RECURSOS SUGERIDOS

Emil Votoček:

- May, L., The Lesser Known Chemist-composers, Past and Present, *Bull. Hist. Chem.*, 2008, *33*, 35-43;
- Frantisek Jurik, Ian D. Rae, and George B. Kauffman, Emil Votoček (1872-1950): A tribute to the chemist-composer lexicographer, *Journal of Chemical Education*, 199, 76, (4), 511
- http://en.wikipedia.org/wiki/Emil_Voto%C4%8Dek

Emil Votoček (1872–1950): A Tribute to the Czech Chemist-Composer-Lexicographer

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Through the centuries, science and music have been associated in more than casual ways (*1*). Links between the two date from the time of the Greek philosopher and mathematician Pythagoras (ca. 580–500 B.C.E.), who discovered not only that the square of the hypotenuse of a right triangle equals the sum of the squares of the other two sides but also that the major intervals in a musical scale are obtained by dividing a vibrating string into proportional lengths. Although in the popular mind physics and music seem to have a special affinity, epitomized by Albert Einstein and his violin, chemistry—especially since the centenary of the death of Russian chemist-composer Aleksandr Porfir'evich Borodin (1833–1887) (*2*)—has received increasing attention, as evidenced by articles and letters concerning chemists who combined a career in chemistry with one in either musical performance or composition (*3*).

In an article in this *Journal* (*4*), Christian A. Wamser and Carl C. Wamser presented a memorial tribute to American chemist-composer Lejaren A. Hiller Jr. (1924–1994). Carl Wamser also organized and presided at a symposium, "Lejaren A. Hiller, Jr.: Chemist and Composer", at the 212th National ACS Meeting, Orlando, Florida, August 25, 1996 (*5*). It featured papers on Hiller and the evolution of computer chemistry and computer music, and it included performances of excerpts from Hiller's musical works and Borodin's *String Quartet No. 2* in D major, whose second and third movements provided Robert Wright and George Forrest with the themes for "Baubles, Bangles, and Beads" and "This Is My Beloved", respectively from their musical *Kismet*.

On October 30, 1990, "Chemists Make Music," an evening of music composed by chemists, was presented by Leicester University in conjunction with the East Midlands Section of the Royal Society of Chemistry (*6*). In addition to Sir Edward Elgar's *Serenade for Strings* and Borodin's *String Quartet No. 2*, the concert featured the world premiere performance of the *Serenade for Horn and String Quartet* by the Czech chemist-composer Emil Votoček (1872–1950). The previously unperformed pencil-written score was brought from Prague and performed by "UNI-PART," whose players had prepared their own parts from this score. On July 7, 1998, "The Chemists' Concert: A Celebration of Music Written and Performed by Chemists", organized by the Royal Australian Chemical Institute, was held at Costa Hall on the Woolstores Campus of Deakin University, Geelong, Victoria, Australia, as part of the 30th International Chemistry Olympiad. Votoček's *Souvenir de Bal* was performed along with Borodin's *String Quartet No. 2*, Elgar's *Chanson de Matin and Chanson de Nuit*, and Mendelssohn's *String Quartet in E Flat Major.* (Mendelssohn's son, Paul Mendelssohn-Bartholdy, was a chemist and cofounder of the Aktien Gesellschaft für Anilin Fabrikation (AGFA)).

Figure 1. Professor Emil Votoček (1872–1950). The date of this portrait is unknown.

In view of this renewed interest in chemistry and music as well as in Votoček, readers of this *Journal* might welcome an article on Votoček, about whom virtually no information is available in English. In addition to discussing his life, personality, and chemical, linguistic, and musical activities, we shall present analyses of his research on fucose and his *Trio for Violin, Violoncello, and Piano* as typical examples of his work.

Life (*7–18*)

Emil Votoček (Fig. 1) was born on October 5, 1872, in Arnau (Hostinné nad Labem) in northeastern Bohemia. The year of his birth is given incorrectly as 1862 in at least one Czech biographical dictionary (*19*) as well as in the 1954 and 1960 editions of *Grove's Dictionary of Music and Musicians* (*20*). (An entry for him does not appear in the 1935 or 1980 editions, but there is a possibility that one by Carl Wamser and Christian Wamser will appear in the forthcoming 7th edition.) Because Votoček's father owned a wholesale paper business in Prague and wanted his son to follow in his footsteps, young Emil, after graduating from high school (*Gymnasium*), attended the School of Commerce (Obchodni akademie). However, at the latter school Karel Lukáš aroused

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his interest in chemistry so he enrolled in the School of Chemistry (now the Prague Institute of Chemical Technology, Vysoká škola chemicko-technologická v Praze) at the Czech Technical University (České vysoké učení technické, founded in 1707) in Prague. He studied organic chemistry, his main field of interest, with Bohuslav Raýman (1852–1910), who had been a pupil of August Kekulé, Charles-Adolphe Wurtz, and Charles Friedel and who had taught at Prague's Charles University (Universita Karlova), the oldest university in central Europe (founded in 1348 by Charles IV [1316–1378], German King and King of Bohemia [1346–1378] and Holy Roman Emperor [1355–1378]).

Because there was no well-equipped organic chemistry laboratory for students at the Czech Technical University, after graduating Votoček left his native land to spend two years at the famed School of Chemistry (*Chemieschule*) at Mulhouse (then Germany, now France), where he worked under the school's director Emilio Noelting (1851–1922), a renowned authority on the chemistry of dyes. After a year Votoček traveled to Göttingen, where he worked at the university under Bernhard C. G. Tollens (1841–1918), noted for his work on the chemistry of saccharides.

After returning to Prague, Votoček became an assistant to Karel Preis, who lectured on inorganic and analytical chemistry at the Czech Technical University in 1895 (Fig. 2). In 1900 he became a Docent with a *Habilitationsschrift* titled *Studium o methylpentosách* (*Study of Methylpentoses*), in which he described methods for isolating methylpentoses from natural material and for analyzing them (Fig. 3). His inaugural lecture was titled "The Importance of Stereochemical Relations in the Saccharide Series".

Votoček's career advancement was brought about by a generous act of Raýman, who, being simultaneously Professor of Organic Chemistry at the Charles University and Docent at the Czech Technical University (*21*), relinquished the latter position in favor of his protégé. In 1906 Votoček was appointed Extraordinary (Associate) Professor of Organic Chemistry, and in 1907 after Preis' retirement he became Ordinary (Full) Professor of Experimental Inorganic and Organic Chemistry (*10a*). He served as Rector (1921–1922) (Fig. 4) and continued to lecture until forced to retire prematurely in February 1939 by a decree of the Department of Education (*7*, *13*). In order to continue his research in the laboratory he enrolled again as a student. But on March

Figure 2. Votoček as an assistant in the laboratory of Karel Preis, Czech Technical University (1895–1900).

Figure 4. Votoček as Rector of Czech Technical University (1921–1922).

