

NIKOLAI ZININ AND SYNTHETIC DYES: THE ROAD NOT TAKEN

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During the nineteenth century and up to 1917, Russian chemists produced a significant number of “cutting-edge” advances in all branches of chemistry. Indeed, one could plausibly argue that—considering the size of the chemical community—Russian chemists were among the most productive chemists at that time. Some of these advances in chemical theory and practice produced by Russian chemists were quickly acknowledged by the international community of chemists, while others were not. In still other cases, the Russian chemists themselves did not follow up their discoveries with additional investigations. Many different factors—such as being on the scientific periphery—influenced these decisions and the reception of these discoveries.

In this paper, I will examine the scientific and cultural contexts of one of the earliest and most important discoveries by a Russian chemist during the nineteenth century: Nikolai Zinin’s reduction of nitrobenzene to produce aniline in 1842. This work done by Zinin is particularly interesting because it later became the key step in the synthesis of many coal tar dyes and was the basis for the explosion of the German chemical industry during the second half of the nineteenth century.

Zinin was well positioned to take the lead in the development of coal tar dyes. He was trained in Liebig’s laboratory and closely allied himself with Liebig’s vision of chemistry. His research interests centered on reactions of various aromatic compounds, which became important building blocks in the production of synthetic dyes. Yet Zinin did not follow up his initial discovery of 1842 with additional investigations of this reaction and he seemed oblivious to the rapid development of the synthetic dye industry during the late 1850s and

1860s. In 1867 at the Paris International Exhibition, D.I. Mendeleev reported that Zinin was astonished by the exhibitions of synthetic dyes. Why did Zinin not see the potential usefulness of his reaction and why did he not participate in the development of synthetic dyes?

Instead of Zinin, it was August Wilhelm von Hofmann, who took the lead in developing the theoretical and practical basis for the coal tar dye industry. Hofmann had also studied with Liebig during the same years that Zinin was in Giessen. Immediately after Zinin published his work, Hofmann realized the value of Zinin’s reaction and devoted much attention to understanding and developing it as a practical tool. Other chemists also studied aniline, as well as Zinin’s reaction. What was it in Zinin’s environment or background that conditioned his actions?

Nikolai Nikolaevich Zinin was born in 1812 in Shusha, a small town in the Caucasus region, where his father was serving as an officer in the Russian army (1). Shortly after Zinin’s birth, however, both of his parents died in some sort of epidemic, and he went to live with his uncle in Saratov, on the Volga River. Zinin received a good education at the local gymnasium and excelled at ancient languages, as well as mathematics and physics. Although he initially planned to attend a technical institute in St. Petersburg after graduation from the gymnasium, the death of his uncle induced him to attend Kazan’ University, which was considerably less expensive than an institution in the northern capital. Kazan’ is located on the Volga River, about 500 miles east of Moscow, and for years it was the easternmost university in Europe.

Zinin enrolled at Kazan' University in 1830, when it was slowly recovering from the deleterious effects of M.L. Magnitskii's seven-year rule as curator of the Kazan' Educational District during 1819-1826 (2). In the years before he went to Kazan', Magnitskii served as a provincial governor and had gained recognition for his attempts to cleanse the province of "atheistic influences." Upon appointment as curator, Magnitskii at first attempted to close down Kazan' University because of its atheism and immorality but grudgingly settled for dismissing those professors whose teaching Magnitskii found to be insufficiently Christian, as well as many of the foreigners who taught at the university. In 1820, Magnitskii drew up instructions that specified how professors should teach their subjects from a religious point of view. For example, professors of astronomy were to demonstrate "how the omniscience of the Creator is written in fiery letters in the heavenly bodies, and how the beautiful laws of the celestial universe were revealed to mankind in the most distant past" (3). Magnitskii's instructions were copied by other universities and led to mass dismissals at these institutions as well. However, Magnitskii and the other officials in both the central and provincial administrations who held similar values became increasingly mystical in their pronouncements of this new conservatism and finally drew opposition from the Russian Orthodox Church. In 1826, Magnitskii was dismissed and replaced as curator by M. N. Musin-Pushkin, a wealthy nobleman, whose family lived near Kazan'.

