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MOSES GOMBERG

1866—1947

A Biographical Memoir by

JOHN C. BAILAR, JR.

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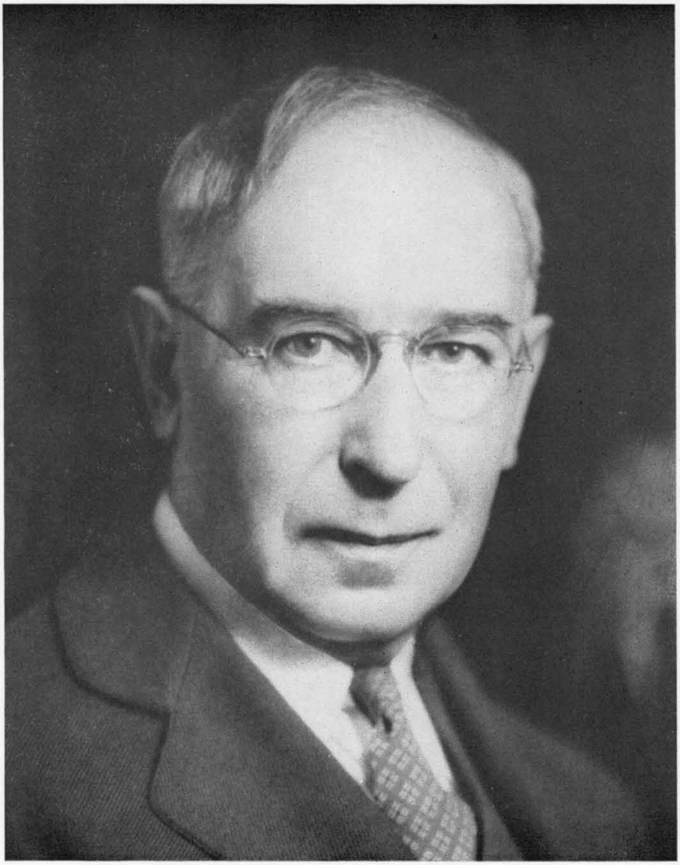


M. Gomberg

MOSES GOMBERG

February 8, 1866–February 12, 1947

BY JOHN C. BAILAR, JR.

MOSES GOMBERG, one of the world's truly great organic chemists, was born in Elizabetgrad, Russia, on February 8, 1866, and died in Ann Arbor, Michigan, on February 12, 1947—four days after his eighty-first birthday. Aside from the fact that his parents were George and Marie Resnikoff Gomberg, and that he had a younger sister, Sonia, almost nothing is known of his family. In his mature life, he rarely, if ever, spoke of his boyhood, and even his closest friends did not know what sort of life he led before coming to America. It is known only that he attended the Nicolau Gymnasium in Elizabetgrad from 1878 to 1884. In the latter year, his father was accused of political conspiracy and, in order to avoid arrest and imprisonment, he fled from Russia to the United States, sacrificing all of his property in Russia. The son, although only eighteen years of age, was also under suspicion, and he either accompanied his father to America, or followed soon afterwards. There is no record of their flight from oppression, and we do not know whether they were allowed to depart peaceably and in comfort, or had to flee in secret. We do not even know whether Mrs. Gomberg came to America, but she probably did, for Sonia came, and lived for many years with her brother after he settled in Ann Arbor. Whether there were other brothers or sisters, and, if so, what happened to them, no one seems to know.

The Gombergs settled in Chicago, where they earned their living at whatever work they could find. Since they spoke no English, this work was usually common labor. Apparently the young Gomberg worked as a laborer in the stockyards—a job which must have been most repugnant to a person of such sensitive nature. Years later, when Upton Sinclair wrote his book *The Jungle,* describing the almost unbelievably horrible conditions that existed in the stockyards, Professor Gomberg told one of his friends that he could attest from personal experience that the description was not overdrawn.[1]

In addition to earning a living, the young man learned to speak English and prepared himself to enter college. He was determined to continue his education at any cost. Whether he attended high school in Chicago or studied independently, we do not know, but the record shows that he was admitted to the University of Michigan in 1886. (This is evidently the earliest written record of the events of his life.) It is reported that he chose the University of Michigan over the university in his "home" state of Illinois because he had to work his way through college and he had learned that student janitors at Michigan were paid better than those at Illinois.[2]

When he enrolled at the University of Michigan, he wanted to take the beginning course in physics, and he presented himself to Professor H. S. Carhart, who was then head of the Physics Department. Professor Carhart explained to the young man that he could not take the course because he had not had training in trigonometry. The youngster went away crestfallen, but three days later he returned, again requesting that he be

[1] Letter from Dr. E. C. Sullivan to Professor W. B. Pillsbury, January 14, 1960.