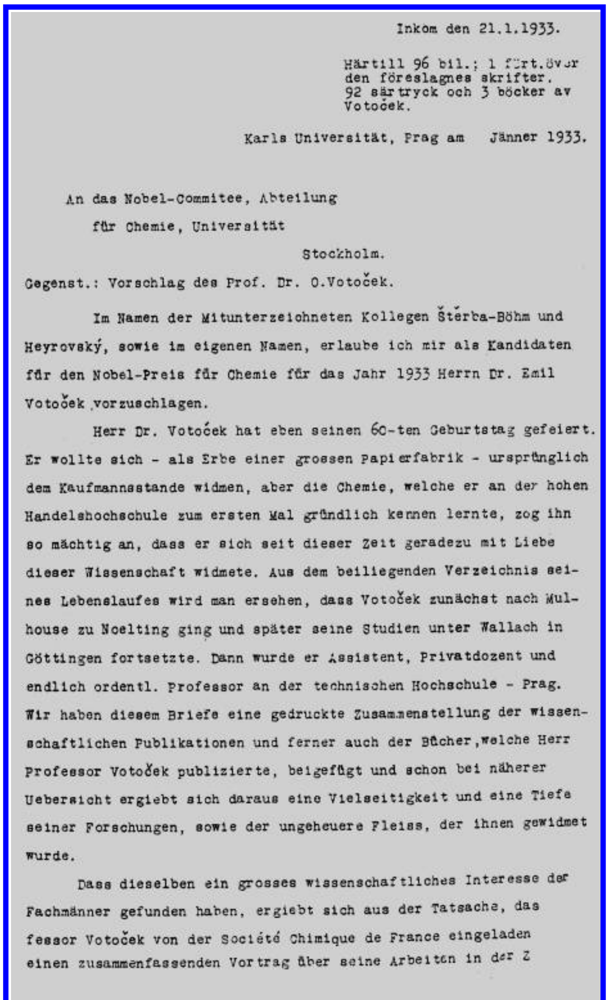
Figure 3. Votoček as a Docent, Czech Technical University (1900–1906).

Figure 5. Votoček and later Academician Otto Wichterle studying a map of Europe at the time of the outbreak of World War II and speculating on the fate of Europe.

15, 1939, Czechoslovakia was occupied by Nazi Germany, and following several student protests, on November 17, 1939, the German occupation authorities closed all Czech universities and technological institutes. They remained closed until 1945 (Fig. 5).

On February 17, 1906, Votoček married Libuše, the daughter of an Austro-Hungarian minister (Mrs. Votočková's maiden name is not recorded among Votoček's personal data in the archives). The couple had two sons, Karel (1907–1924) and Emil (b. 1914), and a daughter, Divica (b. 1906).

Votoček was amiable, brilliant, and broadly educated (*15*). A highly sociable person who enjoyed good company, food, and wine, he was often the life of the party (*13*). When social occasions required, he could be indefatiguable. On an excursion to the 1944 Normandy invasion site during the Congrès de la Victoire held in 1946, despite his age (74), he climbed every pontoon, inspected every piece of military equipment, and visited places accessible only with difficulty. When Votoček and Rudolf Bárta, one of his former students, arrived at the Deauville spa that evening, Votoček appeared tired, and Bárta wished him good night. However, Votoček replied, "Dear colleague, how about going to the dance at the casino?" and the two then went out for the evening.



Inkom den 21.1.1933.

Härtill 96 bil.; 1 fört.över den föreslagnes skrifter. 92 särtryck och 3 böcker av Votoček.

Karls Universität, Prag am Jänner 1933.

An das Nobel-Commitee, Abteilung
für Chemie, Universität
Stockholm.

Gegenst.: Vorschlag des Prof. Dr. O.Votoček.

Im Namen der Mitunterzeichneten Kollegen Šterba-Böhm und Heyrovský, sowie im eigenen Namen, erlaube ich mir als Kandidaten für den Nobel-Preis für Chemie für das Jahr 1933 Herrn Dr. Emil Votoček vorzuschlagen.

Herr Dr. Votoček hat eben seinen 60-ten Geburtstag gefeiert. Er wollte sich - als Erbe einer grossen Papierfabrik - ursprünglich dem Kaufmannsstande widmen, aber die Chemie, welche er an der hohen Handelshochschule zum ersten Mal gründlich kennen lernte, zog ihn so mächtig an, dass er sich seit dieser Zeit geradezu mit Liebe dieser Wissenschaft widmete. Aus dem beiliegenden Verzeichnis seines Lebenslaufes wird man ersehen, dass Votoček zunächst nach Mulhouse zu Noelting ging und später seine Studien unter Wallach in Göttingen fortsetzte. Dann wurde er Assistent, Privatdozent und endlich ordentl. Professor an der technischen Hochschule - Prag. Wir haben diesem Briefe eine gedruckte Zusammenstellung der wissenschaftlichen Publikationen und ferner auch der Bücher, welche Herr Professor Votoček publizierte, beigefügt und schon bei näherer Uebersicht ergiebt sich daraus eine Vielseitigkeit und eine Tiefe seiner Forschungen, sowie der ungeheuere Fleiss, der ihnen gewidmet wurde.

Dass dieselben ein grosses wissenschaftliches Interesse der Fachmänner gefunden haben, ergiebt sich aus der Tatsache, das
fessor Votoček von der Société Chimique de France eingeladen
einen zusammenfassenden Vortrag über seine Arbeiten in der Z

Figure 6. The first page of the nomination of Emil Votoček by Bohuslav Brauner, Jan Štěrba-Böhm, and Jaroslav Heyrovský for the 1933 Nobel Prize.

Votoček exhibited hypochondriac tendencies (*10*). Once, when František Petrů, later a Professor, visited him at home, Votoček's wife told him that he could not speak to her husband because he was laid up with lumbago. Petrů answered that it could not be serious because Votoček was a hypochondriac who tended to exaggerate his illnesses. He told her that once when Votoček came to the institute, he complained to him that he could not ascend to the second floor because of his difficulties in breathing. Yet during the climb Petrů told Votoček something in which Votoček was interested, and Votoček failed to notice that he had reached the second floor without any problem. Votoček, who had been listening to this story, suddenly called out from the other room, "What, I'm a hypochondriac?" When he entered the room, his wife asked him, "Emil, can you move? Can you even walk?" He replied, "Busho [the familiar form of Libuše], offer our guest some cognac and for me too. But more for me!"