Although the traditional view claims that it took 25 years for Kazan' University to recover fully from the effects of Magnitskii, in reality, Curator Musin-Pushkin quickly acted to improve the teaching and research at the university (4). With the assistance of the mathematician Nikolai Ivanovich Lobachevskii, who was the University Rector—essentially, the university president—

the new curator secured funds to build new classrooms, laboratories, and other facilities and worked to build up the faculty ranks, which had been decimated by Magnitskii's actions (5). Zinin was a direct beneficiary of Musin-Pushkin's actions.



Zinin entered the physics-mathematics faculty as a "state student," who would receive a free education in return for agreeing to work for the Russian government for a specified period of time following graduation. This type of arrangement was vital for the state at this time because relatively few nobles, who could afford to pay tuition, entered the universities, and few of them remained until graduation. Thus when the state wanted to reduce its reliance on foreign-born professors, as it did in the 1810s and 1820s, it needed to provide support for students such as Zinin, who was not a member of the nobility. Kazan' University was in particular need of Russian profes-

sors as many of the foreign-born professors at the university had been purged during the Magnitskii years (6).

In his studies, Zinin primarily concentrated on astronomy, taught by Professor Ivan Matveevich Simonov, and mathematics, taught by Lobachevskii. As part of the requirements for students in the physics-mathematics faculty, he also took courses in chemistry from Professor Ivan Ivanovich Dunaev, who had been teaching chemistry at Kazan' University since 1811 (7). The available evidence indicates that Dunaev conducted little or no laboratory work himself and that he likely had an outdated knowledge of chemical theory. Dunaev's lectures in chemistry were presented without lecture demonstrations until 1832 when he was compelled by the university administration to introduce some demonstrations, as well as some minimal laboratory training for the students. While the premises of the chemistry laboratory were quite substandard, Professor Adol'f Iakovlevich Kupfer (who had taught at Kazan' University during the 1820s) had managed to supply it with adequate supplies and equipment (8).

Zinin graduated from Kazan' University in 1833 with a gold medal as the most outstanding student in the physics-mathematics faculty. The title of his *kandidat* [candidate's] dissertation—"Perturbations of the Elliptical Movement of the Planets"—suggests his close relationship with Simonov, the astronomy professor. Zinin's accomplishments had attracted the attention not only of his professors, but also the administration of Kazan' University, including Curator Musin-Pushkin. Following graduation, Zinin was kept on at the university for advanced training in order to prepare him for a teaching position. In 1833, Zinin was appointed "repetitor" in physics, assisting Professor Knorr, while the following year he also taught astronomy in the absence of Professor Simonov, who was conducting research away from Kazan'. Later in 1834, Zinin assisted Simonov in this research by collecting data on magnetic phenomena. Also in 1834, after the move of Professor Brashman to Moscow, Zinin also took over the teaching of hydrostatics and hydrodynamics as well as an introductory chemistry course. Thus it seems clear that Zinin was being groomed to teach physics or astronomy at Kazan' University.

However, at this time the direction of Zinin's career changed dramatically. Apparently, in 1835, the administration of Kazan' University—likely Curator Musin-Pushkin—decided that Dunaev, the professor of chemistry, needed to be replaced, and he settled on Zinin to be Dunaev's replacement (9). Zinin was relieved of his other teaching duties and was ordered to teach only chemistry "in support of Dunaev" (10). Meanwhile Zinin prepared for the extensive series of examinations for the *magistr* [master's] degree, which he passed in April 1835. The *Sovet* [Council] of the physics-mathematics faculty then gave Zinin the topic for his *magistr* dissertation: "The phenomena of Chemical Affinity and the Superiority of Berzelius's Theory about Constant Chemical Proportions over the Chemical Statics of Berthollet." Upon defending this dissertation—purely a literature investigation, with no laboratory work involved—in October 1836, Zinin received the degree *magistr* of physical-mathematical sciences. The university quickly appointed Zinin as adjunct, and in early 1837 the curator requested permission from the Ministry of Education to send Zinin abroad for two years for advanced training in chemistry.

