AFTER THE REVOLUTION: NIKOLAI MATVEEVICH KIZHNER (1867-1935) IN SOVIET MOSCOW

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Nikolai Matveevich Kizhner (Николай Матвеевич Кижнер, 1867-1935) (1) is familiar to most students who have completed an introductory course in organic chemistry as the Kishner of the Wolff-Kishner reduction (2, 3). Rather fewer organic chemists, however, know that he also discovered the related, platinum-catalyzed, base-promoted decomposition of pyrazolines to cyclopropanes, now known as the Kishner cyclopropane synthesis (4). Both of these discoveries were made while Kizhner was Professor of Organic Chemistry at Tomsk Technological Institute, in the city of Tomsk, in Siberia.

The first decade of his independent career was an extremely eventful period in Kizhner's life. Not only did he discover the two reactions that bear his name, but, during the Revolution of 1905, he joined the fight of the students at Tomsk against the heavy hand of the central government over the universities. As a result of his activities, he was exiled from Tomsk in February, 1906, only to be reinstated in May, 1907. Remarkably, he did all these things after he had fallen victim to a gangrene of the extremities that resulted in amputation of his right leg above the ankle in 1904. Even more remarkably, he discovered the two reactions that bear his name after 1910, when his left leg, also, had been amputated above the ankle, confining him to a wheelchair. It is not difficult to imagine that the support of his wife, Sofia Petrovna Kazantseva, whom he had married while a student in Moscow, and son, Boris Nikolaevich, (b. 1894), were critical to his continued success during these difficult periods of his life.

Kizhner was finally forced out of his position as Professor in May 1912, although he gave his poor health as the official reason for his resignation (5). Since the Chair (*kafedra*) of Organic Chemistry also carried with it the perquisite of a professorial apartment in the building, his resignation from the *kafedra* meant that he also had to move out of his apartment; this was enforced in July 1912.

Kizhner left Tomsk with a great deal of regret: it was at Tomsk that he had established his first laboratory and taught his first students, and it was at Tomsk that he had made the discoveries that established him on the international stage. After his ouster he would still talk fondly of his first laboratory. But Tomsk had also revealed the darker side of Russian society at the time—the major reasons for Kizhner's ouster were anonymous accusations of disloyalty to the Tsar, and the petty enmity of Leonid Ivanovich Lavrent'ev (Леонид Иванович Лаврентьев, 1835-1914), a trustee (curator) of Tomsk educational district, who considered him a dangerous "free thinker." The position of trustee was a powerful one that gave the holder direct access to the Minister, and Lavrent'ev used it: in 1906, he had orchestrated the exile from Tomsk of several professors, including Kizhner and the Director of the Institute, Efim Luk'yanovich Zubashev (Ефим Лукьянович Зубашев, 1860-1928), and his efforts against these two "disloyal" professors continued after their reinstatement. In 1912, as the pressure mounted from Lavrent'ev's undermining his position at the Tech-

nological Institute, and veiled threats of action against his family by the ultra-conservative gangs known as "Black Hundreds" (6), Kizhner formally resigned his position, officially for reasons of health. One (perhaps unintended) consequence of his resignation for health reasons was that he was awarded a full pension after just over a decade of work at Tomsk.

His resignation notwithstanding, Kizhner remained at the Technological Institute for the 1912-1913 academic year at the request of his faculty colleagues there. During this year, he taught a course in organic chemistry on contract from the Board. But, the loss of the professorial apartment close to his laboratory added a physical hardship to what was clearly a psychological hardship. Kizhner left Tomsk in 1914, never to return. One of his students, Georgii Vasil'evich Khonin (Георгий Васильевич Хонин, 1878-1952), later became Dean of the chemistry faculty at Tomsk Polytechnic University.