The author of more than 300 articles, Votoček was widely recognized abroad, receiving honorary doctorates from the Czech Technical Universities of Prague (1948) and Brno (1927) as well as from the Universities of Padua, Nancy, and Toulouse (1929), and from the Sorbonne. He was a member of the Czech Academy, Royal Czech Society of Sciences, and an honorary member of the Polish, Italian, Spanish, and Romanian chemical societies. An honorary member of the Société de Chimie Industrielle and the Société Chimique de France, he received the latter society's Le Blanc Medal, and he was named Officier de la Légion d'Honneur and Officier de l'Instruction Publique. Other honors included the Ordine Corona d'Italia and Commander of Poland's Order of Polonia Restituta (1932). In 1933, a year in which the prize was not awarded, he was nominated for the Nobel Prize in Chemistry (*22*) (Fig. 6). He died in Prague on October 11, 1950, aged 78. In 1972, on the centenary of his birth, a commemorative medal, awarded by the Rector of the Prague Institute of Chemical Technology as the highest recognition of scientific activity, was minted (Fig. 7).

Experimental Work

Votoček's interests encompassed organic, inorganic, and analytical chemistry as well as phytochemistry. Although an entrepreneur's son, he concentrated on basic rather than applied research problems. His three main areas of interest were artificial dyestuffs, especially those of the triphenylmethane group; the carbohydrates, his most extensive area of research; and analysis, mostly of natural products. Despite their diversity, his works were joined by a unifying thread—

Figure 7. Votoček Commemorative Medal (1972). (a) Left: Votoček portrait. Right: symbol of Prague Institute of Chemical Technology.

the chemistry of the methylpentoses. At the beginning of his career, influenced by his former teacher Noelting, Votoček studied derivatives of carbazole (dibenzopyrrole) (*23*) (used chiefly in the preparation of blue sulfur dyes), triphenylmethane dyes (*24*), including malachite green (*25*), and the Sandmeyer reaction—the replacement of the diazonium group by halogen in a diazonium halide by heating with copper(I) chloride or bromide (*26*). These works led to the application of carbazole as an analytical reagent and the discovery of Votoček's reagent (a solution containing fuchsin and malachite green) for the determination of sulfite in the presence of thiosulfate and thionate (*27*). Votoček's introduction of sodium nitroprusside ($Na_2[Fe(CN)_5NO]\cdot 2H_2O$) as an indicator in mercurimetric titrations made this long-known method of practical importance for the first time in analytical chemistry (*28)*. He used it for estimating chlorine in urine (*29*) and organic compounds (*30*).

Votoček was primarily interested in the saccharides, particularly the methylpentoses (*31*), an interest arising from Raýman's investigation of rhamnose (6-deoxy-L-glucose) and Tollens' investigation of fucose (6-deoxy-L-galactose), which led to his own studies of the derivatives of rhamnose (*32*), fucose (*33*), and rhodeose (an isomer of fucose) (*34*). Votoček's naming of rhodeose and his color reactions suggest a fascination with color.

In his phytochemical investigations (*35*) Votoček sought methylpentoses in natural materials, using methods that he invented himself or modified from known techniques. In his search for specific precipitants for saccharides he synthesized and analyzed new hydrazines (*36*). Some of his hydrazine derivatives found application in determining configuration according to Hudson's rule.

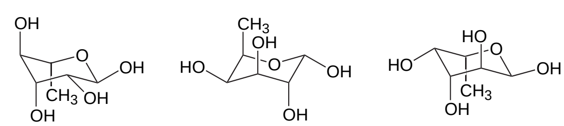
Votoček contributed to the nomenclature of sugars and carbohydrates (*37*), for instance, suggesting that the name *d*-mannose should be replaced by epiglucose-*d* to indicate the nature of the structural relationship between the two hexoses. He also proposed modifications of Czech inorganic nomenclature (*38*); with Alexander Sommer-Batěk he proposed Czech chemical nomenclature principles that were accepted in 1918 and, with some modification, are still in use today. For many years he was a member of the IUPAC Commission on the Nomenclature of Organic Chemistry (*39*), and he, K. Andrlík, and B. Šetlík were the first Czech IUPAC representatives.

In his work on rhodeose, Votoček suggested a terminology for carbohydrates. In 1911 he isolated from purgic acid a sugar that he called isorhodeose (*34l*). He found the purified sugar to be identical with Emil Fischer's *d*-*iso*-rhamnose. Votoček called these two sugars that can be converted into each other "epimers" (from the Greek επι, beside or over) (*37a*), and the process, "epimerization." To promulgate the spread of this term in saccharide chemistry Votoček prepared another two kinds of sugar, calling them epirhodeose (*34o*) and epifucose. Epimerization was initially rejected by Fischer but was viewed favorably by American carbohydrate authority Claude S. Hudson. The concept was later extended to similar cases of stereoisomerism in other areas of chemistry.

Not confining himself to the isolation and analysis of compounds, Votoček synthesized a number of saccharides (*40*) and saccharide acids and alcohols. He studied the conversion of saccharides to furan (*41*), pyran (*42*), and nitrogen derivatives (*43*). In the chemistry of nitrogen derivatives of saccharides he resolved the structure of Raýman's rhamnodiazine and studied the cyanohydrin synthesis of saccharide α-amino acids (*44*). He also introduced oxidation with nitrous acid into the chemistry of saccharides (*45*) and concerned himself with the biological oxidation of saccharides.

Studies on Fucose

The chemistry of the 6-deoxy hexoses (methylpentoses) provides an opportunity to relate Votoček's work to that of his contemporaries and to see how important these substances have become in biochemistry (called biological chemistry in Votoček's day). Votoček's interest in this field can be traced to Raýman's influence. In 1887 Raýman had reported the isolation from *Resina quereitri* of a crystalline deoxy sugar, which he named *iso*-dulcitol (*46*). The compound gives a weak positive iodoform reaction because it contains the $CH_3CH(OH)$– group, and it is a reducing sugar as shown by the silver mirror test. Initially Raýman thought that he was dealing with a hexitol, $C_6H_{14}O_6$, hence the name *iso*-dulcitol. In a subsequent paper (*47*) he isolated the anhydrous compound and showed that the substance he had first isolated was the monohydrate, $C_6H_{12}O_5\cdot H_2O$, of a compound that he now called rhamnose and recognized as a congener of arabinose. The complete structure was reported by Will and Peters (*48*), who proved that L-rhamnose is 6-deoxy-L-mannose. It is a common component of glycosidic sugars. In 1910 Votoček isolated it from the convolvulin (*34k*, *49*).



L-Rhamnose (6-deoxy-L-mannose) D-Fucose (rhodeose, 6-deoxy-D-galactose) L-Fucose (6-deoxy-L-galactose)

The isolation of L-fucose (6-deoxy-L-galactose) from the hydrolysate of a polysaccharide was reported by Günther and Tollens in 1890 (*50*). Although Votoček worked for a year in Tollens' laboratory before returning to Prague to become a colleague of Raýman and Preis (*51*) at the Czech Technical University, he was not involved in the work on L-fucose.