The plan for Zinin's training abroad was drawn up by Curator Musin-Pushkin, presumably with Zinin's assistance (11). The plan called for him to attend lectures by Jöns Jacob Berzelius and Eilhard Mitscherlich,

both important chemists, but also nearing the end of their influence. Numerous other chemists were mentioned, including Liebig, but the plan indicated that Zinin would visit these chemists only for brief periods of time. Based on the information contained in this plan of study, it is likely that Zinin's conception of chemistry at this time was formed by the ideas of Berzelius, probably derived from his work on his *magistr* dissertation. It is also possible that Zinin and the university administration relied on Dunaev for information in order to draft the plan of study. The plans for Zinin's study abroad did not include any provisions for conducting original research or even any laboratory training whatsoever. This was not unusual, however, as few Russians conducted original laboratory research for a *magistr* degree until the 1850s and 1860s. The curator was mainly concerned with having Zinin learn enough while abroad to be able to teach chemistry upon his return to Kazan', and it is evident that work in the laboratory was not part of the original plan.

Zinin traveled to Berlin in September 1837 and spent the first year of his study trip there attending lectures in mathematics, physics, chemistry, and mineralogy with Heinrich Rose, Eilhard Mitscherlich, and Rudolph Fittig. Zinin was not satisfied with these lectures, though, believing them to be too elementary for him to learn much of interest (12). In addition to attending lectures, he also visited mines, factories, and various manufacturing plants near Berlin. During the spring of 1838, he traveled with some Berlin friends to various cities in Germany, intending eventually to go to Switzerland, France, and England. However, while visiting Giessen, Zinin was captivated by Liebig's lectures, and he decided to remain there until January 1839 to work with Liebig. It appears that Zinin did little laboratory research at this time since there was no room for him in Liebig's laboratory (13).

In the meantime, circumstances in Kazan' changed, which altered the objectives of Zinin's study abroad. Curator Musin-Pushkin had originally intended for Zinin to take over the teaching of chemistry from Dunaev, but in 1837—while Zinin was studying abroad—Karl Karlovich Klaus (aka. Carl Ernst Claus) moved to Kazan' (14). Klaus had worked for many years as a pharmacist in Kazan' but had given up his business in order to obtain a degree in chemistry at Dorpat University, with the goal of becoming a professor of chemistry at a Russian university. Curator Musin-Pushkin quickly recognized that Klaus could easily fill the position of chemistry professor, while Zinin could then become professor

of technology, a position that was also vacant. The curator thus arranged for Zinin to remain abroad for an additional year in order to study technology and to visit sites of industrial importance (15). Zinin did not object to this change in plans. Indeed, he submitted a detailed description of his intended activities—mainly concerning technology—if granted an extension by the Ministry of Education, perhaps because it would afford him extra time abroad and thus would enable him to spend more time in Giessen with Liebig (16).

Technology had been taught at Russian universities from the creation of the university system in the early nineteenth century. The original educational statute in 1804, which provided a blueprint for many educational developments up to 1917, included the teaching of technology at all educational levels and was greatly influenced by Marquis de Condorcet's essay on public instruction (17). For the universities, a *kafedra* (chair) of "Technology with Application to Trade and Industry" was to be included in the physics-mathematics faculty (18). This utilitarian impulse received greater emphasis during the reign of Nicholas I (1825-1855), particularly during the years when Count Sergei Semenovich Uvarov was the Minister of Education (1833-1848). Uvarov hoped to stimulate the development of agriculture and industry throughout Russia by means of instruction and public lectures, and he greatly increased the number of teaching positions and resources for technology (19). Thus Curator Musin-Pushkin was responding to this increased emphasis on technology when he decided that Zinin should occupy the *kafedra* of technology at Kazan' University instead of that of chemistry.

Ending his first stay in Giessen in January 1839, Zinin returned to Berlin to continue his studies there. However, he soon fell in with a group of Russian students, who were in Berlin studying medicine. Zinin was so influenced by these fellow Russians that he began studying medical subjects and almost decided to become a physician himself (20). This incident has drawn fleeting attention from Zinin's biographers, but they do not note its implications. It is possible that Zinin was not happy with the idea of concentrating on teaching "technology and analytical chemistry" as he was beginning to center his chemical interests on organic chemistry under Liebig's influence. Becoming a physician may have been a way for Zinin to avoid the concentration on technology. It is also possible that Zinin's attachment to any one particular field of study was not yet settled. Remember, at this time it was less than a scant four years

since Zinin had switched from astronomy and mathematics into chemistry, a move that also was not of his own choosing. Contacts with enthusiastic disciples of another field of science might have swayed Zinin's ideas about his future.