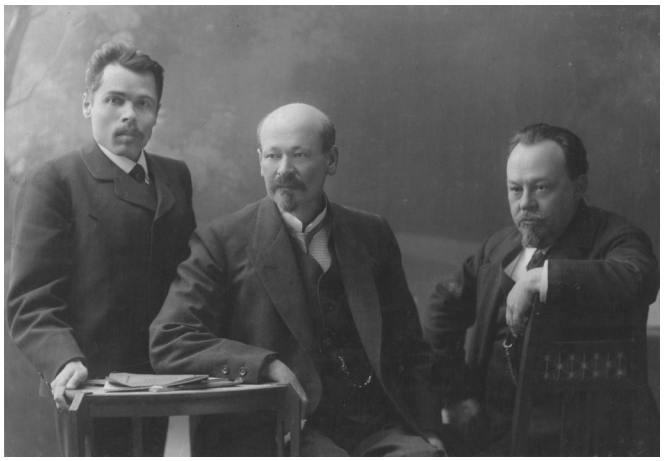

Figure 1. *Members of the Chair of Organic Chemistry at Tomsk Technological Institute ca. 1910: (l-r) Laboratory Assistant (later Professor) Georgii Vasil'evich Khonin (1878-1952), Professor Nikolai Matveevich Kizhner, and an unidentified member. Photograph courtesy of Tomsk Technological Institute.*

To gauge the loss to Tomsk by the departure of this eminent and productive scientist, one need only look at what he accomplished in his last two years there—the two years after he had lost his professorship and was on an annual appointment. In 1912-1913, Kizhner published eleven papers in the *Zhurnal Russkogo Fiziko-Khimicheskogo Obshchestva* (4b-g, 7), the flagship Russian chemistry journal, and three more in 1914 (8). Even with the plethora of journals available to chemists today, publishing fourteen papers, all but one with a single author, in less than three years would be a remarkable feat. It must surely stand as an astonishing accomplishment by a chemist at the beginning of the twentieth century (9)—especially a disabled chemist working in an era when there were no special accommodations for disability!

The details of Kizhner's career after his departure from Tomsk are not easy to assemble. One source that contains vivid details of his character is the biography of Russian dye chemist Nikolai Nikolaevich Vorozhtsov (Николай Николаевич Ворожцов, 1881-1941) by Vladimir Mikhailovich Rodionov (Владимир Михайлович Родионов, 1878-1954) (10); Rodionov knew and worked with Kizhner.

In 1914 Kizhner returned to Moscow, where he had spent the happier days of his youth—the year that he won the major Butlerov Prize (the Academy's highest award in organic chemistry). There he hoped, as he put it, to find a place in a laboratory where he could work "for the good of his soul" (10). All who have written biographical memoirs of Kizhner seem to be in agreement that he was fanatically devoted to his science and that it was unimaginable that Kizhner could be happy without his beloved laboratory. At the time of his arrival in Moscow, higher education in the capital was in turmoil thanks to the heavy-handed and reactionary actions of the Minister of Education, Lev Aristidovich Kasso (Лев Аристидович Кассо, 1865-1914; Figure 2). Kasso was a lawyer who had been educated abroad (in Paris, Heidelberg, and Berlin) before returning to the Russian empire to teach civil law. Between 1892 and 1908, he had taught, in turn, at Dorpat University (1892-1895), Khar'kov University (1895-1899), and Moscow University (1899-1908), and then had become Director of the Imperial Lyceum (1908-1910). In September 1910, he was appointed the Chief Administrator of the Ministry of Education, and in February 1911, he was raised to the position of Minister of Education.

