in the professional community and Ralph was the type who would want a unique position. After much searching he finally chose a position with Armour and Company in the old Union Stockyards. This was against his mother's wishes because she viewed Chicago only as a city of gangsters and Indians. His first term at Armour was unchallenging and he left after six months to work for Sinclair Oil for nine months. The first session with Armour was very fortunate for him, however, in that during that time he met his future wife, Nancy, who worked as a chemist for Armour.

His stint at Sinclair Oil exposed Ralph to oil cracking and refining and this knowledge opened all kinds of opportunities to Ralph and Armour Auxilliaries, a complex of nonfood divisions of Armour, upon his return to Armour. Armour Auxilliaries' main function was to convert by-products of the meat packing plants to more profitable products. This was a challenge and a great opportunity for Ralph.

One of the main operations of Armour Auxilliaries was to convert tallow and grease to quality fatty acids for the manufacture of soap, greases and candles. This was done by hydrolyzing the triglycerides to fatty acids and glycerine and then purifying the fatty acids by distillation. With tallow and grease at 2 cents per pound, any upgrading meant a good deal to Armour and Company.

From his work at Sinclair Oil, Ralph knew that the fatty acids possibly could be distilled into distinct fractions and that these fractions could be of more value. For example, the lower boiling acids were not as useful for soap making as the higher fractions and Ralph was able to prove this point. Also, by fractionation one could use lower grade feedstocks to produce the final product.

Convincing management to build a fractionating unit was not easy. Ralph did it by putting in requests to the machine shop for parts he needed under the guise of pump repairs. This resulted in the first fatty acid fractionating still (built in 1925). The fractionating column was constructed of brass pipe filled with broken milk bottles which acted as the packing material. The bottom of the column was suspended in a brick firebox and heated by a gas burner. The still did not last long, but the theory was proven to be fact as fatty acids were fractionated.

In the early 1930s, the original cast iron stills, built by Armour and Company and used for simple distillation, were gradually disintegrating and the company had a hard decision to make—either replace the stills or gradually go out of the fatty acid distillation business. Armour decided that, in spite of the depression, it was making a profit on distilled fatty acids and so it would invest the capital to replace the stills with new and more versatile equipment. Armour used limited laboratory data and the data from Ralph's 1925 brass unit to engineer and build a completely new unit in 1933. The still had serious start-up and corrosion problems, but by early 1935 it was in full operation, producing quality products. Customers no longer had to formulate with natural mixtures of fatty acids but could use special pure cuts or blends to suit specific needs.

While the new stills produced fatty acids that Armour sold at a profit, it became very apparent that the supply of tallow and greases from the packing houses far exceeded the market demand for the final products. Even edible lard hit 2 cents per pound, and Armour initiated an extensive research program to find new uses and products from the animal triglycerides.

The program was under the direction of Vic Conquest and A. W. Ralston, who directed the Central Research Laboratories of Armour and Company. Ralph was still employed by the Armour Auxilliaries, but very fortunately Mr. Conquest and he had apartments in the same building and many ideas and notes were exchanged by these two gentlemen during pinochle games or martini sessions. Since the main purpose was to improve the profits for the company, the two programs at the Auxilliaries unit and Central Research were combined.

One of the first objectives was to convert fatty acids into a rubber precursor for the production of golf balls. The idea never did work, but Research did learn that with catalysts and high temperatures you could alter the hydrocarbon chain and convert the carboxyl function into many, many different molecules.

One of these molecules was nitriles produced by reaction of ammonia, also produced at that time by Armour, and fatty acids under the proper temperature and catalytic conditions. While nitriles themselves found limited use, the chemists at Central Research found that nitriles could be converted to valuable fatty amines. Ralph Potts quickly used his engineering ingenuity to design and construct units to convert the laboratory data to practical production systems. Pilot plant production was successful and the first commercial shipment of fatty amines was made to mining companies in 1938.