[2] Reported by Professor G. F. Smith, based on a conversation with Professor Gomberg.

allowed to enroll in the physics course. Again, Professor Carhart told him that he could not take the course because he had not studied trigonometry. "But I have studied trigonometry," the young man answered. In order to show him how little he knew of the subject, Professor Carhart began to question him about his knowledge of trigonometry. Much to his amazement, he discovered that the young man was able to answer all of his questions and that he had a thorough knowledge of trigonometry. He had mastered the entire subject in three days.[3]

Young Gomberg received the Bachelor of Science degree from the University in 1890 and, with the help of an assistantship, he was able to continue in graduate work. He received the Master's degree in 1892 and the Ph.D. in 1894. His thesis work was done under the direction of Professor A. B. Prescott, and concerned the reactions of caffeine. In those days, chemistry was primarily concerned with analysis, and although Professor Prescott was principally an organic chemist, he was also widely known for his work in analytical chemistry, and was frequently called upon by commercial firms for help in analytical problems. It was doubtless through Professor Prescott that Dr. Gomberg was able to earn money in his spare time by analyzing materials for numerous clients. The samples which came to him were of wide variety and included minerals, drugs, foods, oils, and fats. The experience which he gained from this work, as well as his training under Professor Prescott, impressed upon him the importance of careful analysis. It was a lesson which he always remembered, and which he impressed strongly upon his own students.

Some of the analytical work which Dr. Gomberg did during this period was necessitated by patent infringement suits, and the young man soon found himself involved as an expert witness, in which capacity he not only had to report the results of

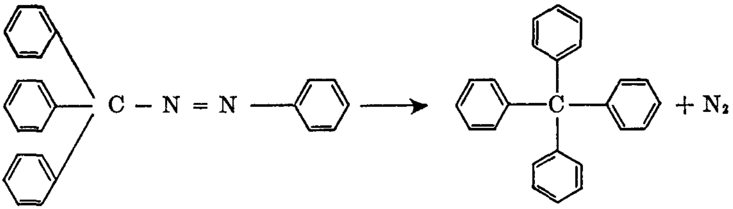
[3] A. H. White, *Ind. Eng. Chem.*, 23 (1931):116.

his analysis but often had to match wits with opposing lawyers. Although he enjoyed this work, he looked upon it only as a means to earn money for further study and, since it took time from his research, he abandoned it as soon as it was economically feasible to do so.

Dr. Gomberg was appointed to an instructorship at Michigan in 1893, and continued as a member of the faculty there until his seventieth birthday in 1936. This remarkable tenure of forty-three years was interrupted only by a leave for foreign study in 1896 and 1897, a leave to do defense research during World War I, and a summer term during which he taught at the University of California. He was so devoted to his teaching and to his research that, aside from these three periods, he traveled little and seldom left Ann Arbor.

During his first leave of absence from Michigan, Dr. Gomberg spent two terms in Baeyer's laboratory in Munich, and one term with Victor Meyer in Heidelberg. The research which he did in Munich was concerned with the preparation of isonitramino- and nitroso-iso-butyric acid. The paper based on this work attests Gomberg's diligence and skill, for it reports a large number of experiments, and far more results than might have been expected from a man working for such a short period of time. The single term with Meyer, however, was even more fruitful, for it was the work he did there that laid the foundation for his discovery of free radicals.

Dr. Gomberg went to Meyer's laboratory bent on attempting the preparation of tetraphenylmethane, a synthesis which had been attempted, without success, by several noted chemists, including Victor Meyer himself. These repeated failures had convinced Meyer and others that tetraphenylmethane was inherently unstable for steric reasons, and that it could not be prepared. He tried to dissuade his young visitor from attempting the synthesis, but Gomberg was determined and went ahead with his plan. He had devised a new method of synthesis, involving the preparation of triphenylmethylhydrazobenzene, its oxidation to the azo compound, and the thermal decomposition of this material to the hydrocarbon shown in equation 1.

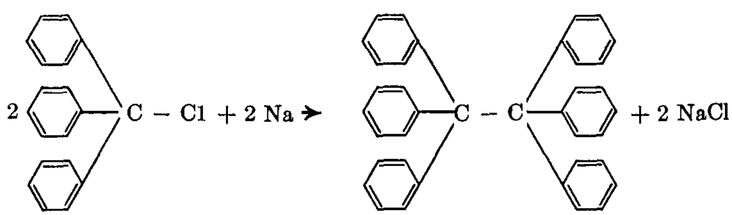


(1)

The first steps of the synthesis proceeded in a satisfactory manner, but when the azo compound was heated to 110-120°, a gummy, sticky residue was formed. Gomberg worked with this for several days, and was eventually able to isolate about three tenths of a gram of crystalline material from it. He believed this to be the desired tetraphenylmethane, but in order to be sure he had to fully characterize it. To appreciate the elegance of this characterization, one must remember that, in 1897, micro techniques had not been developed. The usual size of sample taken for elemental analysis was two tenths of a gram, which, in this case, would have taken nearly all of the available material. Before attempting the analysis, Gomberg tested the solubility of his compound in several solvents, took its melting point, and determined its molecular weight by the lowering of the freezing point of naphthalene in which he had dissolved the material. After the completion of these tests, he recovered and purified his compound, and analyzed it for carbon and hydrogen. The analysis showed 93.32 percent carbon and 6.36 percent hydrogen, which agreed remarkably well with the calculated values for tetraphenylmethane (93.75 percent and 6.25 percent). He felt, however, that tests performed on such small samples, and without checks, were inconclusive, so a year later, after he had returned to Michigan, he repeated the work and published another paper. The two tenths of a gram of substance which he obtained in the second run was nitrated to the tetranitro compound, which he obtained in practically quantitative yield. He determined the solubility of this material in several solvents, took its melting point, reduced a portion of it to the rosaniline dye, studied its reactivity (or rather, its lack of reactivity) with sodium ethylate and with metallic potassium to show that it contained no active hydrogen atoms, and analyzed the material for nitrogen. Still later, he had a student prepare the material on a much larger scale, and repeated his earlier measurements just to be sure that he was right.