Whatever the case, Zinin did not continue with the study of medicine and instead returned to Giessen in the summer of 1839, at which time he was finally able to work in Liebig's laboratory. He focused on experiments concerning the benzoyl radical, which was one of the primary topics of interest in Liebig's laboratory at the time (21). Liebig gave Zinin the problem of obtaining benzoin, benzil, and their products, using oil of bitter almonds, which contained benzaldehyde, as the starting material. This research formed the basis for two articles published by Zinin in Liebig's *Annalen* in 1839 and 1840 (22). The first article briefly describes a new method of preparing benzoin from oil of bitter almonds with potassium cyanide as a catalyst. Zinin treated amygdalin, a glucoside of bitter almonds, with emulsin in the presence of potassium cyanide to produce a mixture of products, including benzaldehyde and benzoin. The second article gave a detailed description of this new method as well as methods for producing benzil from benzoin with nitric acid, benzoic acid from benzil, and several other products. Zinin demonstrated that one of these compounds was identical with "Benzamid" produced by Laurent. The two articles are straightforward descriptions of Zinin's methods and contain no discussion of any possible theoretical significance of the reactions.

In September 1839, Zinin left Giessen and went to Paris, where he attended lectures of Joseph Louis Gay-Lussac and Jean Baptiste André Dumas on organic chemistry and of Theophile Jules Pelouze on analytical chemistry. He was able to work in the laboratory of Pelouze, continuing his investigations of the benzoyl radical. In addition, he visited mines, factories, and other sites of interest for chemical technology. Finally, in June 1840, Zinin went to England for three weeks and then returned to Russia.

Zinin arrived in St. Petersburg in September 1840. However, instead of returning immediately to Kazan', as would be expected, he sent a letter to the Ministry of Education requesting permission "to undertake the examinations for the doctoral degree at St. Petersburg University" (23). In this petition Zinin stated that he was an adjunct of chemistry, had been sent abroad for advanced training in chemistry, had spent three years

abroad studying chemistry, had attended lectures by famous chemists, had worked in chemistry laboratories, and had published two chemistry articles. Note that this petition mentions only the field of chemistry and includes nothing about technology. The Ministry quickly gave him its approval to remain in St. Petersburg while completing the requirements for the doctoral degree, but also requested that he “hurry” in order to minimize the amount of time spent there (24). Zinin then requested permission from St. Petersburg University to begin the examinations for the doctoral degree (25).

At the same time, Curator Musin-Pushkin wrote from Kazan’ to the Ministry of Education, stating that he approved Zinin’s request, believing that “through an examination in the capital Mr. Zinin can prove that he satisfactorily made use of the time he spent abroad.” However, the curator also requested that Zinin remain in St. Petersburg only for the short amount of time necessary to pass the examinations for the doctoral degree: “The writing of the dissertation . . . the review of it, and, finally, the defense may better be conducted here [Kazan’], where meanwhile he would be very useful for presenting lectures in the *kafedra* of technology, which has remained unfilled for such a long time” (26).

Zinin successfully completed both oral and written examinations in chemistry and several other subjects by early November and then quickly turned to writing his dissertation (27). This dissertation, “About the Benzoyl Series and about the Discoveries of New Bodies Relating to This Series,” was completed by the end of November; but he was not able to defend it until the end of January 1841 because of a delay in the readers’ reports (28). The first part of the dissertation is a theoretical discussion of organic compounds based on ideas about complex radicals and the theory of types. Next, Zinin examined the production of oil of bitter almonds from amygdalin. By analogy, he asserted that the formation of bitter almond oil occurred through the same type of process as in the formation of oil from the seeds of black mustard, thus supporting Liebig’s idea of “metamorphosis” rather than Berzelius’ idea of catalysis (29). The final part of the dissertation is a reworking of Zinin’s two earlier papers.

In letters sent to Zinin and the Ministry of Education during the months Zinin was in St. Petersburg, Curator Musin-Pushkin urged Zinin to return to Kazan’ as soon as possible. However, Zinin was not eager to return. While finishing his doctoral dissertation, he learned that the *kafedra* of chemistry at Khar’kov University

