JOURNAL OF THE
AMERICAN CHEMICAL SOCIETY

VOLUME 66 OCTOBER 9, 1944 NUMBER 10

PAUL SABATIER

1854–1941

Napoleon, it is said, in his country's hour of need, asked French science what was the difference between liquid and solid fats and how the one could be converted into the other. By 1823 Chevreul had answered the first problem authoritatively, but though he lived to be 103 years of age, he never found a technically possible solution for the second. The problem was intrinsically simple, the addition of one or more molecules of hydrogen to a liquid, unsaturated fat to produce the solid, saturated fat. The technical solution of the problem came from the discovery by two Frenchmen, Sabatier and Senderens, of the catalytic activity of finely divided metals, freshly reduced from their oxides, in the hydrogenation of a wide variety of organic compounds. With this discovery, the modern era of catalytic chemistry may be said to have begun. Its beginning must ever be associated with one of the most brilliant representatives of the French chemical school at the dawn of the 20th century, who lived for four decades of that century to witness the fertility of his discoveries and died August 14, 1941, at the age of 86 years, the dean of French chemists, Paul Sabatier.

Born of humble parentage at Carcassonne, November 5, 1854, Sabatier received his secondary school education at the Lycée of this town and then prepared at Toulouse for entrance examinations at the École Polytechnique and the École Normale Supérieure. Accepted by both in 1874 he chose the latter and graduated three years later, first in his class. He entered the laboratory of Berthelot at the Collège de France in 1878, after a year of teaching in the Lycée at Nîmes, and there prepared for his doctorate, receiving the degree of Doctor of Science in 1880 with a thesis on the thermochemistry of sulfur and the metallic sulfides.

After a year spent in the Faculty of Sciences at Bordeaux he took charge, in January, 1882, of a course in physics and in 1883 of a course in chemistry at the University of Toulouse and became Professor of Chemistry there in November, 1884. At Toulouse he remained to the end. The most attractive offers from elsewhere, notably the succession to Moissan at the Sorbonne in 1908, never sufficed to separate him from his adopted city. He retired from his professorship in 1930 after nearly fifty years of uninterrupted service in the Faculty of Science, of which he was Dean for more than twenty-five years. Though retired, Sabatier was permitted, by special authorization, to continue lecturing, which he did almost to the end. His students speak of "a marvellous professor, exercising a veritable fascination on his auditors; his pupils surrounded him with a real veneration." Those pupils, who shared the joys of pioneering in the newly opened fields of catalysis in organic chemistry, include the Abbé Senderens, Mailhe, Murat, Espil, Mignonac, Gaudion.

Sabatier's earliest researches were in the field of physical chemistry, determined doubtless by his training in physics and the influence of Berthelot. From 1879 to 1897 there were numerous thermochemical researches on sulfides, chlorides, chromates, copper compounds. They include studies on the velocity of transformation of metaphosphoric acid, on the distribution of a base between two acids and on absorption spectra. In the same period there were numerous articles on the inorganic chemistry of metallic sulfides, sulfides of boron and silicon, selenides, chlorides and bromides, notably of copper. From 1896–1899 there were penetrating studies of the oxides of nitrogen, of nitrosodisulfonic acid and its salts.

The investigations in the field of organic chemistry began in 1897 and the tempo of furious effort that followed in the next ten to fifteen years is well revealed in the classical text published in 1912, "La Catalyse en Chimie Organique." This volume certainly marks a milestone in the evolution of modern chemistry and its general utility today, thirty years after its publication, is the best index of its lasting worth. Sabatier has himself recorded how his interest in the field arose (*Ind. Eng. Chem.*, **18**, 1005 (1926)). Intrigued by the ability of carbon monoxide to form nickel carbonyl, demonstrated by Mond, Langer and Quincke in 1890, dissatisfied with experiments of Moissan and Moureu in 1896 which indicated that acetylene reacted with reduced iron, nickel and cobalt with incandescence to yield carbon, hydrogen and liquid hydrocarbons, Sabatier and Senderens in 1897 directed the "less violent" hydrocarbon, ethylene, over reduced nickel. Reaction only occurred on heating to around 300°, giving a voluminous deposit of black carbon. The vital observation and the brilliant deduction were made, however, on the gas generated. It "contained only a little hydrogen and was mainly ethane. The latter could only proceed from a hydrogenation of ethylene not destroyed, and this hydrogenation had been without doubt provoked by the presence of nickel." Here once more, as so often before and since, a discovery of major significance for the future of the science depended on an observation that might easily have been overlooked and on a cogent deduction from that observation. The smooth catalytic hydrogenation of ethylene–hydrogen mixtures rapidly followed. Acetylene was shown also to yield ethylene and ethane. Reduced cobalt, iron and copper, as well as platinum, were shown "to possess an analogous but less energetic action." The generality of the special power of reduced nickel was decisively tested by the hitherto unaccomplished direct reduction of benzene to cyclohexane. In the first test, the transformation of benzene was complete.

