The Growth of Industrial Catalysis with the Platinum Metals

"If one considers that the acceleration of reaction by catalytic means occurs without expenditure of energy or material, and is in this sense gratis, it is evident that the systematic use of catalysts may lead to the most far-reaching advances in technology."

WILHELM OSTWALD, 1901

The discovery of the great activity of platinum and palladium in the catalysis of chemical reactions and the early researches of the two Davys, Döbereiner, Faraday and others were reviewed in Chapter 12, together with the famous patent of Peregrine Phillips of Bristol in 1831 and the early practical applications of Frédéric Kuhlmann in the production of sulphuric and nitric acids in his chemical works in France in 1838.

For almost forty years no progress was made in the further application of catalysis in industry. The phenomenon was but little understood, while the chemical engineering techniques required to handle gases at high temperatures had not been developed. But as the dyestuffs industry grew the need for more concentrated sulphuric acid increased and two independent steps were taken in 1875. Then Dr. Rudolph Messel (1848—1920), who had come to London five years earlier after studying chemistry in Zürich, Heidelberg and Tübingen to join William Stevens Squire (1835—1906), later to found the firm of Spencer Chapman and Messel, devised a process of producing oleum by passing the vapour of ordinary sulphuric acid over platinised pumice at a red heat. The patent was filed in Squire’s name only (1), and the process was put into operation, an account being given to the Chemical Society (2). Almost simultaneously a paper was published by Clemens Winkler (1838—1902), Professor of Chemistry at the Freiberg School of Mines, in which he proposed the use of platinised asbestos in what was virtually Peregrine Phillips method of employing sulphur dioxide and oxygen in stoichiometric proportions (3). Winkler did not patent his process, but used it in a chemical works in Freiberg of which he was a director.
Rudolf Theophil Josef Knietsch 1854-1906

A native of Oppeln in what is now Poland, Knietsch first became a mechanic and then studied chemistry in Berlin. In 1884 he joined the Badische Anilin und Soda Fabrik and carried out a long and successful investigation on the production of sulphuric acid by the oxidation of sulphur dioxide over a platinum catalyst. His study of varying conditions of temperature, the rate of flow of the reactants and the poisoning of the catalyst by arsenical fumes made possible the large scale production of acid by the contact process which then began to supersede the lead chamber method.

Photograph by courtesy of Badische Anilin und Soda Fabrik

However, his method pointed the way for others until the researches of Rudolf Knietsch at the Badische Anilin und Soda Fabrik. In a lecture given to the Deutschen Chemischen Gesellschaft in 1901 (4) he reported an extensive series of investigations on the behaviour of platinum catalysts in varying conditions of temperature and showed clearly that the concept of using a stochiometric mixture of gases was fallacious. The contact process thus began to replace the lead chamber process (and so the days of the platinum boiler was also numbered) first in Germany and then in England and the United States. Very large quantities of platinum were consumed over a long period but during World War I the supply in Germany was interrupted and as a substitute vanadium pentoxide was used and began to be adopted in about 1926 by American acid manufacturers and later in England.

The Manufacture of Nitric Acid

While the use of a platinum catalyst for the production of sulphuric acid became one of the few applications of platinum to fall away, a very different state of
affairs has characterised the production of nitric acid and here platinum is still in use in large quantities.

During the latter years of the nineteenth century discussion began to arise among men of science who were interested in the broader issues of their subject on what later became known as “The Nitrogen Problem”. Typical of the expositions which now and then reached even the public press was the Presidential Address given by Sir William Crookes to the British Association for the Advancement of Science at its Bristol meeting in September 1898 (5). Crookes was concerned to show that at the prevailing rate of increase of population the world’s supplies of wheat would soon prove insufficient, and that the land would not continue to produce the same yield year after year unless adequate quantities of nitrogenous manure were ploughed back. He appealed to the chemist to help remove the fear of famine by establishing a means of fixing atmospheric nitrogen, since the only available source – Chile saltpetre – might be exhausted in a comparatively short period of years.