was vacant, and he wrote a petition to the Ministry of Education, asking for an appointment to that position instead of returning to Kazan’ University as professor of technology. Zinin requested the move to Khar’kov because he did not want to teach technology, as is clearly shown in a letter from Curator Musin-Pushkin to the Minister of Education on December 12, 1840 (30). Musin-Pushkin noted that he was “astonished” to receive a letter from Zinin requesting permission to enter the competition for the *kafedra* of chemistry at Khar’kov University. The curator stated that, in this letter, Zinin wrote that he “does not see any use in occupying the *kafedra* of technology at Kazan’ University that was intended for him.” In a letter to the Ministry, the curator strongly opposed losing Zinin to Khar’kov University (31). He argued that Zinin was sent abroad by Kazan’ University for advanced training in both chemistry and technology, and he noted that the one-year extension was designed so that Zinin could concentrate exclusively on technology. The curator emphasized how much money Kazan’ University had spent on Zinin’s education, in addition to the cost of his time abroad. The Ministry supported the curator, and, thus, Zinin was forced to return to Kazan’ in early 1841 following the defense of his dissertation in St. Petersburg.

Zinin remained at Kazan’ University until 1847 when he was appointed to the *kafedra* of chemistry and physics at the Medical-Surgical Academy in St. Petersburg. Shortly after his return to Kazan’ University in 1841, Zinin was elected extraordinary professor (similar to associate professor) and in 1845 ordinary professor (similar to full professor) of technology. Despite his official position as professor of technology, he spent less time teaching technology than he did other areas of chemistry although he was not able to teach organic chemistry, the subject of his research. For example, during the 1843-1844 academic year Zinin taught analytical chemistry for two hours per week and the “chemistry of living things” for two hours per week, while teaching only two courses in technology for one hour each per week. Klaus taught inorganic chemistry for three hours per week and organic chemistry (“according to Liebig”) also for three hours per week (32).

Perhaps more revealing about Zinin’s attitude toward technology is his evident neglect of the technology laboratory (33). As noted above, a new chemistry laboratory had been built in the mid-1830s, and space in this new building was provided for the technology laboratory. However, Zinin did not devote much attention to equipping it. In 1844, the technology laboratory

contained only six items, valued at 310 rubles, 57 kopecks. At the same time, the chemistry laboratory contained 4,730 items valued at 6,106 rubles, 7 kopecks. Moreover, it was noted that the technology laboratory was “combined with the chemistry laboratory, due to a lack of space” (34). The items in the technology laboratory were intended not only for research in technology but mainly for demonstrations during lectures in technology. In 1845, the chemistry laboratory added equipment and glassware worth 444 rubles, 28 kopecks, while there is no record of any additions to the technology laboratory (35).

Thus it appears that Zinin had little interest in fostering the growth of technology as a subject at the university. He did not personally conduct research in technology and did not promote the subject of technology outside his lecture courses. This is in stark contrast to his successor in the *kafedra* of technology, Modest Iakovlevich Kittary, who actively worked to stimulate interest in technology by offering public lectures on various topics in technology, resuscitating the moribund Kazan’ Economic Society and making it an effective organ for publications and information, founding the Society of Young Technologists, as well as developing contacts with local factory owners and entrepreneurs. In addition, Kittary served as a consultant for several factories in Kazan’ and attended many exhibitions both in Russia and abroad (36).

While Zinin did not have much interest in technology, he did continue his research in organic chemistry. This was fairly unusual for chemistry professors in Russia during the first half of the nineteenth century, even for those who studied with Liebig. Most conducted some research for their doctoral dissertations but little or no research after that. They were mainly concerned with building a “local” reputation as this would help gain them promotions and other types of honors, such as bureaucratic awards, which were coveted in Russia (37). Most chemists during these years were active in the affairs of their university and also served on committees for various government agencies or, much more rarely, acted as consultants for private companies. Zinin, however, did not pursue such committee assignments or consulting work while he was in Kazan’. The archival record indicates only one instance of his doing such a “local” activity during his years in Kazan’; he performed a chemical analysis of an ore sample at the request of a government agency (38). While it is possible that Zinin did not have the opportunity to undertake many such activities during his years in Kazan’, I believe it is more likely

that he chose not to pursue them. Instead, he concentrated on his research in organic chemistry, perhaps in hopes of building a scientific reputation that would allow him eventually to move to a different institution where he could concentrate on teaching chemistry and not technology. Even though his scientific output was modest during these years, it was sufficiently unusual and impressive to help him win the position of professor of chemistry and physics at the Medical-Surgical Academy in St. Petersburg in a competition with other chemists, including another student of Liebig.