Votoček's contribution to this chemistry of mirror images was the isolation of D-fucose, which he named rhodeose (*34b*, *c*) after rhodeoretin, the old name for the cathartic resin convolvulin, which is the ether-insoluble part of Vera Cruz jalap, the resin of *Exogonium purga* (Convolvulaceae) (*52*). He obtained it, along with glucose, by acid hydrolysis of this complex glycoside. Unlike Raýman, Votoček never isolated rhamnose from this hydrolysate; but because of the great confusion over the identification of these jalapa resins, it is possible that the two Czechs may have worked with different materials. In a clever piece of separation chemistry Votoček destroyed the glucose in his hydrolysate by fermentation and isolated the new sugar as its methylphenylhydrazone. An exchange reaction of this hydrazone with benzaldehyde yielded the free crystalline sugar.

Two years later Votoček reported that comparison of the properties of rhodeose with those of Tollens' fucose suggested that the two are optical antipodes (enantiomers) (*34d*). In 1904 Müther and Tollens made the same suggestion, basing their proposal on a more extensive comparison of optical rotations and melting points of hydrazones (*53*). They did not acknowledge Votoček's priority and might not have been aware of his article in the *Zeitschrift für Zuckerindustrie in Böhmen*, even though it was abstracted by such periodicals as the *Journal of the Chemical Society* (*54*). Votoček was quick to defend his territory, restating his claim in the more prominent forum provided by the *Berichte der Deutschen Chemischen Gesellschaft* (*34i*), where he included the critical detail that a 1:1 mixture of fucose and rhodeose is a racemic compound with a melting point more than 10 °C higher than that of either enantiomer. Because any other mixture of two compounds would have a lower melting point, Votoček's evidence was absolutely compelling.

We know of only a few pairs of enantiomers that occur in nature. The carvones and certain amino acids, each of which has a chiral center, and the menthols and tartaric acid, with two chiral centers, are familiar examples. In saccharide chemistry the naturally occurring enantiomeric pairs include the arabinoses ($C_5H_{10}O_5$), with three chiral centers, and the galactoses ($C_6H_{12}O_6$) and fucoses ($C_6H_{12}O_5$), with four.

The two decades on either side of the year 1900 saw much activity in this field, and Votoček had to defend himself against Tollens on yet another occasion. He restated his conclusions, originally published in the *Zeitschrift für Zuckerindustrie in Böhmen* (*34f, g*), on which he had based his configuration of rhodeose. These included its reduction to rhodeitol, a penta-ol, which is not oxidized by sorbose bacteria (carbohydrate chemists were adept at coupling chemical with biological evidence), thus excluding a sorbitol configuration. Furthermore, reduction of a rhodeose–fucose mixture yields another racemic compound. In a subsequent paper intended to bring his work to the attention of a wider audience (*34j*), Votoček added results from experiments resulting in the oxidation of rhodeose to a trihydroxyglutaric acid and referred to his 1902 demonstration that fucose and rhodeose are enantiomers. He claimed that Mayer and Tollens (*55*) had given an incorrect account of his work and that Tollens and Rorive (*56*) had ignored it altogether "despite the fact that it anticipates all of their conclusions which are correct."

Votoček's claims have been recognized by subsequent writers, and although D-fucose is the approved name, rhodeose is still found as a synonym (e.g., in chemical catalogs). One writer (*57*) noted that it is usually found in glycosides in which the sugar moiety is relatively simple. Perhaps its most notable occurrences are in the cardiac glycosides (*58*), but D-fucose methyl ethers are also found as components of antibiotic substances produced by bacteria. L-Fucose, on the other hand, is widely distributed in nature

Modern biochemistry continues the tradition of great elegance set by Votoček and his peers. Their work predated chromatography, magnetic resonance techniques, and the chemistry of silylation, yet they performed their deductive miracles using highly selective fermentation chemistry, powerful logic, and the cheapest and simplest physical measurement of all—that of melting points.

Teaching Activities

Votoček was considered the most influential, learned, and respected professor on the chemistry faculty of the Czech Technical University (*15*). Attractive, tall, and bearded, he was strict, tenacious, animated, energetic, and outspoken. An excellent speaker whose lucid and witty lectures were accompanied by meticulously prepared demonstrations and were well attended, he lectured every weekday and in French on Saturdays (*15*).

Although cheerful by nature, he was often hot-tempered, irritable, and impulsive. As a case in point, one day Professor Bárta knocked at the door of Votoček's study, where Professor Emil Švagr was already present and speaking to him. Being invited to enter, Bárta was surprised to have a book thrown at his head. Švagr had been teasing Votoček, who threw the book at him, but the missile missed its intended target (*13*). On another occasion, Votoček accused a doctoral candidate of turning in a sample of natural glutamic acid instead of the desired racemic compound. He called together all the laboratory members and in their presence drove the candidate, who swore that he was innocent, out of his laboratory. This ouster was likely a great injustice, for it is now known that racemic glutamic acid readily yields enantiomers by spontaneous resolution (*59*).

As an examiner, Votoček was strict and sometimes moody but always fair (*10*). His examinations were difficult, and before them he would warn students, saying, "Everybody who does not expect to get top grades had better leave" (*15*). Once, on examining an unprepared student, he became so angry that he chased the student down the corridor, tossing his undergraduate course record at him (*15*).

Working in Votoček's original laboratory, called "Devil's Island", required not only great enthusiasm but also real courage, for there was no fume hood, and the appalling conditions made it resemble a medieval alchemist's workshop. To improve the atmosphere doctoral students released oxygen from a cylinder from time to time (*14*). However, conditions improved when a new institute was built.

Students feared Votoček's visits to the laboratory, for he was very particular; everything, especially apparatus, had to be precisely arranged. If he found fault with anything, he would hurl it on the floor regardless of the cost (*15*). Students took defensive measures against his visits. They would spill bromine so that Votoček, who suffered from bronchitis, would not enter the laboratory. Some students simply left when he was expected.

In Votoček's laboratory everyone worked intensively, often late into the night or all night long. Despite his insistence on persevering activity, careful experimental work, and endless patience, Votoček and his colleagues enjoyed breaks for tea and butter-rolls at which chemical problems and other matters were informally discussed (*10, 16*). Singing while working in the laboratory was an established custom among his organic chemistry students, and once while they were singing an aria from the Czech composer Smetana's opera *Dalibor,* he joined them (*13*).

Votoček lectured on both organic and inorganic chemistry and wrote textbooks on both subjects (*60, 61*), which served several generations of Czech chemists and remained unsurpassed in the Czech scientific literature for several decades. In his *Organic Chemistry* (*60*) he introduced a new classification of organic compounds, later adopted by 1937 Nobel chemistry laureate Paul Karrer in his own organic textbook. Votoček's classification was based on whether a compound was derived from an original hydrocarbon by substitution on one, two, or more carbon atoms. He also wrote a manual, *Návody ze cvičení v organické chemii* (*Instructions for Laboratory Work in Organic Chemistry*) (1902, 1909, 1922).