As Chief Administrator, and then Minister, he was ruthless. He crushed the student movement and prohibited student unions, he outlawed student meetings, and he intensified the after-school surveillance of students. He greatly exacerbated the existing division between the government and the professoriate by dismissing progressive professors and students from the universities (11). In 1910, Moscow University lost about one third of its best instructors, who resigned their positions en masse following Kasso's summary dismissal of three of their leaders, Rector Aleksandr Apollonovich Manuilov (Александр Аполлоноивич Мануйлов, 1861-1929),

Figure 2. *Minister of Education, Lev Aristidovich Kasso (1865-1914) at his desk in 1913.*

Deputy Rector, Mikhail Aleksandrovich Menzbir (Микчаил Александрович Мензбир, 1855-1935), and Prorector, Pyotr Andreevich Minakov (Пётр Андреевич Минаков, 1865-1831), who had, all three, protested police action against the students. In 1912 he expelled all the women students from the Higher Medical Courses in St. Petersburg, ostensibly for their participation in political rallies and their political unreliability. One consequence of Kasso's actions was the rapid rise in importance of the Shanyavskii People's University.

Figure 3. *Science philanthropist, General Al'fons Leonovich Shanyavskii (1837-1905)*

This university had been founded in 1909 by a bequest from science philanthropist, General Al'fons Leonovich Shanyavskii (Альфонс Леонович Шанявский, 1837-1905; Figure 3) (12). As an unofficial university, Shanyavskii could not confer degrees, but it offered courses that were as rigorous as those offered at Moscow University, and its faculty was held in high esteem. Despite its unofficial status, this institution became quite influential, and a number of future Academicians received at least part of their education there. The Russian Revolution of 1917 led to the nationalization of the university in 1918, with control passing to the state, and with its full merger with Moscow State University (thus completing the circle) in 1920.

When Kizhner arrived in Moscow, the renowned pyridine chemist, Aleksei Yevgen'yevich Chichibabin (Алексей Евгеньевич Чичибабин, 1871-1945; Figure 4), helped him obtain an appointment at the Shanyavskii Moscow City People's University. At Shanyavskii, Kizhner was provided with a single room where he could do his experiments, and he obtained modest support from the Society to Promote the Success of the Experimental Sciences and Their Practical Applications (5e). This society had been founded in 1909, thanks to the merchant and philanthropist, Khristofor Semyonovich Ledentsov (Христофор Семёнович Леденцов, 1842-1907; Figure 5), who bequeathed all his wealth for its formation. To put this bequest in perspective, it amounted to a sum

Figure 4. *Aleyksei Yevgenievich Chichibabin (1871-1945). Photograph from RGAKFD (Rossiiskii Gosudarstvennyi Arkhiv Kinofotodokumentov).*

exceeding that which Alfred Nobel bequeathed to establish the Nobel Prizes. Of course, given the cash-strapped nature of the nation after over a decade of war and civil war, one of the first acts of the Soviet government was to seize these funds, so the Ledentsov awards never had the chance to rival the Nobel Prizes. In addition to the Ledentsov funds, Kizhner used a substantial portion of his professorial pension to equip his laboratory and support his science.

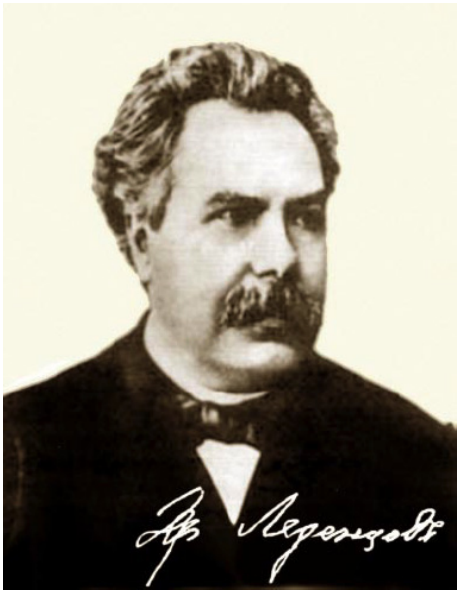

Figure 5*. Merchant and philanthropist, Khristofor Semyonovich Ledentsov (1842-1907)*

Rodionov (10) paints a vivid picture of Kizhner as an antagonist:

> Arguing with N. M. Kizhner was interesting. [During the argument] it would seem as if he thoroughly hated you, but that was not correct. After the dispute was over, he once again became the good-natured man he was, and would offer to play a game of chess with you. He loved the game, but it excited him so much that his partners found pretexts not to play with him—he had high blood pressure and all this excitement was dangerous.
>
> ... N. M. Kizhner was an interesting conversationalist, and his stories about living and working in Moscow with Markovnikov gave a vivid picture of the late '90s. I still remember his story about how he had to steal back a water bath that Markovnikov had taken from his bench...