It was during Zinin’s few years in Kazan’ that he completed his most famous work, the reduction of nitrobenzene to aniline. When Zinin returned to Kazan’ following his study trip abroad, he was faced with the problem of selecting a new research problem. His work in Liebig’s laboratory had utilized oil of bitter almonds as a starting material, as had a considerable amount of the work in Liebig’s laboratory during the late 1830s. However, Zinin was not able to continue using this substance upon his return because its import into Russia was prohibited since it contained small amounts of hydrogen cyanide and, thus, was potentially very toxic. Instead, he decided to investigate the action of hydrogen sulfide on a series of organic compounds closely related to oil of bitter almonds, first studying nitrobenzene and nitronaphthalene. In this work Zinin found that the two oxygen atoms of the nitro group are replaced by two atoms of hydrogen (39). Zinin himself named the reaction products (Benzid and Naphthalid, respectively), but Iulii Fedorovich Fritzsche (also known as C. J. Fritzsche), chemistry academician at the Academy of Sciences in St. Petersburg, soon noted that Benzid was identical to Anilin (40). Fritzsche had obtained aniline in 1840 by the decomposition of indigo.

The significance of this reaction soon became apparent. At the same time as Zinin was investigating this reaction, A.W. von Hofmann and several others began the difficult process of unraveling the constitution of coal tar. Continuing this work when he moved to London in 1845, Hofmann, together with his students, isolated twenty or so basic substances that became the foundation of the coal-tar dye industry. Zinin’s work on the reduction of nitrobenzene to aniline provided a key step in the production of various coal-tar dyes. In an obituary of Zinin written in 1880, Hofmann stated that “[i]f Zinin had done nothing more than to convert nitrobenzene to aniline, even then his name should be inscribed in gold letters in the history of chemistry”(41).

Zinin described his continuing investigation of methods to produce different aromatic amines in two papers in 1844 and 1845, his last publications before he left Kazan' University (42). The first paper examines the use of ammonium sulfide to form diaminobenzene from dinitrobenzene, and likewise for the analogous naphthalene compounds. In the second work Zinin described a method to produce benzidine from azobenzene and a method to produce azoxybenzene from nitrobenzene. To produce benzidine Zinin reduced azobenzene with ammonium sulfide, then treated the product with weak sulfuric acid. He showed that hydrazobenzene was formed from azoxybenzene, and then in the presence of acid it underwent a rearrangement to form benzidine. As in his earlier papers, Zinin did not include any discussion of possible theoretical significance for this work.

In 1847, Zinin learned that the *kafedra* of chemistry and physics at the Medical-Surgical Academy in St. Petersburg was vacant. An old friend of Zinin's, Professor P. A. Dubovitskii, who taught at the Medical-Surgical Academy and at that time was its secretary, urged Zinin to submit his name as a candidate for this position (43). At about this same time, Zinin delivered a public lecture at Kazan' University titled "A View of the Current Direction of Organic Chemistry" (44). In this speech, Zinin did not discuss his current work in organic chemistry or related studies but focused, instead, on two main themes. The first and main theme concerned the importance of organic chemistry for understanding the physiology of plants and animals. Zinin closely followed Liebig's ideas, particularly from *Chemistry and its Applications to Agriculture* (1840) and *Animal Chemistry* (1842), although he did not emphasize that fact. The other theme in this speech was a strong critique of *Naturphilosophie* and similar trends, which were grouped by Zinin with astrology and alchemy as not being scientific methods of analysis. In addition to being valuable as a reflection of his ideas at that time, this speech likely was connected to his attempt to obtain the position at the Medical-Surgical Academy. During his years in Kazan', Zinin had shown little interest in research on questions concerning physiology or agriculture although he did sometimes teach a course about physiology. Perhaps this public lecture was a way for him to indicate his acquaintance with the topics that he would be responsible for teaching at the Medical-Surgical Academy.