His success with the preparation of tetraphenylmethane led Dr. Gomberg to attempt to prepare the next fully phenylated hydrocarbon, hexaphenylethane.

He planned to prepare this material by the treatment of triphenylmethyl chloride with metallic sodium (equation 2)



(2)

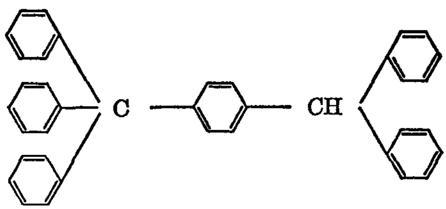
and was disappointed to find that the expected reaction did not occur. When he used "molecular" silver, however, reaction occurred readily, and from the solution he obtained a white, crystalline substance which he supposed was hexaphenylethane. However, analysis for carbon and hydrogen showed that the percentages of both elements were lower than the calculated values (calculated for carbon, 93.83, for hydrogen, 6.17; found for carbon, 87.93, for hydrogen, 6.04). He repeated the preparation and the analysis under a variety of conditions, but the results were always essentially the same. This led Gomberg to the conclusion that the compound contained oxygen, which he at first suspected came from silver oxide that might have been present as a contaminant in the silver; but especially prepared silver, which he knew to be free of silver oxide, gave the same result. Substitution of zinc and mercury for the silver yielded the same compound. He was finally forced to conclude that the oxygen must have come from the air. He then devised methods of performing the experiment in the complete absence of air, using apparatus with ground-glass joints. Such equipment is available now, even to elementary students, but in those days it was rare, and its use was almost revolutionary. Gomberg was unwilling to use either cork or rubber stoppers, for he feared that some oxygen might diffuse through them. When he treated triphenylchloromethane with metals in this new apparatus, the crystals which he had observed to form in the earlier experiments did not precipitate. By careful evaporation of the solution in the absence of air, he obtained a material which gave a satisfactory analysis for the hydrocarbon (calculated for carbon, 93.74, for hydrogen, 6.26; found for carbon, 93.28, for hydrogen, 6.22).

Not long before performing this critical experiment, Dr. Gomberg had read a paper by Carl Engler, who postulated that atmospheric oxidation always gives a peroxide as the initial product.[4] This peroxide may decompose to a normal oxide, but, according to Engler, the peroxide must be formed first. This hypothesis suggested to Gomberg that his oxygen-containing product was triphenylmethyl peroxide—a conclusion which subsequent study has confirmed.

The new, oxygen-free compound behaved as a highly unsaturated hydrocarbon. In benzene solution, it not only reacted with oxygen of the air but combined avidly with the halogens. Gomberg wrote: "The experimental evidence . . . forces me to the conclusion that we have to deal here with a free radical,

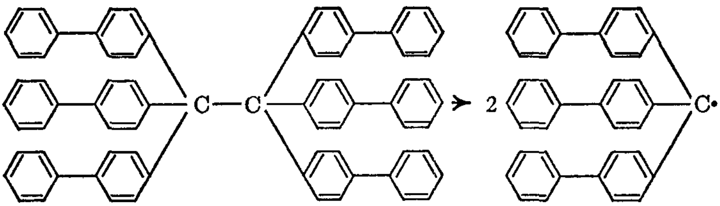
[4] Reported to the author by Professor Gomberg.

triphenylmethyl, $(C_6H_5)_3C$. On this assumption alone do the results described above become intelligible and receive an adequate explanation." Such a conclusion was quite at variance with the theories of organic chemistry which were then current, and Gomberg's compound attracted the attention of a large number of chemists—among them several of the best-known chemists of the day. Many questioned the existence of triphenylmethyl, for, although the chemical reactivity of "hexaphenylethane" indicated a highly unsaturated character, molecular weight determinations did not indicate a significant degree of dissociation. Moreover, Ullmann and Borsum prepared a compound (1902) which had the same elemental composition and which they supposed to be hexaphenylethane. This material was later shown to be the isomeric para-trityltriphenylmethane (equation 3).



(3)

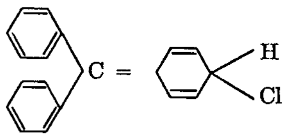
The unwillingness of Ullmann and Borsum to accept the existence of trivalent carbon led other chemists to suggest that hexaphenylethane is unstable and decomposes in the presence of oxygen or halogens. Still others suggested quinoid formulas. Gomberg continued to maintain that none of these suggestions were supported by the experimental evidence. Studies of the molecular weights of a variety of hexaarylethanes eventually showed his view to be the correct one, for, although hexaphenylethane is only slightly dissociated in benzene solution, other hexaarylethanes are dissociated to much greater degrees, and hexa-para-biphenyl ethane is completely dissociated (equation 4). Even in the solid state it exists in the free radical form.