Votoček taught a number of outstanding organic chemists, including Academician Rudolf Lukeš (1897–1960), the distinguished authority on heterocyclic compounds, who became his successor at the Institute of Organic Chemistry when it reopened in 1945; Academician František Šorm (1913–1980), who initiated the foundation of the Institute of Organic Chemistry and Biochemistry of the Czechoslovak Academy of Sciences and was later President of the academy; Academician Otto Wichterle (1913–1998), a noted authority on polymer chemistry known for his invention of contact lenses based on hydrogels; and Vladimir (Vlado) Prelog (1906–1997), the 1975 Nobel laureate in chemistry.

Votoček had a keen sense of humor. He enjoyed telling jokes but disliked being upstaged. Once in the laboratory, with a smile he asked Docent Lukeš and doctoral candidate Prelog, "Gentleman, do you know how you can prepare an epigram from a gram?" When they answered that they did not know, he smiled more broadly and said, "It's very easy. You take a gram and epimerize it," in obvious reference to the terminology that he had introduced into saccharide chemistry. "I don't agree with you," replied Lukeš. "To obtain an epigram, you must first of all oxidize the gram with bromine water to gramic acid. This must be converted to gram lactone, which can then be epimerized to epigram lactone, which after reduction with sodium gives epigram." After a short silence, Votoček left the laboratory, slamming the door as he went.

Editorship

In 1929, together with later (1959) Nobel chemistry laureate Jaroslav Heyrovský (1890–1967) (*62*), Votoček founded the monthly journal *Collection des travaux chimiques de Tchécoslovaquie—Collection of Czechoslovak Chemical Communications* (*10a*). (The French part of this title was later deleted.) The two acted not only as editors but also as translators—Votoček into French and Heyrovský into English. Except for during the World War II years, the journal has been making the worldwide scientific community (especially scientists who do not read Slavic languages) familiar with the contributions of Czech and Russian chemists.

Linguistics, Phonetics, and Translations

In addition to his native Czech, Votoček, a veritable polyglot, spoke perfect Polish, Serbo-Croatian, French, Italian, Spanish, German, and English, all of which he learned as an adult (*10*, *13*). His favorite foreign language was French, which he mastered to the finest nuances. He lectured in French at home and abroad, and he translated Albert Reychler's monograph on physical chemistry from French into Czech (*63*). He spent many of his holidays in France, and whenever he visited Paris, he sedulously attended the theater with a thick notebook, in which he noted interesting examples of phraseology or pronunciation. The action on the stage did not interest him (*10*). Votoček's knowledge of languages was so perfect that many persons fluent in French were afraid to speak it in his presence because he tactlessly corrected everyone. At a conference of the Société de Chimie Industrielle, held in Paris in 1946, before signing the minutes of the conference, written by Professor A. Granger, Votoček began to improve the French. When Bárta pointed out that Granger was a Frenchman, Votoček exclaimed, "Tell him that he does not know French!" (*13*). On another occasion, when Votoček learned that Bárta was devising a Czech nomenclature for glass technology, he upbraided him publicly on the street, "Why do you want to make new names when you do not know the essence of the Czech language?" (*13*).

Votoček's admirable ability to translate simultaneously from one language to another was proverbial. During the interwar period, when European political relations were strained, the organizers of a scientific conference held in Italy insisted that the official language of the conference be Italian, whereas the Spanish participants claimed that it should be Spanish because more people in the world spoke Spanish. Votoček saved the day by suggesting that he translate from both official languages into French, a proposal that was readily accepted (*13*).

As he grew older, Votoček became more interested in phonetics. He had a penchant for linguistic work because of his natural talent in conjunction with his active interest in linguistic problems, both of technical style and of informal, colloquial language. His musical gift contributed to his mastery of the sounds of different languages. An avid traveler, he visited all the continents except Australia and exercised his linguistic abilities.

Lexicography (*11*)

Votoček's linguistic fluency and his editorial and translating tasks were closely related to his lexicographical activities (Fig. 8). He compiled a *Shorter German–Czech and French–Czech Chemico-Technical Dictionary* (*64*); a *Czech–French Terminological and Phraseological Dictionary for Chemistry, Physics and Related Sciences* (*65*); a *Polish–Czech Chemical Dictionary with Partial Regard to Mathematics, Physics, Geometry and Mineralogy* (*66*); a *Czech-German-French-English-Latin Chemical Dictionary* (*67*); and a (six-language!—a record for that time) *Czech–German–French–English–Italian–Latin Chemical Dictionary* (*68*). The *Czech–French Terminological and Phraseological Dictionary* (*65*), dedicated to the memory of his son, Karel, contains 50,000 terms and idioms from inorganic, analytical, and physical chemistry as well as physiology, geometry, mineralogy, and crystallography and is considered his best lexicological work.

As an active translator Votoček was well aware that idioms and phrases are as important as individual words, and therefore he compiled a *Czech–French Terminological and*

Figure 8. Votoček at work on one of his dictionaries. Drawing by his daughter, Divica Votočková, 1925.

Phraseological Dictionary. In his *Czech–French Conversation and Phraseology* (*69*) he collected 27,000 French conversational sentences, phrases, and idioms in order to include all the nuances of the language in a textbook in which items could be rapidly located.

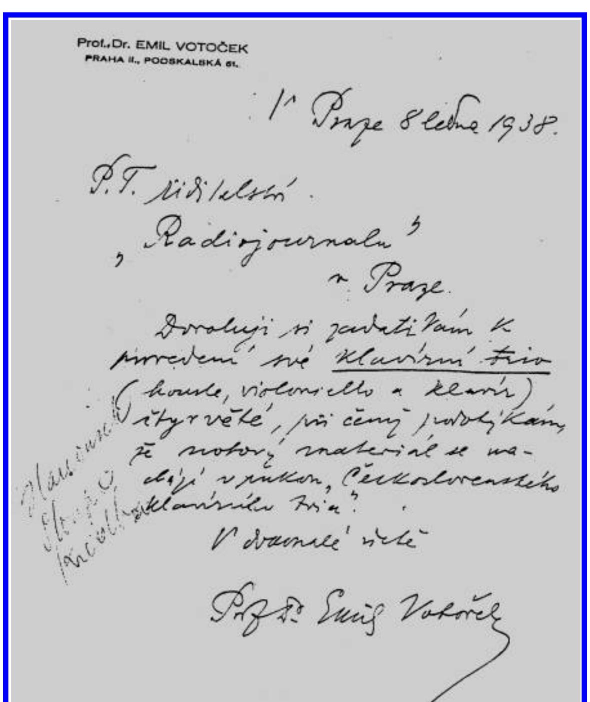
Musical Activities and Compositions (*12*)

For many years the city of Prague, home of the Prague Symphony and Prague Philharmonic Orchestras, has supported a renowned and active musical life, which reaches its high point each year with Prague Spring (*Pražské jaro*), its internationally known music festival. Steeped in this tradition and imbued with exceptional natural talent, Votoček became a musician, composer, and musicologist. His *Musical Dictionary of Foreign Expressions and Phrases* (*70*), comprising 12,000 entries, would alone be sufficient to assure him a secure place in Czech musical life. Attracted to music since childhood, at home he played and could improvise on several instruments. He devoted himself to the double bass, an instrument not usually favored by amateur musicians, which he played in his quintet. While still an amateur, he acquired unusual skill. He played in public concerts and became principal double bassist in Ostrčil's Orchestral Association. However, he did not begin a systematic study of music until his thirties.