This problem, of obtaining from the unlimited supplies of uncombined nitrogen in the atmosphere those compounds – principally ammonia and nitric acid – required for agricultural needs, was soon intensified by the realisation in a number of European countries that a precisely similar need for assured supplies of nitric acid existed in the manufacture of explosives, and that in the event of war the Chile nitrates might well prove to be inaccessible.

This is not to say that such thoughts inspired governmental action in any part of Europe; they were, in fact, confined to but a handful of scientists who could foresee their countries’ long-term needs. One such man was Professor Wilhelm Pfeffer, (1845–1920), the famous botanist of the University of Bonn who in 1901 expressed his concern about the need for supplies of fixed nitrogen to his friend in the University of Leipzig, Professor Wilhelm Ostwald. At this time Ostwald had occupied the Chair of Chemistry at Leipzig for some fourteen years and had built up a school of physical chemistry, devoting much of his energy to investigating the effects of catalysts on chemical reactions. His response to Pfeffer’s representations was immediate; it was obviously his duty as a chemist to play his part in making his country independent of Chile saltpetre, and in obtaining nitric acid from other sources.

Two possible lines of investigation presented themselves. Either free nitrogen and oxygen from the air could be combined, or ammonia, then readily available from the gas industry, could be oxidised to give nitric acid. As it seemed more simple to re-combine nitrogen which was already fixed than to fix free nitrogen, Ostwald decided to give his attention to the oxidation of ammonia.

The reaction was known, and Ostwald would have been well aware of the earlier work of Kuhlmann. It was clear to him that the theoretical basis of the ammonia oxidation reaction would have to be elucidated before it could be developed on a large scale, and experiments were begun by Dr. Eberhard Brauer, at that time Ostwald’s private assistant. The first experiments were made using a clean glass tube only a few milimetres in diameter containing
The historic apparatus with which Ostwald and Brauer first studied the oxidation of ammonia over a platinum catalyst to produce nitric acid in the University of Leipzig in 1901. The investigation showed that the conversion was practicable and relatively simple but many problems had to be solved before a commercial process could be developed.

Platinised asbestos. Ammonia and air were passed over the catalyst in known quantities and with known velocities, and it was at once clear that the conversion to nitric acid was practicable and relatively simple to carry out, although some difficulties lay in the absorption of the reaction products. The historic apparatus used at this stage is shown above.

The first experiments using platinised asbestos gave only small yields and a platinum-lined tube proved little better. A new reaction tube was therefore made, consisting of a glass tube 2 mm in diameter in which was coiled a strip of platinum about 20 cm long. The whole tube was heated to redness, and the first experiment gave a conversion of more than 50 per cent, while increasing the gas velocity gave a conversion of 85 per cent.

Investigations were then carried out on the effects of variations in the ammonia: air ratio, in the time of contact and in the temperature of the catalyst. Thus were laid the foundations of a technical process for producing nitric acid from ammonia, but the translation from idea to practice presented many problems before the project was brought to fruition.

Ostwald filed patents for his procedure in 1902 (6) although his German patent was disallowed on account of Kuhlmann’s earlier disclosures.

A small factory was made available to Ostwald and Brauer, and here a pilot
By 1904 a pilot scale ammonia oxidation plant comprising three reactors had been built in a small powder factory put at Ostwald's disposal by the Director of the German Explosives Combine. Porous platinum sheets were used as the catalysts, a yield of 75 per cent of nitric acid was obtained, and it was decided to erect a larger plant to produce 300 kilograms of acid a day.

This plant was brought into operation in May 1906 and fully proved the feasibility of the process. A larger-scale plant was then designed and built, and by the end of 1908 was producing some three tons of 53 per cent nitric acid per day.