The business proved to be viable and profitable, and the small units soon ran out of capacity. A larger, truly commercial facility was authorized and a committee of three, including Ralph Potts, searched the Chicago area for a suitable site. World War II caused delays, but land was bought in McCook, Illinois, and construction on the first truly commercial fatty amine plant was started in 1949. The plant also included modern fatty acid production and fractionation. Of course there were cost overruns and delays which frustrated Ralph and Armour management. In fact I still remember the statement made by an Armour food executive who said he would trade Potts, all his patents and the McCook plant for six sausage plants. By 1951 the plant was in full production and very profitable.

While he was starting up the McCook plant Ralph Potts did not quit inventing new procedures and processes. In fact, during the 1950's, while in charge of the main pilot plant and organic research in Armour's Central Research unit, I remember many sessions with Ralph on highly technical problems in which his input was of great value. After the McCook plant was in full operation Ralph returned to Research and Development, using his knowledge to assist in the design and improvement of several plants. His processes were used to build plants in England, Canada, Japan, Belgium and Brazil.

In 1962 Ralph officially retired, but he was quickly hired by Armour and Company as a consultant. In that position he had much freedom and continued inventing, designing new systems and transforming lab data into meaningful production units. He continued this function until 1980 and never stopped making significant contributions to the fatty chemical industry. His ingenuity, resourcefulness and inventiveness will never be equalled. Without him the fatty acid and fatty amine business would not have advanced so rapidly to its present success.

An Evaluation of Contributions to the Oleochemical Industry

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One way to evaluate Ralph Potts' importance to the oleochemical industry is to examine the growth of those parts of the industry where he made his major contributions. This paper will examine Ralph Potts' major patents on production of fatty acids from animal and vegetable fats and oils as well as from tall oil, and the production of fatty nitrogen chemicals.

The Fatty Acid Producers' Council (FAPC) reported production of 428 million lb of fatty acids in 1955, with a growth to 650 million lb by 1975. The author's estimate is that domestic fatty acid production by 1985 will be about 1,100 million lb. Tall oil fatty acid production was listed at 105 million lb in 1955 by the Pulp Chemicals Association, rising to 366 million lb by 1982.

Fatty acids

Here are three key U.S. Patents issued to Ralph Potts (and associates) on fatty acid and tall oil fatty acid fractional distillation.

U.S. Patent 2,054,091 (Sept. 15, 1936). This early patent pertains to a process of fatty acid fractional distillation employing reflux in which heated and evolved vapors of mixed fatty acids are passed through a successive series of heat-exchanging pools of liquid fatty acids, with recirculation of a major proportion of the low-boiling vapors back to the pools as reflux liquid and elimination of low-boiling fatty acids at the upper pool and high-boiling fatty acids at the bottom one. The reflux technique formed the basis of the later improved method.

U.S. Patent 2,224,925 (Dec. 17, 1940) was perhaps the first disclosure of the complete Potts-McKee process for satisfactory fractional distillation separation of mixed fatty acids. Basically, it outlined and pinpointed the combinations of process conditions necessary. Limited use of steam, countercurrent reflux and the use of heat at the pool site were called for, as distinct from the previous use of superheated steam. Rarely has a U.S. patent in oleochemistry offered such a variety of process and product quality advantages. It showed the way to a more complete fractional separation of homologs than was possible heretofore. It lowered the thermal requirements for separation. Steam was used sparingly and only to the extent of providing optimized lower boiling points. Heat stability of the acids was improved because the temperatures required were reduced. The height of the fractionating column was decreased because pressure drops down the column were minimized. The controlled use of steam permitted the elimination of fatty acid anhydride in the pitch, eliminating restripping operations, and reducing the loss of fatty acid as anhydride, and ketonic and decarboxylated components in the pitch residue.