The widespread field of investigation of catalytic methods in organic synthesis was practically completely explored by Sabatier and his students. Many of the modern applications of the technique in the last thirty years owe their origins to the work recorded already in 1912 in Sabatier's classic text. In addition to the hydrogenation–dehydrogenation activities of metals, those of oxides, such as zinc and manganese oxides, were explored. Oxides such as thoria, silica and alumina were shown to possess dehydration–hydration characteristics. The phenomenon of selective catalysis was demonstrated. The sensitivity of catalysts to traces of poisons, revealed by the researches of Knietsch on platinum contact masses for sulfuric acid formation, was shown to be a general phenomenon, and could be utilized for the control of extent of reaction. The conversion of nitrobenzene to cyclohexylamine in stages was one example studied in detail. His work revealed also the general increase in catalytic activity arising from the spreading of the active material on suitable supports. As early as 1897 he was measuring the temperature coefficients of surface catalyzed reactions.

Sabatier remained always the teacher with little or no personal interest in the practical application of his discoveries. Oil hydrogenation, methanol synthesis, catalytic esterification and synthesis of amines and thiols, hydration of olefins, all the modern applications of catalysis to hydrocarbons proceed in direct line from his work and that of his students. A realization of those manifold applications served but to intensify his efforts to provide at Toulouse better facilities for education in applied science. Institutes for the training of electrical, chemical and agricultural engineers were founded as a result of his personal initiative. It was his disinterested devotion to the purely scientific aspects of his work that stimulated the generosity of the Procter and Gamble Company of Cincinnati, Ohio, to provide

Sabatier with an honorarium and the expenses necessary for a visit to America in 1926 to receive the Honorary Membership of the American Chemical Society and the Doctor of Science (*honoris causa*) of the University of Pennsylvania at the September meeting of the Society in Philadelphia.

Reserve and detachment were characteristic of Sabatier. There is as a consequence little to record of his private life. From his marriage to Mlle. Herail there were four daughters, one of whom became the wife of the Italian chemist, Emilio Pomilio. This daughter and son-in-law accompanied Sabatier on his American visit.

The highest distinctions came to Sabatier as the result of his discoveries. In 1912 he shared the Nobel Prize for Chemistry with his countryman, Grignard. He received the Davy Medal of the Royal Society in 1915. As early as 1897 the Academy of Sciences in Paris awarded him the Lacaze prize and in 1905 the Jecker prize. He became Correspondent Member of the French Academy of Sciences in 1901 and first non-resident member in 1913. Chevalier of the Légion d'Honneur in 1907 he was named Commander in 1922. Foreign academies elected him to membership: to Madrid, 1913; to the Royal Society in 1918; to the Amsterdam Academy in 1919; to the Academia dei Lincei of Italy in 1923; to the Royal Society of Bohemia and the Academy of Roumania. Numerous societies elected him to honorary membership and decorations came to him from many foreign lands, Italy, Portugal, Serbia, Tunis among others. The Franklin Institute bestowed its highest honor, the Franklin Medal, on him in 1933. Of the many distinguished foreign scientists who visited America on the occasion of the Philadelphia Sesquicentennial an observer recorded that Sabatier was "easily the most popular of the foreign guests—although the only one not speaking English." He carried back with him to his beloved Toulouse the memory of a warm and kindly reception from American chemists and a sense of wonder and awe at the development, attained even then, of the industries which were applying his discoveries. Like Faraday before him, Sabatier chose science, rather than the wealth, and cares, of applied science. As Tyndall wrote of Faraday in England, so we may write of Sabatier "for more than forty years his was the glory of holding aloft among the nations" the scientific name of France.

Hugh S. Taylor

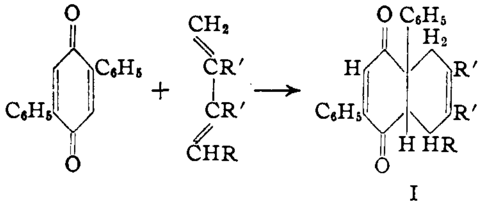
[Communication No. 976 from the Kodak Research Laboratories]

Some Reduced Naphthoquinones Containing an Angular Phenyl Group

By C. F. H. Allen, A. Bell, J. H. Clark and J. E. Jones

In connection with our work on the 1,3-rearrangement of a phenyl group,[1,2,3] it seemed desirable to attempt the synthesis of a bicyclic system in which the shift of a phenyl group would not be anticipated. A reaction that would be expected to give a substance having such a structure is a diene synthesis, using 2,5-diphenylquinone and butadiene. In such an addition product, the phenyl group is attached to one of the carbon atoms which is common to both rings and which is not a part of an allylic system, so that a 1,3-rearrangement would not be expected. However, a migration was encountered during the subsequent bromination, the phenyl appearing in the 2-position on the quinone ring.

It has been found that butadiene, 1-phenylbutadiene, and 2,3-dimethylbutadiene all add to 2,5-diphenylquinone.



I

The proof of structure of these addition products I is difficult. In chemical reactions, the products resemble those that result from the interaction of quinones and Grignard reagents. In most instances, there are formed large amounts of intractable oils, the components of which resist separation and identification.

The addition products are yellow, like unsaturated 1,4-diketones. They decolorize permanganate instantly, but react slowly with bromine. In the Grignard machine, the diene adducts consume one mole of methylmagnesium halide by addition, and undergo a slow enolization which is

---

(1) Allen and Spanagel, This Journal, 55, 3773 (1933).

(2) Allen and Gates, *ibid.*, 64, 2123 (1942).

(3) Allen and VanAllan, *ibid.*, 64, 1260 (1942).