 (4)

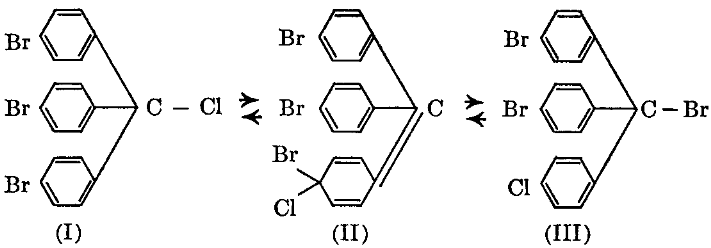
It is now well known, of course, that the formation of free radicals is not solely a property of triarylmethyls, but that a great number of organic compounds exist as free radicals, at least as reaction intermediates. It is generally accepted that organic reactions proceed by one of two types of mechanism—they are either "free radical" or "ionic." In many cases, "free radical intermediates" are of long enough life that they can be studied readily by modern techniques.

Dr. Gomberg's interest in compounds containing several aryl groups found an outlet also, in his early synthesis of pentaphenylethane, the first synthesis of unsymmetrical tetraphenylethane, and the synthesis of biaryls by the diazo reaction. The last of these syntheses is now commonly known as the Gomberg reaction.

Although Professor Gomberg is best known for his discovery of trivalent carbon, he made many other contributions to organic chemistry. Among these was his work on the quinoid structure of aromatic compounds. This work began with his explanation of Schmidlin's discovery that solutions of triphenylmethyl contain two forms of the substance. Gomberg assumed that one of these forms was quinoidal. Quinoid structures had been proposed for other compounds, chiefly to account for color in substances which might be expected to be colorless, and there was a good deal of debate on the entire matter. Gomberg had found that triphenylchloromethane forms highly colored complexes with some metallic salts, and Kehrmann suggested that these were quinoidal; e.g.,



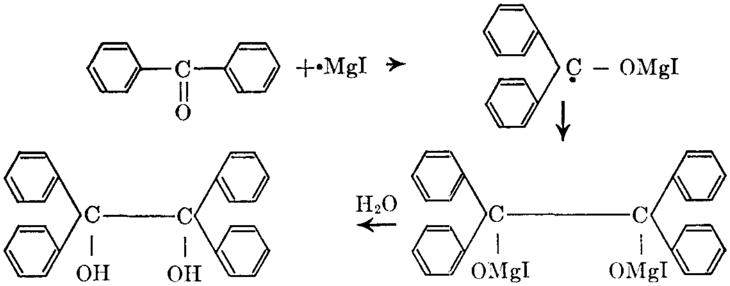
Gomberg reasoned that if this was correct, the chlorine atom in p, p′, p′′-tribromotriphenylchloromethane should be able to shift to a para position under suitable conditions; thus, the chlorine atom and a bromine atom would occupy identical positions (equation 5). This point of view was vigorously at-



(5)

tacked by Baeyer, but Gomberg proved his point by allowing a solution of compound (I) in liquid sulfur dioxide to stand for several days, and then evaporating the solvent. The product was found to be a mixture of compounds (I) and (III), the latter, in some cases, being present to the extent of 85 percent. Other compounds of this class showed similar behavior.

Gomberg's last series of investigations concerned the reducing action of mixtures of magnesium and magnesium iodide. This system, in a mixture of benzene and ether, reduces many unsaturated systems, somewhat resembling metallic sodium in that respect. Gomberg accounted for these results by assuming that a free radical, •MgI, was present in the reducing system. For example, aromatic ketones are reduced to pinacols (equation 6). Similarily, aldehydes, acids, and esters are reduced to benzoins.



(6)

Although Professor Gomberg is known almost exclusively for his "academic" research, he also made notable contributions to applied chemistry. He is credited with the development of the first antifreeze compound used in automobiles, and with the development of new solvents for automobile lacquers. The manufacture of ethylenechlorohydrin, which was used in the synthesis of mustard gas during World War I, followed a method which he devised. As a major in the Ordnance Department, he served as an adviser in the manufacture of smokeless powder and high explosives.

When Professor E. D. Campbell died in 1925, Dr. Gomberg was invited to become Chairman of the Chemistry Department at the University. He did not wish to do so, but agreed to accept the position temporarily while a search was made for someone else. This search proved fruitless; none of the men who were suggested and who were acceptable to the department wished to assume the post. After two years, even Professor Gomberg was persuaded that there was no profit in looking further, so he accepted the position on a permanent basis. He served until his retirement on his seventieth birthday.

Professor Gomberg was deeply committed to science and to chemical research, but he was also extremely interesting as an individual—brilliant, yet modest; shy, yet friendly; famous, yet humble. Since I was one of the last of his students, I knew him only in his later years, and for earlier descriptions of him I have had to rely upon students and colleagues who were acquainted with him before my time.