The catalyst used at this time consisted of a roll of corrugated platinum strip about 2 cm wide and weighing about 50 g, heated initially by a hydrogen flame. The life of the catalyst was no more than a month or six weeks. The disadvantages of the process included the relatively large amount of platinum required per unit of acid produced, and the uncertainty of temperature control of the catalyst, but improvements were not long wanting.

The Platinum Gauze Catalyst
Professor Karl Kaiser, of the Technische Hochschule, Charlottenburg, attacked the problem, and filed patents in 1909 covering the pre-heating of the air to 300
or 400°C and the use of a layer, usually four in number, of platinum gauzes. He was the first to employ platinum in the form of gauze, and it is a tribute to his experimental skill that the precise form of gauze he settled on--wire 0.06 millimetre diameter woven to 1050 mesh per square centimetre--is still very largely employed. By 1912 Kaiser had a pilot plant in operation at Spandau, Berlin, but while this was inspected repeatedly by British, French and American industrialists, he failed to interest them in his process, although a plant was erected at Kharkov in Russia.

Further work was carried out by Nikodem Caro and Albert Frank at the Bayerische Stickstoffwerke. Several patents were filed during 1914, the process being based upon a single platinum gauze which was electrically heated. Progress was slow for a time, and numerous experimental plants failed, but the outbreak of war gave a much greater urge to the project and by 1916 the picture had changed radically. The Frank and Caro converter had by then been engineered by the Berlin-Anhaltische Maschinenbau A.G. (BAMAG), who had constructed more than thirty plants, first for the supply of nitric oxide to lead chamber sulphuric acid plants and later for nitric acid production. The single platinum gauze was subsequently replaced by multiple gauzes, and the electrical heating was discontinued. This type of plant supplied all the nitric acid required for explosives in Germany during the later years of the war. The converter had a diameter of 20 inches, the catalyst consisting of a layer of three platinum gauzes woven from 0.006 inch diameter wire of 80 mesh to the linear inch, operating at about 700°C.

A much greater catalyst life was obtained in this design of plant, extending to six months provided that conditions were uniform and that the gases were free from impurities that might have a poisoning effect.

The Synthesis of Ammonia

Shortly after Ostwald’s development of the ammonia oxidation process the raw material began to become more readily available. The same considerations on the great importance of the fixation of nitrogen prompted Fritz Haber (1868–1934), then an assistant professor at the Karlsruhe Technische Hochschule, to investigate the catalytic formation of ammonia from its elements, nitrogen and hydrogen. This reaction had already been studied in 1881 by George Stillingfleet Johnson, a demonstrator in chemistry at King’s College, London, who obtained ammonia in small quantity by passing the two gases over heated platinum sponge (9), and Ostwald had given some consideration to the process in 1904, but Haber established that a successful process depended upon the reaction being carried out under high pressure and at a high temperature. The investigation was taken over in 1909 by the Badische Anilin und Soda Fabrik who assigned Carl Bosch (1874–1940) to carry the project further. Haber had employed osmium as his catalyst (10) but the commercial success of the process required a metal that was both less expensive and available in greater
quantity, and after some twenty thousand experiments by Alwin Mittasch (1869–1953), the head of catalyst research at BASF, a solution was finally arrived at with a mixture of iron and its oxides. Both Haber and Bosch were awarded Nobel Prizes for Chemistry, the latter commenting on the initial experiments at high pressures in the course of his address:

"The two contact tubes, made by Mannesmann, had an operating life of eighty hours, then they burst. If we had filled them with osmium instead of the new catalyst the entire world stock of this precious metal, which we had by now bought, would have disappeared." (11)

The Production of Nitric Acid in America

At the beginning of the 1914 war the United States possessed no source of nitric acid other than Chile saltpetre, and it became distressingly evident that the nation was dependent upon a foreign country in this respect, while the production of nitric acid from this starting-point required large quantities of sulphuric acid already in short supply.