Kizhner was comfortable at Shanyavskii, and his first year there was productive. In 1915, he published five papers (13) in the *Zhurnal*, but this proved to be the last of his years of high productivity (at least, when measured in terms of the numbers of research publications). He had arrived in Moscow just three years before the Russian Revolution, and the Revolution had an immediate, quantifiable impact on the careers of many Russian scientists, Kizhner included. His first paper in the *Zhurnal* after the Revolution appeared in 1918 (14); his next papers did not appear for another six years (15).

In the Fall of 1916, Kizhner agreed to teach a short course, "The chemistry of strained cyclic compounds," in which he presented the work of—among others—his mentor, Vladimir Vasil'evich Markovnikov (Владимир Васильевич Марковников, 1838-1904; Figure 6), another of Markovnikov's students, Nikolai Yakovlevich Dem'yanov (Николай Яковлевич Демьянов, 1861-1938; Figure 7), and, of course, himself, on small-ring compounds (5e). It was notable for its predominant focus on the contributions of Russian chemists to the field, which had begun with the synthesis of cyclopropane itself by Gavril Gavrilovich Gustavson (Гаврил Гаврилович Густавсон, 1842-1908; Figure 8) by a modification (16) of the original procedure (17), developed by Austrian chemist, August Freund (1835-1892). Magidson (5e) reported that his lectures were distinguished by conciseness, clarity, objective coverage and generalization of material that was very new for the time; they were attended not only by students from Shanyavskii, but also by many prominent Moscow Professors and Docents. Unfortunately, no notes of the original course that he taught have survived. At the same time, he continued his studies of the two reactions that he had discovered while at Tomsk.

Figure 6. *Vladimir Vasil'evich Markovnikov (1838-1904)*

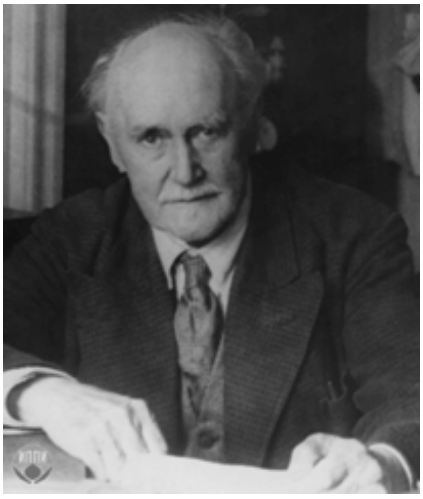

Figure 7*. Nikolai Yakovlevich Dem'yanov (1861-1838)*

Figure 8*. Gavril Gavrilovich Gustavson (1842-1908)*

Despite the surgery that saved his life, his gangrene of the limbs would periodically recur, which meant that at times he was in his laboratory with painful sores on the bottoms of his legs. He also, according to some reports, lost at least some of his fingers at this time (5e), and yet he was still able to make his own apparatus, including such things as thermometers and barometers. Kizhner was an active laboratory worker at Shanyavskii, moving about on crutches or in a wheelchair. His physical disabilities meant that the daily journey from his home to his laboratory was a severe physical ordeal for him. Kizhner viewed chemistry as an experimental, not a theoretical science—he distrusted theoretical work not based on experimental observation, so, despite the torment that it became, he still spent long hours in the laboratory, repeating experiments to ensure reproducibility. He demanded similar dedication to these principles from his students, but they still viewed him as "an extremely charming man and a delicate soul," rather than an overbearing taskmaster, and as a gregarious lover of art, music, and conversation (5e). He was a voracious reader, not only of chemistry, but also of literature. One of his favorite authors was the Russian satirist, Mikhail Yevgrafovich Sal'tykov-Shchedrin (Михайл Евграфович Сальтыков-Щедрин, 1826-1889), and he would frequently quote from his works (10).