Although not a Czech composer of international stature like Antonín Dvořák, Bedřich Smetana, Leoš Janáček, or Bohuslav Martinů, considering the time required by his primary profession as a chemist and educator, Votoček wrote an astonishing number of works (nearly 60 during a relatively short period of 15 years), including five orchestral works, many chamber works, piano sonatas, sets of poetic pieces, songs, and part songs (*20*). He first began to compose during his musical studies with František Spilka (1877–1960), Administrative Director of the Prague Conservatory, but his professional obligations forced him to abandon composition for some time. In 1934, however, he resumed his studies with Spilka, with whom he studied for six years, and again devoted himself to composing. With the exception of compositions dated 1903 and 1917, most of his musical works were concentrated in the period 1935–1950 (Fig. 9).

Although the majority of Votoček's compositions have been performed at public and broadcast concerts (Fig. 10), most remain in manuscript. Only a few were published, and none have been recorded. As a composer, Votoček belonged to the past, being strongly influenced by composer Vítězslav Novák (1870–1949), Professor of Composition at the Prague Conservatory (particularly Novák's early work, which accounts for the prevalence of lyricism in Votoček's music. Nevertheless, he carefully followed trends in modern music. He dedicated himself primarily to chamber music; few of his works were scored for orchestra. There does not seem to be any relationship between his chemical research and his musical compositions.

Votoček composed about 70 songs and a number of works for piano and various ensembles: for example, his *Thema con variazioni for Piano and Soprano Voice* (published in 1934 by Hudební matice Umělecké besedy, Prague); *Trio for Piano, Violin and Violoncello* (1938); and *Quintet for Clarinet, English Horn, Two Violoncellos and Harp* (1939). On his 60th birthday (1932) the publishers of the *Collection of Czechoslovak Chemical Communications* published his *Allegretto grazioso*. Another of his prewar works, the second part of his *Suite for Violin and Piano* (1936), was not published by Fechtner until 1944. Works composed during World War II include *Three Ballatine for Viola da Braccio and Piano* (1940, published in 1945 by Hudební matice), *Serenade for French Horn and*


Prof. Dr. EMIL VOTOČEK
PRAHA II., PODSKALSKÁ St.

V Praze 8 ledna 1938.

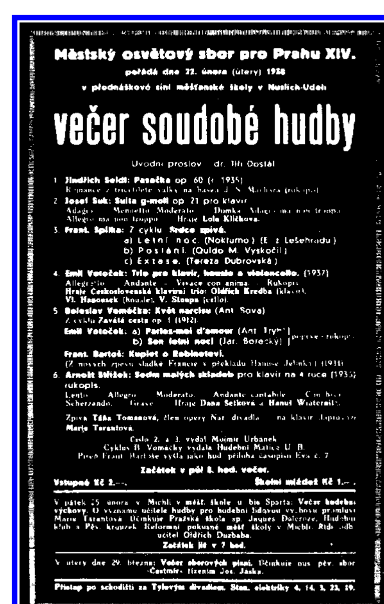
P.T. ředitelství
„Radiojournalu"
v Praze.

Dovoluji si zadati Vám k provedení své Klavírní trio (housle, violoncello a klavír) čtyrvěté, při čemž podotýkám, že notový materiál se nachází v rukou „Československého klavírního tria".

V dokonalé úctě

Prof Dr Emil Votoček

Figure 9. Votoček's handwritten letter of January 8, 1938, to Czech radio asking to perform his *Trio for Violin, Violoncello, and Piano* in a broadcast concert.


Městský osvětový sbor pro Prahu XIV.
pořádá dne 22. února (úterý) 1938
v přednáškové síni měšťanské školy v Nuslích-Údolí

večer soudobé hudby

Úvodní proslov dr. Jiří Dostál

1. **Jindřich Seidl: Pasečka** op. 60 (r. 1935)
2. **Josef Suk: Suita g-moll** op. 21 pro klavír
Allegro ma non troppo. Hraje **Lola Kličková.**
3. **Frant. Spilka: 7 cyklu Srdce zpívá.**
a) Letní noc. (Nokturno) (E. z Lešehradu)
b) Poslání. (Quido M. Vyskočil)
c) Extase. (Tereza Dubrovská)
4. **Emil Votoček: Trio pro klavír, housle a violoncello.** (1937)
Allegretto. Andante. Vivace con anima. Rukopis.
Hraje **Československé klavírní trio: Oldřich Kredba** (klavír), **Vl. Hasoušek** (housle), **V. Stoupa** (cello).
5. **Boleslav Vomáčka: Květ narcisu** (Ant. Sova)
Z cyklu **Zavátá cesta** op. 1 (1912).
Emil Votoček: a) **Parlez-moi d'amour** (Ant. Trýb)
b) **Sen letní noci** (Jar. Borecký)
Frant. Bartoš: Kuplet o Robinsonovi.
6. **Arnošt Střížek: Sedm malých skladeb** pro klavír na 4 ruce (1933) rukopis.
Lento. Allegro. Moderato. Andante cantabile.
Scherzando. Grave. Hraje **Dana Setková** a **Hanuš Wiaternik.**

Zpívá **Táňa Tomanová**, člen opery Nár. divadla
Marie Tarantová.

Číslo 2. a 3. vydal Mojmír Urbánek.
Cyklus B. Vomáčky vydala Hudební Matice U. B.
Píseň Frant. Bartoše vyšla jako hud. příloha časopisu Eva č. 7

Začátek v půl 8. hod. večer.

Vstupné Kč 2.—. **Školní mládež Kč 1.—.**

V pátek 25. února v Michli v měšť. škole u bia Sparta: **Večer hudební výchovy.** O významu učitele hudby pro hudební lidovou výchovu promluví Marie Tarantová. Účinkuje Pražská škola sp. Jaques Dalcroze, Hudební klub a Pěv. kroužek Reformní pokusné měšť. školy v Michli. Řídí odb. učitel Oldřich Durbaba.
Začátek již v 7 hod.

V úterý dne 29. března: **Večer sborových písní.** Účinkuje mus. pěv. sbor „Čestmír" řízením Jos. Jáska.

Přístup po schodišti za Tylovým divadlem. Stan. elektriky 4, 14, 3, 23, 19.

Figure 10. Program of Municipal Cultural Assembly for Prague XIV concert, "Evening of Contemporarary Music," February 22, 1938, featuring a performance of Votoček's *Trio for Piano, Violin and Violoncello*.