It may not be amiss to say a little about Professor Gomberg's appearance. He was of average size, perhaps five feet eight inches, and average build—not thin and not stocky. Dr. Lee Cone Holt, describing him as he was long before I knew him, spoke of his black hair, his close-clipped black mustache, and the glasses which he wore on a black ribbon that hung over his right ear.[5] By the time I made his acquaintance, his hair was gray and thinning and the mustache had long since been shaved off, but he still wore the pince-nez on a ribbon. I remember particularly well his hands, for it did not seem to me that a man with short, almost stubby, fingers could have the fine experimental technique that I had been told about. However, I soon learned that he had remarkable manipulative skill. He dressed neatly and in a conservative manner. In the Chemistry Building, he always wore a short lab coat of white or ecru color. His first act, when he came to his office, was to remove his street coat and don his laboratory jacket. He wore it even to his lectures. One could always tell whether the Professor was in the building by looking in his office to see whether his lab coat was hanging there. If it was, he was not in the building; if it was not there, he must be close by.

The picture of Professor Gomberg which accompanies this memoir must have been taken when he was about seventy years old, but it shows a man who looks much younger. There are few wrinkles in his face, his eyes are bright and twinkling, and he has the alert expression of a young man. He enjoyed his

[5] Lee Cone Holt, C. S. Schoepfle, F. W. Sullivan, Jr., A. H. White, and F. W. Willard, *Ind. Eng. Chem., News Ed.,* 14 (1936):65.

youthful appearance, as is illustrated by his telling a story on himself. It records an event which happened about the time he retired. One day, as he was driving across Ann Arbor, he came to a stop sign, but since it would have necessitated shifting gears to come to a stop, he merely slowed down and then went across the intersection. A policeman stopped him and gave him quite a lecture on his error in this matter, ending his talk with the statement, "The next time, I want you to come to a complete stop." The Professor, in what must have been wide-eyed innocence, asked, "Is there any other kind of stop?" The story would never have been told except that Professor Gomberg was highly pleased with the policeman's answer, "Don't give me none of your lip, young feller."

Professor Gomberg spoke with a slight accent—not enough to cause any trouble in understanding, but just enough to give his speech a charming individuality.

In collecting material for this biographical sketch, I have written to and talked with many persons who knew Professor Gomberg well over a period of many years. They have all commented on his modesty, politeness, kindness, and generosity—admirable traits, and all very true. It is because of his modesty and his unwillingness to talk about himself that so little is known of his childhood. In his lectures, if he spoke of his own research, it was referred to only as "work done in this laboratory." He received many honors, but he never mentioned them. Among these honors were membership in the National Academy of Sciences (1914), honorary membership in the Netherlands Chemical Society, the Nichols Medal (1914), the Willard Gibbs Medal (1925), the Chandler Medal (1927), the presidency of the American Chemical Society (1931), honorary Doctor of Science degrees from the University of Chicago (1929) and the Polytechnic Institute of Brooklyn (1932), and the degree of Doctor of Laws from his alma mater in 1937.

There is an interesting anecdote that illustrates his modesty and kindness. Professor Gomberg let it be known that he felt that it would be inappropriate for him to endorse applications for membership in the American Chemical Society during the time he was President of the society. He feared that his endorsement might indicate to some that he was using his presidency to push his friends ahead. One of the graduate students in the Chemistry Department at Michigan who wished to join the society evidently had not heard of Professor Gomberg's feeling on the matter, so he asked the Professor for his endorsement. When the Professor hesitated, the student asked, "You *are* a member of the society, aren't you?" to which the Professor responded, "Yes, I am a member," and signed. He could not bring himself to embarrass the boy by explaining that he was president of the society. Yet, this modesty was not built on an inferiority complex. Dr. Bertrand Summers, a long-time friend, has written: "Most of the men whom you consult will probably mention the fact that he seemed rather shy and reticent. My own memory of those years when I knew him best was not so much these pleasing attributes that impressed me as it was the idea that there was considerable strength in his personality."[6]

One of his early colleagues, Dr. Eugene C. Sullivan, wrote: "He was dignified, quiet, and modest, although even in his early days rather conscious of his powers."[7]

Although Professor Gomberg was extremely kind and gentle, he could become angry if sufficiently provoked. During World War I, the United States found it difficult to obtain important synthetic drugs such as veronal, novocaine, and salvarsan, and there was much talk of synthesizing them here in the United States. A chemistry student at Michigan became

[6] Letter from Dr. Summers, March 30, 1960.

[7] Letter from Dr. E. C. Sullivan to Professor W. B. Pillsbury, January 14, 1960.

interested in the preparation of salvarsan, and discussed his plan with Professor Gomberg. Although the Professor felt that the synthesis was too difficult for an inexperienced chemist, he did not discourage the boy, for it was quite foreign to his nature to discourage anyone who wanted to do something worthwhile. In his enthusiasm, the young man mentioned his plan to a reporter on one of the Detroit papers, and said that he had discussed it with Professor Gomberg. The reporter added his own misdemeanor to that of the student, and wrote that Professor Gomberg and one of his students had synthesized salvarsan. When this came to the Professor's attention, he was terribly upset. As soon as he could locate the offending student, he took him to his office, and chastised him verbally with such anger and ferocity that everyone in that part of the building heard what he said.[8]