By 1918, both Moscow and St. Petersburg were under Bolshevik rule; by the end of the Russian civil war in 1923, Russia was a Soviet state. The consolidation of power by the Soviets in the capitals led to the implementation of Soviet economic schemes, and to a sea change in the direction of Russian science. The exhaustion of many of Russia's resources by the decade of war and civil war from 1914-1923 meant that the new rulers of the state were faced with a collapsed economy requiring rebuilding. This, in turn, led to a major shift in the focus of the scientific efforts in Russia from basic to rigidly defined, applied research, with the limitations that this entails.

Kizhner's first work for Soviet Russia after the nationalization of the Shanyavskii People's University was in the testing laboratory of the new Government Commissariat Department, where he could apply his skills as an analyst. However, within a year, he had agreed to lead the aniline dye industry in Russia as Director of the Central Laboratory of the Aniline Trust (AnilTrest), although according to Rodionov (10) he refused any administrative obligations that he felt he could not carry out due to his health problems. In fact, those very health problems gained him a private room (quite unusual in Soviet Russia) in the central laboratory to live in with his wife, due to his difficulties moving about on crutches. In 1919, the "Russian Joint Stock Company of the Chemical Industry in 1914" (also known under the name "Russkogo-Kraska," or "Russian Paint") was nationalized, and became the state-owned enterprise, "Glavanil" (or "Main Anil"). This company was an important part of the Russian dye industry. Kizhner carried out this thankless task well, and under his guidance the Soviet dye industry flourished.

Figure 9*. Laboratory Building of the Russkogo-Kraska, 1914, which became Glavanil after nationalization in 1919.*

The job at Glavanil again showed Kizhner's fanatical dedication to his science. Another of his students, V. A. Izmailskii, wrote about his time living with Kizhner, from 1919-1922 (5f). He writes that due to his amputations, Kizhner could only carry out scientific work while he lived in the laboratory—the trips to and from his apartment on Arbat Street in Lefortovo to the Glavanil laboratory were simply too arduous. As a consequence, Kizhner would leave the comforts of the apartment that he shared with his wife, and live on an oilcloth sofa in his laboratory. He would drink his tea from beakers, and would occasionally heat up the food that the "tireless" Sofia Petrovna would bring him.

At this time, Soviet industry was almost at a standstill for want of raw materials, and the dye industry was no exception. However, there were stockpiles of a few important industrial chemicals left over after the war—naphthalene, phthalic anhydride, anthranilic acid, toluene, and xylene; and the possibility of manufacturing chloroacetic acid still existed. The central government proposed that Kizhner investigate the synthesis of indigo from these raw materials, especially *o*-xylene (5f). The synthesis of indigo and its derivatives was to be a major focus of the remainder of his career: under the Soviet regime, Kizhner's research became very applied.

The job of directing the national aniline dye industry placed a huge burden on Kizhner's shoulders. He remained the dedicated chemist that he had been in Tomsk, and he continued to study the synthesis of cyclopropanes (12, 18), and the reduction of carbonyl compounds (15, 19), but the rate at which he now published was dramatically reduced by the time taken by his administrative duties—between 1918 and his death, he published only thirteen more papers abstracted by *Chemical Abstracts*.

Figure 10*. Kizhner (1867-1935) in his laboratory at AnilTrest, Moscow, around 1930.*

During this period, the bulk of his work, which concerned aniline dyes (e.g. the Fast Violet B analogues in Figure 11) and sulfur dyes (e.g. sulfur black) was seldom published (only two of his dye papers (20) were ever abstracted by *Chemical Abstracts*), and when it was, it was in specialized trade journals such as *Anilkrasochnaya Promyshlennost* (*Aniline Dye Industry*). Much of the work was tedious, and involved the careful study of the minutiae of the commercial manufacture of dye intermediates. Even so, students still sought to work with Kizhner, who was appreciated for his great knowledge and his willingness to talk about chemistry with any of the students.