Ralph Potts did not invent steam distillation, nor did he invent fatty acid fractional distillation separation. What he and McKee did was combine all the process variables in a practical optimized process. Truly, a breakthrough had been achieved. Of course, other processes had been available before the advent of the Potts-McKee method, viz. Garanflo (1), New Process Fat Refining Corp., and Wecker's method and still (2). But the Potts-McKee method revolutionized the industry and caused a flurry of patent activity, among which the Mills patent (3), Procter & Gamble Co. (1942), and the Ittner patent (4), Colgate-Palmolive-Peet Co. (1944), were noteworthy.

Potts' previous work on fractional distillation separation of fatty acids had resulted in a 1935 Armour distillation unit in Chicago, Illinois. Armour started distilling crude tall oil in 1943 at Chicago using the Potts-McKee process; the rosin cut contained 70% rosin, the fatty acid cut had 6% rosin. General Mills started an operation at Kankakee, Illinois, in 1948 using the Potts-McKee process. Foster Wheeler of Livingston, New Jersey, was the construction organization for many of these plants. Badger Co. of Cambridge, Massachusetts, joined the rank of plant construction organizations. Since 1940, literally dozens of innovations and modifications of the separation have been introduced. None would have been possible had Potts and McKee not laid the groundwork.

U.S. Patent 2,224,986 (Dec. 17, 1940) is frequently cited when the Potts-McKee process is referred to, presumably because it was issued by the U.S. Patent Office on the same day as U.S. Pat. 2,224,925. Apparently, Ralph intended to use this modification of the distillation process as a vegetable oil deodorization process. It is obvious that the process conditions suggested are at variance with today's conventional deodorization conditions. For example, Potts outlined an example in which 600 lb of steam/hr was used for 15,000 lb of 7% palm oil fatty acids in palm oil at 420 F (215 C) and 5-25 mm Hg, whereas a typical modern unit, EMI's double shell deodorizer, operates at 400-525 F (202-274 C) at a steam rate of 3 lb/100 lb SBO oil at 6 mm Hg, using total steam from 10-50% of the weight of oil charged. It is doubtful if Armak used Potts' process for oil deodorization. Nevertheless, this is an example of Ralph's foresight in attempting to protect all potential applications of his broad invention.

Nitriles, amines

Potts also made major contributions to fatty nitrile and fatty amine technology. A relatively educated guess as to 1983 production of fatty nitriles in the U.S. would be 150 million to 170 million lb, far below total capacity. Armak plants in McCook and Morris have a capacity of about 110 million lb a year. Sherex Chemical Company's plants in Mapleton, Illinois; Janesville, Wisconsin; and Oakland, California, have a total capacity of about 85 million lb; Humko's plant in Memphis, Tennessee, has a capacity of 20-25 million lb a year. Henkel Corporation's Kankakee, Illinois, plant and the Jetco Chemicals' plant in Corsicana, Texas, each has a capacity of about 20 million lb a year. Tomah Products of Milton, Wisconsin, roughly doubled its capacity to 40 million lb a year, from 20 million lb a year, with the purchase of the Nostrip Chemical Works at Pedricktown, N.J. Onyx Millmaster, Lonza and Ethyl have nitrile capacity, but these organizations are largely committed to other than the fatty acid ammonolysis route of production.

Fatty nitriles are rarely marketed as such, but serve as intermediates for a whole range of fatty amines and derivatives. They afford a good indication of the present magnitude of the fatty amine segment of the fatty nitrogen derivatives industry. In 1975, fatty amines usage was approximately as follows: 40 million to 50 million lb of asphalt emulsifiers, 25 million lb for ore flotation; 10 million to 15 million lb for textile chemicals, and around 40 million lb as chemical intermediates. The dollar value increase in the fabric softener segment of the fatty amine quaternary market was startling: to $125 million in 1971 from $25 million in 1961.

Turning now to Ralph Potts' process development contributions in the area of fatty nitrogen derivatives, we find the patents primarily between 1943-1967, but the actual contributions probably extended until just before his death in 1981.