The Professor was so extremely courteous that it was almost impossible to go through a door behind him. He always stood aside to wait for whoever was with him to precede him through the door. Many persons who have written to me about Professor Gomberg have commented on this. Of course, we noted it when we were students, and we sometimes tried to arrange things so that he would have to precede us, but always to no avail. Professor Halford tells me that on one rare occasion he was able to rig the situation so that there was no alternative, and the Professor had to go through the door first. He knew that he had been tricked into this situation, and he accepted his defeat gracefully. Both he and Halford laughed about it.[9]

Professor Gomberg's kindness and generosity are illustrated by his solicitude for his sister, and this also introduces a sad note into the story. During the early days in Ann Arbor, they lived very humbly, almost like Russian peasants, but by the

8 Reported by Professor H. H. Willard.
9 Reported by Professor J. O. Halford.

time I knew them, they had a modest, but delightful, home near the campus. They used to entertain his graduate students at dinner once or twice a year, and we all remember Miss Gomberg as a pretty, very gracious woman. About the time Dr. Gomberg retired, his sister's health began to fail, and he spent the years of his retirement taking care of her. Many of his friends felt that she needed his help less than she felt she did, and that he was more solicitous of her health than was necessary. In any event, his concern for her kept him close to home. He once told me, with sadness but with no bitterness, that he had planned to spend those years in research and in travel, but because of her illness such activities were impossible. After his retirement, he seldom came to the Chemistry Building, although he had an office there, and he felt that travel away from Ann Arbor was completely out of the question.

Dr. Summers has written that, in 1944, he and Dr. Sullivan called on the Professor, and he adds, "I thought Dr. Gomberg had aged perceptibly. He wanted to prolong our visit and he even walked with us part of the way back to the university. I think he was a lonely man after his energetic life's work."[10] The Gombergs' friends often speculated on what dire consequences would ensue if Sonia should outlive her brother. This concern, too, proved to be unjustified, for she did live for several years after his death, in relative comfort.

Professor Gomberg was deeply interested in his students, both professionally and personally—even in their love affairs. He counseled them not to marry until they had finished their training, but not to wait too long after that. When he learned that his assistant, D. D. Van Slyke, had become engaged, he shook his head sadly and said, "It is too bad. He was *such* a good assistant." When Lee Cone Holt joined the Professor's group, he was asked to promise that he would leave the girls

[10] Letter from Dr. Bertrand Summers, March 30, 1960.

alone. He kept this promise reasonably well, and when he finished the work for his degree, the Professor told him, "You have kept your promise well. Now, don't wait too long."[11] When Werner Bachman told the Professor that he was engaged and planned to marry soon, the Professor replied with astonishment, "But, Werner, I had other plans for you." It developed that these other plans involved a post-doctorate fellowship for Werner in Karrer's laboratory in Zurich. Fortunately, both the marriage and the other plans were soon arranged.

The laboratory in which we worked joined the Professor's private laboratory, and he usually came in to see us five or six times every day. He commonly came to the building about half-past eight in the morning, donned his laboratory jacket, and came directly into our laboratory. Usually, he found us all at work, but one morning I was the only one of the three students who was there. After he had talked with me about my research for a moment, he asked, "Where are the other boys?" I explained that one of them was teaching a class and the other one had not yet arrived at the Chemistry Building. A cloud passed over his face and he said, "But you should all be here every morning at eight o'clock." Of course, I told the others, as he knew I would, and thereafter we were always there before he arrived.

He advised us that we should not work in the laboratory in the evenings, but spend that time in the library. He was a prodigious reader, and he expected us to be so, too. He told us that when he decided to be a chemist he read the *Berichte* from cover to cover, starting with Volume 1, Number 1. I think that when I worked with him thirty years later he was still reading the *Berichte* from cover to cover, and he seemed to remember everything that he read. Sometimes, when discussing our research with us, he would suggest that we look up a

[11] See footnote 5.

certain article. He could always give us the name of the author and almost the exact year in which the article had been published. When Bachman was preparing to go to Switzerland, the Professor had him read the *Helvetica* in its entirety, beginning with Volume 1, so he'd know who the Swiss chemists were and what they had done. When I won an appointment at the University of Illinois, he instructed me to read all of the papers that the organic chemists at Illinois had published. I had only a little over a month for this rather ambitious project, and I hardly made a start on it. Nor did we follow his advice about spending our evenings in the library, for we knew that he would greet us in the laboratory in the morning, as he always did, with "Well, what have you done here since I saw you last?" He rather discouraged us from working in the Chemistry Building on Sundays and asked that, if we did so, we pull down the blinds so that we wouldn't offend any passers-by who might object to our laboring on the Sabbath. This pattern must have been different in earlier days, for Lee Cone Holt records that the entire research group, including the Professor, sometimes worked all night and often took their lunches to the laboratory on Saturdays and Sundays, so they could work through the entire day without interruption.

During my tenure at Michigan, Professor Gomberg had a weekly seminar with his little group of three or four students. When the name of some well-known organic chemist came into the discussion, he frequently told us anecdotes about the man or gave us some interesting bit about his life or his character. How he learned all these things, I never understood, for he seldom left Ann Arbor, and he didn't have many guests. In any event, these interludes were important, for in later years, when we read articles by the men whom he had described to us, we knew the authors not just as names but as live human beings, not unlike other people. It made chemistry come alive for us.