String Quintet (1943), and *Czech Polka* (1944), an orchestral version of the second piece from his *Piano Moods.* His favorite composition was the orchestral rhapsody *From Dawn to Dusk of Life* (1945), which was performed by the FOK (Film, Orchestr, Kultura) Czech Symphony Orchestra at a concert in 1947. *The May Fairy Tale* for nonet and harp dates from 1949. Twenty-nine songs, some with French texts by himself, and 27 of Votoček's other compositions have been publicly performed.

Trio for Violin, Violoncello, and Piano (1938)

Votoček's trio is cast in four movements: an extended *Sonata Allegro*, a *Scherzo*, a songlike *Intermezzo*, and a *Rhapsody*. The rather conservative use of the instruments, especially the two strings, and late Romantic harmonic language effectively complement the straightforward structural plan. On examining the rhythmic processes, one is reminded of many of the devices favored by Dvořák, particularly in development sections. The basic harmonic language recalls the late Romantic period with an occasional addition of parallel fourth harmonies and use of whole-tone material adding spice to the mixture, similar to Janáček's music.

The trio employs a rich harmonic palette, running the gamut from traditional chordal structures and fourth chords to whole-tone sonorities. The overall key plan of the movements also reflects this interest. The trio begins with the first movement in F sharp, and the last movement is in C major. The tritone described by the piece on the macro level is reflected on the micro level with much use of the tritone, both melodically and harmonically. After the first movement the key plan, movement by movement, is G — E flat — C, keys related by thirds, reflecting Votoček's interest in thirds as a structural device. Within such a conservative formal plan and use of the instruments, the real charm of this trio lies in the harmonies and their deployment on a large scale.

Conclusion

As if to defy C. P. Snow's contention of an opposition between "the two cultures" (*71*), Emil Votoček attempted to combine careers in disparate fields. His outstanding success as a chemist, university lecturer and teacher, linguist, lexicographer, and musician and composer demonstrate that although the humanities and the sciences may differ in their areas of study and in their methods, there is no necessary conflict between them.

Acknowledgments

For information about Votoček's activities as a composer we are indebted to Jiří Paulů and Petr Bělohlávek, Supraphon, Prague; J. Pešková, Zuzana Petrášková, and Julius Hůlek, Music Department, Czechoslovak State Library, Prague; Oleg Podgorný, Executive Manager, Music Information Center, Czech Music Fund, Prague; piano teacher Vera Tancibudek, Adelaide, Australia; Jan Stockigt, Australian Music Examinations Board, Melbourne; Carl C. Wamser, Department of Chemistry, Portland State University; music publisher Thomas C. Strangland of Portland, Oregon; and Diane Majors, Reference Department, Henry Miller Madden Library, CSUF. We wish to thank Christer Wijkström, Librarian, Center for History of Science, The Royal Swedish Academy of Sciences, Stockholm, for a copy of Votoček's Nobel Prize nomination; and Vladimir Karpenko, Charles University, Prague, and the late Vladimir Prelog, Eidgenössische Technische Hochschule (ETH), Zürich, for critical readings of the manuscript. We acknowledge the technical assistance of Randy Vaughn-Dotta, Instructional Media Services, CSUF. Our thanks also go to Jack R. Fortner, Department of Music, CSUF, for the analysis of Votoček's *Trio for Violin, Violoncello, and Piano*, excerpts of which appear above. Fortner's complete analysis and a complete list of Votoček's musical compositions, in both English and Czech, are available from the senior author (GBK) on request.

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THE LESSER KNOWN CHEMIST-COMPOSERS, PAST AND PRESENT *

Leopold May, The Catholic University of America

The most prominent chemist-composer was Alexandre P. Borodin (1833-1887), organic chemist, about whom much has been written (1). The chemistry and music of another chemist-composer, Lejaren A. Hiller, Jr., (1924-1994), polymer chemist, have been the subject of several publications (2). In addition to Borodin and Hiller, there were four previous chemist-composers, George Berg, amateur chemist-composer, Sir Edward W. Elgar, amateur chemist-composer, Georges Urbain, inorganic chemist-composer, and Emil Votoček, organic chemist-composer. There are also three contemporary chemist-composers, E. L. Bearer and Morris Kates, both biochemists, and Carlo Botteghi, industrial chemist. Their chemistry, music, and short biographies will be presented.

Previous Chemist-Composers

George Berg, Amateur Chemist-Composer
(~1720-1775) (3-5)

Although the exact date is not known, George (or Georg) Berg was born about 1720 and as some sources suggest in Germany. He was an organist and a teacher of violin and harpsichord. At the Ranelagh Gardens in the late 1750s he probably played either the organ or the violin. He was elected a member of the Royal Society of Musicians in 1763, and was listed in Thomas Mortimer's *The Universal Director* as 'composer & teacher on the harpsichord, Lincoln's Inn Fields.' In the same year he won a gold medal from the Gentlemen and Noblemen's Catch Club (5). Although publication of his songs continued into the nineteenth century, the last book of his music appeared in 1769. He was elected a member of the Society of Arts in 1769 and served on the Polite Arts, Mechanical Arts, and Chemistry committees. By 1771 he was organist at St Mary-at-Hill, Billingsgate, London, where he remained until his death.

He was a composer of instrumental and vocal music, including a collection of songs, especially those he wrote for entertainments performed at the Marybone, Ranelagh, Spring Gardens, and other pleasure gardens (entertainment complexes) in London. He published six books of Ranelagh songs; but nothing survives of his operas, his oratorio, *The Cure of Saul*, or of his ode, *The Invitation*. In 1763 he won a prize with one of his glees, *On Softest Beds*. A glee is an unaccompanied song for three or more solo voices in harmony (4). In 1759 he was the first to use the word sonatina in his *Twelve Sonatinas or Easy Lessons* (6). His galant works are considered cliché (5). Galant is a musical style featuring a return to classical simplicity after the complexity of the Baroque era. He was best known for his catches and part-songs, many of which were published in anthologies. Catch is a type of round in which the lines of music often interact so that a word or phrase is produced that does not appear if it is sung by only one voice (4). Part-songs written for multiple voices may be performed with or without instrumental or orchestral accompaniment. He also wrote an opera *Antigno* that was performed at Spring Gardens in London in February, 1764.

His more than 672 experiments in glassmaking were described in his "Experiment Book" (3,4). He was interested in learning chemistry, as it appears that he had no formal education in chemistry or glassmaking. Other objectives of the experiments were to prepare a clear glass melt, produce colored glass, some of which would be imitations of natural gemstones, and make glasses for enameling metals. He was able to make colored glasses that could be ground and used to color enameled wares. He made gem-like glasses, either for the carved or molded "cameos and intaglios" that imitated antique stones or for the more prosaic false stones set into buckles, jewelry, picture frames, or other small metal wares. The Falcon, Salpetre Bank, and Whitefriars glasshouses allowed him to use their muffle or wind furnaces. These furnaces were found in the workshops of goldsmiths, watchmakers, and other artisans who might regularly use enameling colors. He probably used a smaller version, a kiln, for most of his experiments. For some of his products, he calculated the proportional gravity ratio of weight of glass in air to its weight in water for some of his products in 1766. In 1765, Delaval (7) suggested that proportional gravity or specific gravity was related to the color of glass. Perhaps Berg did not find this helpful as he did not use it after this year (3).