U.S. Patent 2,314,894 (March 30, 1943): Although Ralph Potts had been engaged in fatty nitrile and amide process development much earlier, the issuance of this patent represents his initial contribution. Essentially, this was a two-stage process for fatty nitriles from fatty acids (or esters) which involved liquid phase ammonolysis as a first step, followed by a vapor phase catalytic dehydration as a second step. The product nitrile thus had an overall quality of a once-distilled nitrile.

U.S. Patent 2,414,393 (Jan. 14, 1947) was a step forward in that the vapor phase heating medium was maintained at about 570-700 F (199-371 C), thus sustaining the overall endothermic nature of the ammonolysis and dehydration reactions.

U.S. Patent 2,448,275 (Aug. 31, 1948). This patent demonstrated that the liquid phase reaction could be carried out in separate zones. Essentially, the liquid fatty acids in the first zone were contacted with vapors from the second zone, passing the residue from the first to the second zone, contacting same with ammonia in the second zone and withdrawing residue from the second zone. The advantage was that residue was "finished" and did not require further stripping treatment.

U.S. Patent 2,504,045 (April 15, 1950) detailed how fatty nitriles could be separated from NH_3, H_2O and hydrogenation-inhibiting impurities by passing the mixture through pools of nitriles, water and ammonia to vaporize the ammonia and water containing some hydrogenation-inhibiting volatiles and condense the nitriles.

U.S. Patent 2,524,831 (Oct. 10, 1950) concerned liquid phase continuous passage of fatty acid and NH_3 through a series of pools of nitrile and fatty acid with NH_3 in excess of the amount theoretically required for nitrile formation, with each pool at the temperature required to keep the fatty acid in liquid phase.

U.S. Patent 2,546,521 (March 27, 1951) outlined how both fatty amide and fatty nitrile could be produced simultaneously by ammonolysis of fatty acids. The method required a temperature sufficient to vaporize nitriles and withdraw nitriles at the top, and fatty amides at the bottom of a column. For exceptionally pure amides and nitriles, the column height was critical. This may be a "defensive" patent, as it is doubtful if the simultaneous manufacture of fatty nitriles and amides was employed routinely.

U.S. Patent 2,555,606 (June 5, 1952) illustrated how either nitriles or amides can be produced separately by continuous countercurrent passage of NH_3 through liquid fatty acids. This is a liquid phase process without catalyst. The patent claims were for nitriles only.

U.S. Patent 2,808,426 (Oct. 1, 1952) is the basic nitrile process operated by Armak at Morris and McCook. This is essentially a continuous three-zone process. In the first zone, liquid phase fatty acid is contacted with ammonia to give amide; in the second zone, amide is converted over to 79% nitrile, and in the third zone a catalytic vapor phase reaction affords high quality distilled nitrile.

U.S. Patent 3,299,117 (Jan. 17, 1967) describes a liquid phase ammonolysis reaction maintained under pressure in which products are further subjected in a second zone to additional NH_3 at 300 C, all in the liquid phase using 0.5 mol NH_3/1 mol fatty acid feed, followed by reducing the pressure to atmospheric and vacuum distilling the product nitrile. The reaction may be catalyzed by a dehydration catalyst or operated non-catalyzed. British Patent 781,123 (Jan. 20, 1965) is similar.

U.S. Patent 3,850,974 (1974), invented by Lichtenwalter and Hammerberg, without Potts name, represents a liquid phase, catalytic ammonolysis of fatty acids at 300-380 C with the use of 1:1 to 1:3 moles of NH_3:fatty acid, and 16-60 min residence time. Doubtless, Ralph may have made some suggestions and recommendations on this process. Apparently, several of the worldwide Akzo Chemie fatty nitrogen plants of vintage later than 1970, such as those in Belgium, Italy, Japan, Canada, England and the forthcoming facility in Brazil (5), employ new innovative liquid phase nitrile processing.

Without a doubt, men like Ralph H. Potts don't come along every year. The oleochemical industry certainly owes this unique and talented man an enormous debt of gratitude for his monumental contributions.

REFERENCES

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5. Anonymous, Chem. Week, June 1, 1983, page 21.