One example of Kizhner's attention to detail is provided by his study of the hydrolysis of dinitrochlorobenzene for use in the production of Sulfur Black (21). Kizhner found that allowing the solution to become strongly basic during the base hydrolysis of 2,4-dinitrochlorobenzene led to displacement of one of the nitro groups instead of the chloro group (Figure 12), thus giving dyes of an inferior and inconsistent quality. Based on his work, he was able to design production protocols that gave a superior product. We have not been able to determine where (or if ever) Kizhner published this work, but his protocols were incorporated into the production of the dye in the west, although without attribution (21). His development of a method for the isomerization of *m*-dinitrobenzene to the *ortho* isomer by means of sodium metabisulfite is another example of his attention to detail

in even the most mundane facets of the dye industry. The remainder of his papers concerned his continuing basic research, as well as other problems in applied chemistry.

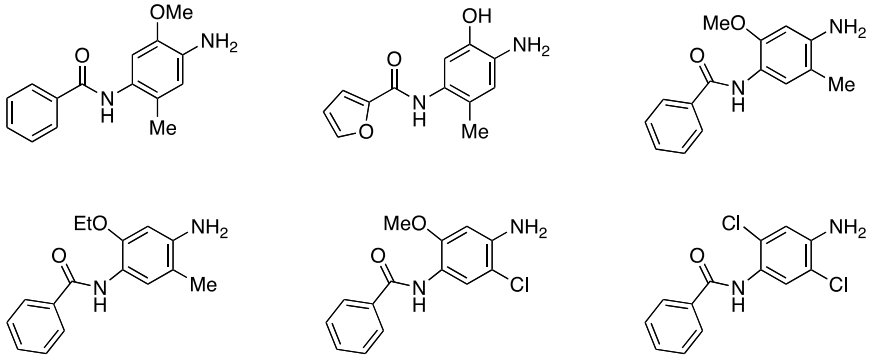

Figure 11. *Some Fast Violet B analogues synthesized by Kizhner and his students*

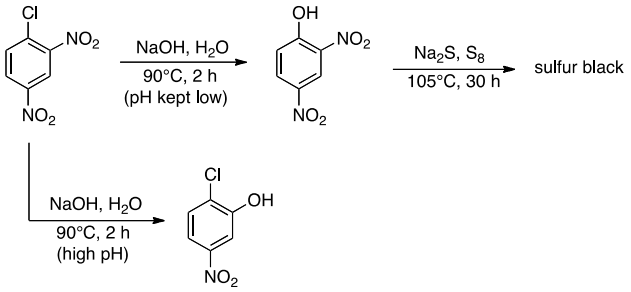

Figure 12. *Kizhner's discoveries affected the manufacture of Sulfur Black T by noting that carefully maintaining the pH was critical in obtaining the correct phenolic precursor to the dye.*

Among Kizhner's later work was the separation of isomers of xylene by exploiting the differing rates of formation and desulfonation of the monosulfonic acids (Figure 13), described in three papers over the course of a decade (15c, 22). This work provided a simple method for the production of the *o*-xylene needed as starting material for the manufacture of indigo. The work was important in the dye industry in another way, because the particular isomer of an aromatic moiety within the dye molecule affects both the chemical stability and the exact shade of the dye. Kizhner's xylene papers exhibit the hallmarks of his typically meticulous approach to experimental organic chemistry.