I remember particularly well the Professor's story of the origin of the long scientific polemic between Arthur Michael at Harvard and John Ulrich Nef at Chicago. When these men were young, they were students together in Germany. There was also a young American woman, Miss Abbott, who was doing graduate work in botany in the same university. Both men fell in love with her and both wanted to marry her. Nef won. This embittered Michael and, thereafter, he lost no opportunity to criticize Nef's scientific theories. It is interesting to note in passing that Michael remained a bachelor throughout his life.

On another occasion, Professor Gomberg told us of an organic chemist who was well known then, but who shall remain anonymous here. This man had taught at one of the prominent midwestern universities, but he incurred the displeasure of the president of the university by frequenting certain places that a professor should not patronize. When the president remonstrated with him, the chemist protested that he did not go to these places for the usual purpose, but that he was interested in sociology, and he wanted to talk with the girls about their profession and the lives they led. The president replied that he was bringing discredit to the university and that he must stop his sociological studies. The chemist promised that he would do so, but he did not keep his resolution and was soon forced to resign from the university. Upon his solemn promise that he would do no more sociological studies, he obtained a professorship at an eastern school of somewhat lower prestige. Unfortunately, his desire for sociology had too great a hold on him, and he was again dismissed. No university would then give him a professorship, and he was out of work for some time. He finally obtained a position with one of the government bureaus in Washington, where there was less concern about his evening activities. Professor Gomberg added that he did not know whether the learned chemist had continued his work in sociology or not. He was amused by this story in a detached sort of way, and he enjoyed telling it to us. If he was trying to interest us in this man's published papers, he could not have found a more effective way.

The Professor knew a lot about us and what went on in the laboratory, too, though we thought we were keeping some things from him. One of the students in the laboratory secreted some small booklets of pornographic literature in his desk, and invited students from other laboratories to come in to read them. If the Professor entered the laboratory, the booklets were quickly slipped into a pocket or dropped into an open drawer. This went on for some days, and the Professor seemed to be completely unaware of this desecration of the laboratory. However, a year or so later, when the owner of the booklets had completed the work for his degree and left the university, Professor Gomberg commented to one of the other staff members, "I was very disappointed in that boy. He kept dirty pictures in his desk, and he thought I didn't know."[12]

His students always held the Professor in great respect, and they did their best to make a good impression on him and to hide their mistakes from him. On one occasion, a student was analyzing an organic compound by the Carius method, in which the sample and an excess of concentrated nitric acid are sealed in a strong glass tube. The whole is then heated to a high enough temperature to bring about the complete oxidation of the organic material. Not infrequently, the pressure within the tube builds up to the point where the tube explodes. In order to avoid any danger, should this happen, it is customary to place the glass tube inside a steel pipe so that flying pieces of glass will be caught. On this occasion, the student who was performing the analysis had his hand over the end of the steel pipe when the glass tube exploded. The palm of his hand was

[12] Reported by Professor J. O. Halford.

peppered with small pieces of flying glass. He knew that the Professor would ask how he had injured his hand and, since he was ashamed to tell the true story of his carelessness, he went to great lengths to make up what seemed to be a credible tale. He told the Professor that he had fallen from his bicycle and that his hand had been rather badly scuffed on the gravel pathway. Whether the Professor believed this story, I do not know, but I rather doubt it.[13]

Professor Gomberg worked very hard in the preparation and delivery of his lectures, and he often left the lecture room perspiring profusely and completely exhausted. Yet, some way, he occasionally slipped in bits of humor that seemed to be completely spontaneous and were doubly enjoyed by the class because they were so unexpected. On one occasion, he was telling the students in his class in organic chemistry about various chemical journals and what might be found in them. Among others, he mentioned the *Bulletin de la Société Chimique de France* and commented, "The name of this journal is abbreviated B-u-l-l, and frequently that's all you find there." On another occasion, in discussing an experiment that the class was to do, he noted that the laboratory manual said that the reaction mixture should be allowed to stand overnight. He explained that this meant that it should stand for several hours, adding slyly, "There is no virtue in darkness." On still another occasion, when he was lecturing about mercaptans, he passed a vial of material around the class and commented that it had such a strong odor that one could smell it even through the glass. The students readily confirmed this, but he told one of his colleagues later, "I didn't tell them that the bottle had a tiny pinhole in it."[14]

Fred Wiselogle served as the Professor's lecture assistant

[13] Reported by Professor H. H. Willard.
[14] *Ibid.*

during his graduate days, and has sent me the following story. It illustrates well the Professor's patience and his unwillingness to say anything about himself.