Cyanamide had been manufactured at Niagara Falls since 1909, and in 1916 the first American plant for the oxidation of ammonia produced from cyanamide was established by the American Cyanamid Company at Warners, New Jersey. The catalyst employed was a single platinum gauze, electrically heated. In the meantime, the ordnance department had decided to take action, and Dr. C. L. Parsons, of the Bureau of Mines, was asked to investigate European methods for nitrogen fixation. As a result the American Cyanamid Company was requested, in 1917, to form a subsidiary company, Air Nitrates Corporation, to act as agent for the United States Government for the construction and operation of a plant at Muscle Shoals, Alabama, to produce 110,000 tons a year of ammonium nitrate. This plant comprised some seven hundred catalyst units each containing a single rectangular platinum gauze woven from 0.003 inch diameter wire, 80 mesh, and heated electrically to 750°C. The total weight of platinum was a little over 300 oz, and the loading ratio about 1 kg per daily ton of ammonia.

Developments in Ammonia Oxidation in Great Britain

There had been little or no commercial interest in nitrogen fixation in Great Britain before the outbreak of war in 1914, and throughout the war period the supply of nitrogen products for munitions depended almost entirely on shipments of Chilean nitrate.

There were, however, a number of attempts to make nitric acid by the oxidation of ammonia, either from gas-liquor or cyanamide. An Ostwald plant was set up at Dagenham Dock by the Nitrogen Products Company in 1916–1917, but never achieved successful operation. The Gas Light and Coke Company developed a plant at Beckton using a pad of three or four flat platinum gauzes as catalyst, and attained an output of a ton of nitric acid per day.

A systematic investigation was undertaken, at the instigation of the Nitrogen
Sir Eric Rideal  
1890–1974

Educated at Trinity College, Cambridge, and then at the University of Bonn, Rideal served in the Royal Engineers in World War I but was invalided out in 1916 and then joined the Munitions Invention Board together with J. R. Partington, J. A. Harker, H. C. Greenwood, E. B. Maxted and others with the object of establishing the ammonia oxidation process in England. Earlier, while on leave from France, he had studied this reaction in the Institute of Chemistry in London. The project, carried out at University College, London, led to the construction of a successful converter but on a very small scale. His distinguished career included much important research in catalysis.

Products Committee, by J. R. Partington, E. K. (later Sir Eric) Rideal and others and was carried out in the laboratory of the Munitions Inventions Department (13). An effective design of converter was evolved, employing either an electrically heated pad with two gauzes or a thicker pad that was self-sustaining in temperature when reaction had been established. Somewhat similar converters were constructed by Brunner Mond & Company and by the United Alkali Company, both of whom turned to Johnson Matthey for advice on the production of the catalyst gauzes.

Although it came too late to be of service in the war, the decision taken in 1917 to erect a synthetic ammonia plant using the Haber-Bosch process led directly to the building of the Billingham plant by Synthetic Ammonia and Nitrates Ltd. (now Imperial Chemical Industries Ltd.). The ammonia plant first came into operation in December 1923 and the nitric acid plant – the first successful large-scale plant in this country – during 1927. An account of the early years of this development has been given by A. W. Holmes (14).

Although the process remains unchanged in principle – and even in some details such as the mesh sizes of the gauze pads – the size and complexity of the plant units has been tremendously increased.
After the war the work of the Munitions Invention Department was taken over by Brunner Mond and Company (later to become part of Imperial Chemical Industries) and this atmospheric pressure ammonia oxidation plant was installed at Billingham in 1927. The platinum gauzes were twenty inches in diameter, by contrast with those now employed running up to five metres in diameter.

The platinum gauze catalyst, supplied by Johnson Matthey, used in the researches carried out for the Munitions Invention Department in 1916. Measuring only six inches by four inches, it comprised two gauzes mounted in an aluminium frame with silver leads for the heating current.
From the 50 grams of corrugated foil in an Ostwald unit, the weight of platinum in a single converter has steadily increased until it may now reach from 20 to 30 kilograms, while the diameter of the rhodium-platinum gauzes, introduced in 1928 by E. I. Du Pont as an improvement on the pure platinum formerly used (15), can be as great as five metres.