Apparently, Zinin did enter the competition for the position at the Medical-Surgical Academy since on Oc-

tober 20, 1847, the War Minister sent a petition to the Minister of Education stating that Zinin had been elected as ordinary professor of chemistry and physics at the Medical-Surgical Academy. The War Minister requested that Zinin be transferred to the authority of the War Ministry (45). However, the Minister of Education did not want to allow this transfer and used almost the same language in his reply that the curator had used in 1840 to thwart Zinin's move to Khar'kov University (46). When he found out about the decision of the Academy, Zinin quickly petitioned the rector of Kazan' University about a transfer to the War Ministry. His petition made it clear that his main reason for requesting this move was his desire to teach pure chemistry and not technology (47):

Your Excellency knows that I have devoted many years to the study of chemistry and the natural sciences necessary for a full understanding of this branch of knowledge. The duties of the *kafedra* of technology have diverted me particularly from laboratory work in chemistry, which has more affinity to my knowledge and abilities [than technology]. In addition, the Kazan' climate and provincial conditions of life have for some time been causing problems for my health. For these reasons and mainly from the desire for the opportunity to use my abilities for the benefit of society and science, I humbly request that Your Excellency petition the higher authorities to transfer me to service at the Medical-Surgical Academy.

Again, Zinin's request was not granted. This put him in an extremely difficult position. In order to leave Kazan' and finally shed his position as professor of technology, he would need to find some way to get around the refusal of the Ministry of Education to agree to his transfer to the War Ministry. Zinin finally resolved to request that he be released entirely from service in the Ministry of Education, and the Minister had little choice but to grant it (48). The Medical-Surgical Academy then again elected Zinin as ordinary professor of chemistry and physics, and the War Minister ratified the decision (49). At long last, Zinin could escape Kazan' and jettison the unwanted position as professor of technology.

After a period of scientific inactivity following his move to St. Petersburg, Zinin resumed his research by returning to materials that he had studied previously. In 1852, he published articles concerning the production of mustard oil, and in 1854 he studied the concept of substitution in organic compounds using mustard oil as a starting material. Later, he continued his work on reactions involving benzil, benzoin, and other substances.

In the 1860s, he was able to convince the Russian customs officials to provide him with samples of bitter almond oil that had been confiscated at the border. He then returned to the topic of his earliest studies, examining the processes of oxidation and reduction in various aromatic compounds in more detail, despite the fact that this was far from the cutting edge in current research, as Butlerov lamented in his obituary of Zinin (50). In the 1870s, Zinin branched out to study the compound lepidene, which later was determined to be tetraphenylfuran. Over the course of several years Zinin studied various reactions using lepidene, carefully separating the different isomers formed in the reactions. Soviet historians of chemistry credit Zinin with stimulating the study of hetrocyclic chemistry in Russia (51).

This brief outline of Zinin's life and career illustrates several general points about the history of chemistry in Russia during the nineteenth century as well as aspects specifically about Zinin himself. The most important thread running through his career was his embrace of "pure" chemistry and his avoidance of applied or technical chemistry. Zinin's biography suggests some possible reasons for his attitude. We remember that Zinin studied mainly astronomy and mathematics as an undergraduate student at Kazan' University, and he obviously intended to pursue these fields in his graduate training. He taught these subjects and assisted the astronomy professor in his research. He apparently had no desire to focus on chemistry until Curator Musin-Pushkin decided that the incumbent chemistry professor was incompetent and needed to be replaced. Since there were extremely few Russian students willing and able to pursue advanced training during the first half of the nineteenth century, the curator had little choice but to select Zinin to be the future chemistry professor. Zinin himself had little choice in the matter. Like so many Russian students during the first half of the nineteenth century, he was not from the elite nobility and had scant opportunities for advancement outside an academic career. The administration officials at Kazan' University selected the topic of Zinin's *magistr* dissertation, and they also drafted his plan for study abroad.

While Zinin sincerely enjoyed studying science, it is not certain that he wanted to devote himself to chemistry at this time. To me, this is the implication of the episode during his study abroad when—under the influence of fellow Russian students in Berlin who were studying medicine—he abandoned his study of chemistry and turned to medicine. Returning to the study of chemistry after a short interlude, Zinin soon decisively

embraced chemistry under Liebig's influence. Thus it must have been especially difficult for him to accept the switch to studying technology as demanded by Curator Musin-Pushkin. Again, Zinin had little choice in the matter, and he likely went along with the plan because it gave him an extra year of research abroad and because the new plan did not significantly alter his intended path of study. He displayed his feelings about having to teach technology, however, when, in 1840, he tried to obtain the position in chemistry at Khar'kov University instead of returning to Kazan' University to teach technology. After being frustrated in this attempt, he reluctantly returned to Kazan', but once there he devoted little attention to teaching technology or conducting any research with applications to technology. Moreover, Zinin fled Kazan' at the first opportunity to take a position at the Medical-Surgical Academy in St. Petersburg.