"During the First World War, Professor Gomberg, working with Jimmy Norris, developed a procedure for mustard gas—an experience that he told with great relish to the organic chemistry class. Furthermore, he impressed on his class the tremendous difference in the toxicity of mustard gas and of the intermediate β, β'-dihydroxydiethylsulfide, by dipping a stirring rod in a bottle of the liquid and running it across his tongue. He then proceeded to hold up a similar bottle of mustard gas and point out the horrible consequences of contact with the skin. As his assistant, it was my responsibility to have the bottles on the lecture table for the lecture—although prior to this I had no idea what he proposed to do with them. Much to my horror, the next day Gomberg came to work with an acute burn on his lip. You can imagine my feeling, since I could only assume that inadvertently he had picked up the wrong bottle or somehow I was responsible for the sore. Professor Gomberg never criticized me nor appeared to give any thought to the burn, and it was only several weeks later that I learned from others that he recalled the stopper of the mustard gas bottle popping out while he was holding it and ascribed the lip burn to a transfer of the spilled mustard gas from his finger to his lips."[15]

The Professor did not enjoy writing, and it was hard for him, but he worked at every paper until it was a model of diction and clarity. When we prepared our Ph.D. theses, he had us read them aloud to him, for he felt that one couldn't get the real meaning of a paper without reading it aloud. Of course, he interrupted us frequently to question and criticize, or to suggest additional experiments. These sessions sometimes

[15] Letter from F. Y. Wiselogle, August 6, 1965.

lasted for two or three hours, and they were very tiring and frustrating. After each such session, we retired to our own laboratory to rewrite and then to read aloud again to him. In some cases, this was done several times before he was satisfied with the writing. It is reported that one student never did get his thesis in such shape that the Professor could accept it; finally, Dr. Gomberg wrote most of the thesis himself. One fairly large section of my thesis was rewritten four times, until at last he seemed to be satisfied. But, as I was leaving the room, he asked, "Is it really important to include this section in your thesis?" The question amazed me, but after a little reflection I had to agree that the section was not important to the thesis, and we decided to omit it. I was angry that he had let me do so much work all to no avail, but I have never forgotten the lesson. Say what needs to be said, and no more.

When it came to making compounds, Dr. Gomberg was amazingly adept. He had remarkably good laboratory technique, and he gave us countless suggestions about the tricks of the trade. I fear that I didn't master them as well as I should have. I remember especially one occasion when I had a compound that refused to crystallize. I had worked for a week on it and had tried all the tricks that I knew, even to leaving the dish open on the desk while I swept the floor, in the hope that a seed crystal in the dust might fall into the mixture, but even this did not work. I was very discouraged, and when he came to the laboratory and asked about my progress, I told him that I felt that I would never get crystals from this material. He took the dish in his hand, looked at it carefully, and said, "This looks very promising. Give me some benzene." When I handed him the bottle of benzene, he poured a few drops of the liquid into the syrup in the dish and stirred it slowly. "Now, some ligroin." He added a few drops of this liquid and stirred some more. Suddenly, crystals appeared. I questioned him eagerly. "How did you do that? How did you know what solvents to use?" He smiled, but his only answer was, "You learn with experience." No doubt this is true, but he had more than experience —he had chemical intuition and keen perception.

Professor Gomberg told us repeatedly, "It is not serious if someone finds your interpretation of an experiment to be wrong, but it is disgraceful if there are errors in your experiments." So he did every experiment over and over until he was sure the results were correct. This habit was most annoying to those of us who were more easily convinced, but time has proved the wisdom of his method.

At the Organic Symposium in Ann Arbor in 1941, Professor Gomberg was the guest of honor at the banquet. When he was called upon to speak, he reminisced about his life and work in Ann Arbor. Many of those in the audience had known him for many years, but they had never heard him open his heart as he did that evening. He talked for more than two hours while the audience sat enthralled by his story and by his warm, friendly personality. Unfortunately, no one took notes. Later, when I began to collect material for this memoir, several persons recalled hearing that talk, and the spell that it cast over them. But, alas, none could remember what the Professor said! Like a fine symphony or the masterpiece of a great artist, this talk lifted the spirits of those who heard it, but none could later describe it. They knew only that it was a wonderful talk and that it recounted the events and the philosophy of an amazingly interesting and productive life.

And so it is. The beginning of the story is quite unknown, and the talk that summed it up is lost. All that can be recorded are the facts which are of public record and the anecdotes that tell something of the spirit of this remarkable man.

ACKNOWLEDGMENTS

Very little has been written about Professor Gomberg's life and work. In addition to the works mentioned in footnotes 3 and 5, there are evidently only two articles—an anonymous obituary, *Chem. Eng. News,* 25 (1947):548, and a somewhat longer obituary by Professor C. S. Schoepfle and Professor W. E. Bachmann, *J. Am. Chem. Soc.,* 69 (1947):2921. The remainder of the material in this article has been obtained by correspondence and conversations with Professor Gomberg's friends. References are given to several of these sources. In addition, I am greatly indebted to Professor L. C. Anderson, Professor B. A. Soule, Professor W. B. Pillsbury, Professor E. H. Kraus, Professor F. F. Blicke, and Mrs. H. S. Bull.

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KEY TO ABBREVIATIONS

Am. Chem. J. = American Chemical Journal
Ann. Chem. = Justis Liebigs Annalen der Chemie
Ber. = Berichte der deutschen chemischen Gesellschaft
Chem. Rev. = Chemical Reviews
Ind. Eng. Chem. News Ed. = Industrial and Engineering Chemistry, News Edition
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