**The Manufacture of Hydrogen Cyanide**

Another process, developed some years later by Leonid Andrußow, like Ostwald a native of Riga, at the I.G. Farbenindustrie plant in Mannheim, also makes use of woven gauzes of rhodium-platinum alloy to convert methane, ammonia and air to hydrogen cyanide (16). This is required in enormous quantities for the manufacture of acrylic resins such as polymethyl methacrylate, known in Britain as Perspex, in America as Lucite and in Germany as Plexiglas, and adiponitrile, an intermediate in the production of Nylon (17). Operating temperatures in the process are appreciably higher than in ammonia oxidation plants, ranging up to 1200°C, so that the mechanical strength of rhodium-platinum at high temperatures and its resistance to oxidation play an important role in addition to its catalytic activity.

**Catalysis in the Organic Chemical Industry**

The wider adoption of catalytic reactions with the platinum metals in the manufacture of organic chemicals, eventually to achieve immense significance in the pharmaceutical, dyestuffs, plastics and synthetic fibre industries, occurred much later than was the case with inorganic products. A great deal of the basic research had been carried out by the beginning of the twentieth century and even before, but the transition into commercial applications was slow in development.

As early as 1874 Professor Prosper de Wilde of the University of Brussels discovered that acetylene could be hydrogenated to ethylene and then to ethane over a platinum catalyst (18) while in 1894 Professor Paul Sabatier and his assistant the Abbé Jean Baptiste Senderens (1856–1936) at the University of Toulouse published the first of their very numerous papers on catalysis (19). Sabatier had been intrigued by Ludwig Mond’s discovery in 1890 of the reaction between nickel and carbon monoxide (page 377) and in 1902 he and Senderens reduced carbon monoxide to methane over a nickel catalyst (20). By 1911 Sabatier had reported at length on the many hydrogenation and dehydrogenation reactions that could be carried out in the laboratory and he became the leading authority on catalysis of his time although he made no attempt to introduce any industrial processes.

**Finely Divided Platinum and Palladium**

Much of the early work involved the use of very finely divided metals, generally in a colloidal state. Carl Ludwig Paal (1860–1935) Professor of Chemistry in the University of Erlangen and later in Leipzig, made a long series of studies on the
preparation of colloidal platinum and palladium and of their effectiveness on catalytic reactions (21) while Aladar Skita (1876–1953), Professor of Chemistry at Karlsruhe, pursued similar investigations on the hydrogenation of aldehydes and ketones with colloidal platinum and palladium (22) and the two collaborated in 1909 in filing a patent for causing these reactions (23). But the use of colloidal preparations was not a practical proposition outside the laboratory because of the difficulty of separating them from the reaction products and attention turned to the so-called “blacks”, a finely divided form of the metal containing an uncertain amount of oxygen. Platinum black had been discovered by Döbereiner in 1833 (page 222), although the product described by Zeise in 1827 (page 264) was possibly of the same nature, but a reliable method for its preparation was first devised by Oscar Loew (1844–1941), a plant physiologist in Munich, in 1890 (24). His method was improved by Richard Willstätter (1872–1942) in 1912 while he was for a period Director of the Kaiser Wilhelm Institute after a long series of investigations on the hydrogenation of aromatics (25). Professor Gustave Vavon of the University of Nancy also carried out a massive research on the hydrogenation of aldehydes and ketones in the presence of platinum black, describing these in his doctoral thesis to the

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Roger Adams
1889–1971

A graduate of Harvard, Adams spent some time studying under Professor Richard Willstätter at the Kaiser Wilhelm Institute in Berlin and in 1916 he was appointed Professor of Chemistry at the University of Illinois where, apart from intervals of government service during two world wars, he remained until his retirement. Under Willstätter he had been engaged in the preparation of platinum black for use as a catalyst and on his return from the first war in 1919 he successfully developed a procedure for its production in a state of high activity and reliability. This useful catalyst still bears his name and is widely used, particularly in the pharmaceutical industry.