On the basis of these experiences, it is easy to see why Zinin did not devote more attention to the possible applications of his research in industry or agriculture. This neglect of practical applications is perhaps surprising in such a devoted follower of Liebig. Zinin not only adopted Liebig's ideas about complex radicals, which guided much of Zinin's research throughout his career, but he also supported many of Liebig's teachings outside of "pure" chemistry, as was shown in the public lecture given by Zinin in 1847. However, despite his evident attachment to Liebig, the Russian adopted only the "theoretical" side of Liebig's ideas as a guide to his research and not the "practical" side. The efforts of Kittary, Zinin's successor in technology at Kazan' University, show that ample opportunities existed there to promote technology.

Thus, when Zinin discovered an easy method to reduce nitrobenzene to aniline in 1842, he did not follow up this work with further investigations and did not explore the possibility of industrial or commercial uses for this reaction. Instead, it was Hofmann who seized upon Zinin's initial insight and developed its practical uses. Zinin was not the first to obtain aniline; several others had obtained it as early as 1826 by alternative methods. Aniline was originally discovered by Otto Unverdorben (as "Crystallin"), and it was subsequently obtained from coal tar in 1834 by Friedlieb Ferdinand Runge (as "Kyanol") and from the decomposition of indigo in 1840 by Fritzsche (as "Anilin"). Note, however, that each researcher gave a different name to the product, which obscured its identity. Not until 1843 did Hofmann demonstrate that all of these products were identical. Auguste Laurent was also interested in these

products, and in 1843, in collaboration with Hofmann, he managed to convert phenol into aniline (52). It is clear that aniline and its related compounds were important and active areas of chemical research at the time when Zinin developed his method for preparing aniline that was far simpler and of greater potential use than any of the earlier methods.

Zinin's aversion to the practical uses of his research was also a common feature of Russian chemistry during the nineteenth century. Very few Russian chemists had much contact with industrialists, and only a small number of Russian chemists were employed in the domestic chemical industry throughout the nineteenth century. The reasons for this lack of contact are not clear although it resulted partly from the emphasis on theory in the academic culture in Russia and partly from the insular nature of the Russian industrialists (53). In addition, Homburg's argument that the key players in the early development of the dye industry were the colorists and not the academic chemists indicates that we should not have expected Zinin to develop his discovery into a practical method for the dye industry (54).

On the other hand, some chemists in Russia—especially during the first half of the century—devoted a considerable amount of time to “practical” activities, such as serving as technical consultants for governmental agencies. These practical activities had little to do with direct industrial applications and were mainly pursued to gain the chemists a “local” reputation. As noted above, while he was in Kazan', Zinin did not have contacts with industrialists and did not undertake practical activities. However, this is in marked contrast to the years after he moved to St. Petersburg when he actively pursued these types of local activities. For example, during his first four years in the capital, he served as a member of the Manufacturing Council of the Ministry of Finance, traveled to the Caucasus region to study mineral water for the Ministry of Finance, served on the commission to build St. Isaac's Cathedral, and was the secretary of the Mineralogical Conference, among other activities. He continued his involvement in a wide range of committees and other assignments until his death (55).

This involvement in local, practical activities after his move to St. Petersburg helps explain, I believe, another facet of Zinin's scientific career. Despite his impressive research, especially that conducted while in Kazan', Zinin remained rooted in the “local” tradition of chemistry in Russia, not in the later “professional”

tradition. This was in contrast, for example, to Aleksandr Mikhailovich Butlerov, who in the late 1850s became one of the first professionalized Russian chemists (56). With this traditional outlook Zinin did not develop a strong interest in chemical theory and thus did not grasp the theoretical implications of his 1841 discovery. Hofmann, on the other hand, used Zinin's work as a key initial part of his far-reaching development of the chemistry of amines and his formulation of the ammonia type (57).

Zinin's work with aniline was not his only brush with a potentially useful compound. In 1853 Zinin conducted research on nitroglycerin as an explosive agent but did not publish this work nor follow it up. Shortly after this, another Russian began studies on large amounts of nitroglycerin. However, it was left to Alfred Nobel to transform nitroglycerin into dynamite and develop large-scale methods for its manufacture, as well as for blasting caps and other associated products. And how did Nobel learn about nitroglycerin? He learned about it from Zinin, who taught chemistry to Nobel in the 1850s.

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