Thus he noted, for example, that the *meta* isomer of xylene is sulfonated much more rapidly than the other isomers (in 30 minutes, 100% of the *meta* isomer dissolves in concentrated sulfuric acid, while only 68% of the *ortho* isomer, and 64% of the *para* isomer dissolve under the same conditions in 30 minutes; Kizhner also noted that after 2 hours, 82% of the *ortho* xylene had dissolved, while 32% of the *para* isomer still had not reacted). Interestingly, the sulfonic acid from *p*-xylene hydrolyzes (desulfonates) much more rapidly, thus allowing one to separate *o*-xylene from *p*-xylene. He also observed that the sulfonic acid from *m*-xylene hydrolyzes faster than that of the *para* isomer. These observations provided the basis for a much more reliable method for separating the isomers than fractional distillation, for example.

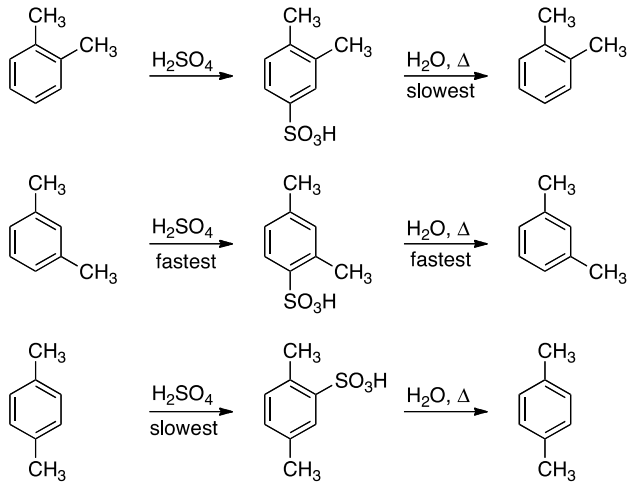

Figure 13. *Sulfonation reactions used by Kizhner as a means to separate xylene isomers.*

The change in Kizhner's scientific focus and output did not mean that he ceased to work on his fundamental organic chemistry projects, but only that he changed the focus of his energy. He still continued working on his previous projects involving hydrazine derivatives. During his Moscow years, he published papers on cyclopropane synthesis in 1918 (14) and 1929 (18). His work on the reduction of carbonyl compounds with hydrazine also continued slowly.

In 1929, Kizhner was elected a Corresponding Member of the U.S.S.R. Academy of Sciences, and in 1934 he was elected an Honorary Academician. When the U.S.S.R. Academy of Sciences moved to Moscow, in

1935, he was offered the opportunity to lead an independent department in the Institute of Organic Chemistry. He accepted this invitation, despite his health problems, and spent the last few months of his life organizing his new laboratory, and working with enthusiastic, young colleagues. The laboratory had begun to produce publishable results when Kizhner was struck down. A scientist to the bitter end, on November 28, 1935, he had completed a Dumas nitrogen analysis and, apparently in good health, returned to his home—as usual, after sundown. By 10 o'clock that same night, he had died of a heart attack.

Unfortunately, we do not know if Kizhner was an official member of the Communist party, but we can infer at least some of his attitudes. In many ways, he was a replica of his mentor, Markovnikov. To begin with, both had little truck with authoritarianism. Markovnikov was one of the seven Professors at Kazan University who had resigned their positions over the Lesgaft Affair. Pyotr Frantsevich Lesgaft (1837-1909), who had joined the faculty of Kazan University in 1868, was a highly popular and progressive professor and an outspoken supporter of women's rights. By 1871, his promotion to *ordinarius* had twice been blocked by the Trustee of the Kazan Educational District, Pyotr Dmitrievich Shestakov (1826-1889), whose conservative views were antithetical to those of Lesgaft. Shestakov had also humiliated Lesgaft by interfering with his courses, and when the University Council did not take what he viewed as suitable action, Lesgaft made the internal scandal public by venting his rage in the local newspaper. Unfortunately for him, Shestakov wielded more power, so he was fired from his position and banned from further teaching. Markovnikov and six other Professors in the Natural Science Division resigned their positions in protest. After he had moved to Moscow, Markovnikov still bristled at authority, and this led to his compulsory retirement in 1893, at the statutory quarter century after his first academic position under the arcane rules of the Ministry of Education.