University of Paris in 1914 (26), while Vladimir Ipatieff (1867–1952) in St. Petersburg, another prolific worker in catalysis, after a series of investigations with nickel, studied a number of catalytic reductions with palladium black in 1912 (27).

At about this time Nicolai Dmitrievich Zelinsky (1861–1953) also began his long series of researches, converting cyclohexane into benzene with both platinum and palladium blacks as catalysts and continuing these investigations for many years (28).

During this early period, however, the platinum blacks often showed a low or a varying activity and it was not until 1919, when the problem was tackled by Professor Roger Adams who had spent some time under Willstätter at the Kaiser Wilhelm Institute, that a product of uniform activity was obtained consistently. Searching for an active catalyst for organic reductions, Adams and his students developed a successful procedure for what is still known as Adams' Platinum Oxide Catalyst (29). An account of their work with comments by Professor Adams himself may be found in *Platinum Metals Review* (30). This
catalyst was at first prepared by individual workers in their laboratories, but before long it came into use in the pharmaceutical industry and the demand increased. Scaling up was undertaken by platinum refiners in the United States, while in England Johnson Matthey collaborated with May and Baker to develop a process for its preparation in relatively large batches for use in a variety of liquid phase hydrogenation reactions (31).

**Supported Platinum and Palladium Catalysts**

These early forms of finely divided platinum and palladium catalysts were, however, largely superseded by supported catalysts, more especially of palladium in the first place, to make more effective use of the metal and to enable a wider range of reaction conditions to be met. Among a great many materials used as supports, including alumina, asbestos and silica gel, the most generally useful has been activated charcoal, and palladium-on-charcoal catalysts have played an important part in low pressure liquid phase hydrogenation reactions in the pharmaceutical industry to produce vitamins, cortisone and dihydrostreptomycin among other products. Their usefulness, and also that of platinum-on-charcoal in one establishment, Merck of New Jersey, has been described by W. H. Jones (32).

**The Growth of Commercial Processes**

Slowly processes based upon catalysis began to come into industrial use for the production in large quantities of chemicals that were otherwise difficult or impossible to produce, although not at first with platinum metals catalysts. The first major liquid phase processes were for the conversion of animal and vegetable oils into edible fats, generally with finely divided nickel catalysts.

In gas phase reactions the first recorded processes, as mentioned earlier, was devised by Sabatier and Sanderens in 1902 for the production of methane from carbon monoxide and hydrogen, also over a nickel catalyst (20) while, following up this work in 1923, a major step forward was made by Franz Fischer (1877–1935) and Hans Tropsch (1889–1935) at the Kaiser Wilhelm Institut für Kohlenforschung at Mühlheim in the Ruhr, in developing their well known synthesis of liquid hydrocarbons by the gasification of coal and by reacting the hydrogen and carbon monoxide produced in the presence of a catalyst, first of cobalt and later of iron (33).

But the great stimulus to the use of the platinum metals as catalysts came when petroleum began to replace coal tar as the major source of organic chemicals, and with the realisation that the platinum metals, although more expensive initially, often displayed greater activity and made it possible to carry out commercially important reactions at appreciably lower temperatures and pressures than those necessary with base metal catalysts. Greater product selectivity could be achieved, while the platinum metals could readily be recovered and recycled, making their use much more commercially attractive.
The Production of High Octane Fuels and Aromatic Chemicals

As long ago as 1894 Francis Clifford Phillips (1850–1920), Professor of Chemistry at Western University in Allegheny, Pennsylvania – another researcher well in advance of industrial exploitation – studied the nature and constituents of the natural gas and petroleum found in his native state and carried out a long series of investigations on the oxidation of hydrocarbons over finely divided platinum, palladium, iridium, rhodium and osmium supported on asbestos (34).

Before World War II the catalytic reforming of petroleum to increase the octane rating of petrol was introduced in Britain, the United States and Germany, using a molybdenum on alumina catalyst, but this was found to be uneconomical and was superseded by a process developed by Universal Oil Products and known as “Platforming” (35). This was devised from the great expertise on catalysis built up in the later thirties under the leadership of Ipatieff and Tropsch, both of whom had by then joined U.O.P., and by one of Ipatieff’s first students at Northwestern University, Vladimir Haensel. The process involved the reforming of crude naphthas to aromatic hydrocarbons, particularly benzene, toluene and the xylenes, over a platinum on alumina catalyst.

Vladimir Haensel

Born in Germany, Haensel received his early training in Moscow and then under the leading catalytic expert Professor Vladimir Ipatieff at Northwestern University in Elvaston, Illinois. He joined Universal Oil Products in 1937, working with Ipatieff who divided his time between teaching and directing research there for many years. His major contribution was the development of a platinum on alumina catalyst that made it possible to produce not only high octane petrol but also a range of aromatic hydrocarbons from crude petroleum. The process, known as Platforming, has been adopted on a world wide basis. In 1964 he was appointed Vice-President and Director of Research at U.O.P., while in 1974 he was awarded the National Medal of Science by the U.S. Government for “his outstanding research in the catalytic reforming of hydrocarbons which has greatly enhanced the economic value of our petroleum natural resources”.

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One of the early Platforming units commissioned by British Petroleum for the production of both high-octane petrol and a range of aromatic chemicals. The process, licensed from Universal Oil Products, employs a platinum-on-alumina catalyst and great numbers of plants of this type were erected in all parts of the world.

Catalyst requirements were met by Universal Oil Products for many users, but in 1953 catalyst manufacturing facilities were set up in the United Kingdom by Universal-Matthey Products, a subsidiary company of Universal Oil Products and Johnson Matthey, in order to meet the growing demand from European licensees of the Platforming process, while a few years later a similar plant was established in Cologne.

The initiative taken by Universal Oil Products was quickly followed by others in the petroleum industry in developing broadly similar reforming processes employing platinum catalysts (36). In fact the response was enormous, and by the mid-1950s plants were being built in many countries of the world (37). Platinum reforming became one of the most versatile procedures available.
to the oil industry – as well as a major user of platinum – and has continued to provide a wide range of intermediates for the chemical industries. The benzene produced has many uses, including the manufacture of styrene and polystyrene, of cyclohexane for the production of Nylon (first discovered by W. H. Carothers whose doctoral thesis under Professor Roger Adams dealt with the catalytic hydrogenation of aldehydes with platinum black (29)), as well as of phenol for phenolic resins, dichlorobenzene for dyestuffs and maleic anhydride for polyester resins. The toluene produced finds extensive use as a solvent for nitrocellulose lacquers, while ortho-xylene yields phthalic anhydride for plasticisers, dyes and pigments and para-xylene is used to produce terephthalic acid for polyester fibres.

Thus the many types of synthetic materials that provide our fuel, our clothing and the many other items made from plastics depend for their production upon large-scale industrial processes in which the vital part is played by platinum.

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Nikolai Semenovich Kurnakov
1860–1941

One of the principal founders of the modern platinum industry in the U.S.S.R., Kurnakov was first a student and then in 1893 Professor of Inorganic Chemistry in the Mining Institute in St. Petersburg. His work on the complex compounds of the platinum metals materially assisted refining methods and on the death of Chugaev in 1922 he was appointed Director of the Platinum Institute.

Photograph by courtesy of the late Academician I. I. Chernyaev and Professor George Kauffmann

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