Like many of Markovnikov's students, Kizhner admired his mentor, and absorbed many of his progressive views. In 1902, Kizhner opposed mass expulsions of striking students, maintaining that it should be sufficient to suspend them from their student status so that they could still attend classes, and so that they would not be separated from the science. In 1905, Kizhner organized strikes by faculty and students, and he gave revolutionary speeches to gatherings both off and on campus. Obviously these activities—including his refusal to discipline striking students—did not sit well with the Trustee of the Educational District, and this led to his internal exile from Siberia to St. Petersburg. He returned to Tomsk after his reinstatement, but the ill will of the conservatives continued, and eventually they were able to force his retirement "for medical reasons." Two years later, he left Tomsk under a veiled threat against his family by right-wing groups (5h).

As described above, in Moscow, Kizhner joined the Shanyavskii People's University, a progressive-leaning university founded by the Professors fired from Moscow University by Kasso. Following the Revolution, Kizhner was moved into industrial research. It is noteworthy that he spent the rest of his life—until 1935—in Moscow. In the late 1920s and early 1930s, there were arrests of chemists, and it was in this era that Vladimir Nikolaevich Ipatieff (1867-1952) left Russia in 1930, following the arrests of several scientists. The previous year, Chichibabin had also left Russia for France, never to return. The fact that there is no hint of Kizhner being the subject of any investigations by the Soviet authorities suggests that he enjoyed the government's favor. In any case, it is clear that Kizhner was a political progressive with strong revolutionary leanings.

References and Notes

1. Russian uses the Cyrillic alphabet, and so names must be transliterated to the Roman alphabet. The exact transliteration used depends on the language into which the transliteration occurs, and even this is not a constant within the same language. In keeping with our previous practice (D. E. Lewis, *Early Russian Organic Chemists and Their Legacy*, Springer-Verlag, Heidelberg, 2012) throughout this paper, the BGN/PCGN romanization system for Russian is used as the most intuitive for English speakers. In citations of articles in western journals, names are given as transliterated by the journals. The Roman alphabet transliteration of Kizhner's name is addressed in our previous papers (Refs. 5h, 5i). Following the Russian Revolution, the Russian alphabet and rules of spelling underwent a simplification. The transliterations used here are, to the extent possible, based on the modern spelling.
2. (a) N. M. Kizhner, "Kataliticheskoe razlozhenie alkilidengidrazinov, kak metod polucheniya uglevodorodov [The Catalytic decomposition of alkylidenehydrazines as a method for the preparation of hydrocarbons]," *Zh. Russ. Fiz.-Khim. O-va.,* **1911**, *43*, 582-595. (b) N. Kizhner, "O kataliticheskom razlozhenii alkilidengidrazinov: St. 2-ya [On the catalytic decomposition of alkylidenehydrazines: 2nd part]," *Zh. Russ. Fiz.-Khim. O-va.,* **1911**, *43*, 951-962. (c) N. Kizhner, "32. O razlozhenii alkilidengidrazinov. Perekhod ionona psevdo ionona i sootvetstvuyushchie uglevodorody, $C_{13}H_{22}$ [32. On the decomposition of

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HIST Plans Symposium on Archaeological Chemistry

The Division of the History of Chemistry (HIST) is planning a symposium on archaeological chemistry to be held at the spring meeting of the American Chemical Society in Orlando, FL, March 31-April 4, 2019. The tentative title of the symposium is "Archaeological Chemistry: Art and Archaeology in the Ancient and Medieval World." Papers on any subject that address this general topic, especially those that integrate chemistry with archaeology, those directed at answering social, political, and economic questions about ancient cultures, and those that incorporate the use of new technologies, are welcome. Please communicate your interest in participating in the symposium along with a tentative paper title and possible co-authors to either of the co-organizers: Seth Rasmussen (Seth.Rasmussen@ndsu.edu) or Mary Virginia Orna (maryvirginiaorna@gmail.com).