Berg died in 1775, between April 17 and May 4 (3).

Sir Edward William Elgar, Amateur Chemist-Composer (1857-1934) (8-10)

Edward W. Elgar was born on June 2, 1857 in Broadheath, England. His father, who with his uncle owned a musical instrument shop, played the organ at the local Catholic Church. In addition to the organ, Edward played the bassoon, piano, and violin as well as being a conductor. When he was eleven, he wrote tunes for a play staged with his siblings, which were later published as *Wand of Youth Suites*. Ten years later, he composed *Harmony Music Four and Five Intermezzos*. In 1879 he became the conductor of the Worcester Amateur Instrumental Society and bandmaster to the Attendant's Orchestra at the Worcestershire County Lunatic Asylum in Powick. During the 1880s he played Popular Concerts in Birmingham, was a soloist at violin recitals for clubs, and taught violin to young middle-class ladies. In 1889 he married one of his pupils, Caroline Alice Roberts. One year later he composed a religious composition, *The Dream of Gerontius*, Opus 38, based on the poem of the same title by Cardinal Newman, a Catholic theologian. It relates the journey of a pious man's soul from his deathbed to his judgment before God and his settling into purgatory. In 1899 he completed the score for *Enigma Variations*. This was the work that finally secured his reputation as a composer of national and international standing. In this piece, fourteen people and one dog are featured. The first two *Pomp and Circumstance Marches* were composed in 1901 and the fifth and last in 1929. About the first march, he appreciated its worth and is quoted as saying: "I've got a tune that will knock 'em - knock 'em flat! … a tune like that comes once in a lifetime …" Elgar had 'arrived' (9).

Sir Edward William Elgar

His interest in science, prompted by new technology of the gramophone, led him to be the first major composer to record one of his own works in 1914. He conducted his composition, *Carissima*, in his first recording at the Gramophone Company on the "His Master's Voice" label, generally referred to as HMV. The company's London studios were located on an upper floor to minimize the effect of traffic noise and vibrations. The music was played with only a few instruments that could be clustered close enough to the recording horn. During World War I he wrote patriotic pieces such as *WWI*. He received many honors, including being created Knight Commander of the Victorian Order (K.C.V.O) in 1928. After this event, he was known as Sir Edward Elgar.

One of his other interests was chemistry (11). At his Hereford house, Plas Gwyn, he set up a small laboratory in the basement. His manuscript of the *Prelude to The Kingdom*, dating from January 1906, bears the stains of his chemistry experiments. In August, 1908 he moved his laboratory to part of an outhouse. It was called The Ark because of the nesting of doves in the shed, and it had a telephone link to the house. A story about Elgar's hobby was related by W. H. Reed (12):

> One day he made a phosphoric concoction which, when dry, would "go off" by spontaneous combustion. The amusement was to smear it on a piece of blotting paper and then wait breathlessly for the catastrophe. One day he made too much paste; and, when his music called him, and he wanted to go back to the house, he

> clapped the whole of it into a gallipot, covered it up, and dumped it into the water-butt, thinking it would be safe there.
>
> Just as he was getting on famously, writing in horn and trumpet parts, and mapping out wood-wind, a sudden and unexpected crash, as of all the percussion in all the orchestras on earth, shook the room, followed by the "rushing mighty sound" he had already anticipated in The Kingdom. The water-butt had blown up; the hoops were rent; the staves flew in all directions; and the liberated water went down the drive in a solid wall.
>
> Silence reigned for a few seconds. Then all the dogs in Herefordshire gave tongue; and all the doors and windows opened. After a moment's thought, Edward lit his pipe and strolled down to the gate, andante tranquillo, as if nothing had happened; and the ruined water-butt and the demolished flower-beds were pre-historic features of the landscape. A neighbour, peeping out of his gate, called out, "Did you hear that noise sir: it sounded like an explosion?" "Yes," said Sir Edward, "I heard it: where was it?" The neighbour shook his head; and the incident was closed.

When he moved to London in 1912, he turned to microscopes to satisfy his scientific curiosity.

Hydrogen sulfide (H_2S), known from alchemical times and variously named sulphur water or "Holy Water'" (13), stinking sulphurous air (14), hepatic air (15), and—by Lavoisier—as "unknown combination" (16), became recognized as an important reagent for inorganic qualitative analysis (17). Elgar was one, although an amateur chemist, who produced a device to generate this important reagent, which he knew as sulphuretted hydrogen. As he wrote in a letter to August J. Jaeger, dated November 11, 1908 (10):

> You will perhaps be amused - I hear that the 'new Sulphuretted Hydrogen Machine designed by Sir Edward Elgar' is to be manufactured & called the 'Elgar S.H. Apparatus'!! I will not offer to send you my invention - you would soon tire of it - although a nice toy.

This toy was "about as small as a hand (finger tip to wrist)." There is an inner chamber with a small hole at the top connecting it to the outer vessel. "The bottom of the outer vessel is perforated with a series of about 15 small drilled holes" (12, 18). It was made by the firm of Philip Harris (12, 18), and one is kept at Elgar's birthplace (19). His godsons, Atkins (20) and Kennedy (21) have written that it was patented. Atkins stated that it was "in regular use in Herefordshire, Worcestershire, and elsewhere for many years" (20).

Elgar died on February 23, 1934. He and his wife had one daughter.

Georges Urbain, Inorganic Chemist-Composer (1872-1938) (22,23)

Georges Urbain was born on April 12, 1872 in Paris, France. While he was studying` at the École de Physique et Chimie de Paris, he was an assistant in the mineralogy chemistry laboratory where he met Pierre Curie, who inspired him to make chemical research his life work. In 1894, after he graduated as an Ingenieur-chimiste, he entered the Faculté des Sciences de Paris, where he started research in rare earths in the Laboratory of Organic Chemistry of Charles Friedel. Four years later he received the DSc. After six years in industry, he was appointed Assistant Professor of Analytical Chemistry at the Insitut de Chimie, Sorbonne, Paris. In 1908 he was promoted to Professor of Mineral Chemistry. During World War I he was Director of the Chemical Laboratory of the Technical Section of the Artillery, a member of Inspection des Etudes et Expériences Chimiques de Guerrre, and President of the Comité Scientifique des Poudres et Explosifs and the Commission de Substances Explosives. In 1928 he became Professor of General Chemistry, Director, Institut de Chimie de Paris, and Codirector and Director of the Chemical Service, Insitut de Biologie Physico-Chimique.

Georges Urbain from (24)

He was very popular with the students who "rose in a body when he entered the room" and "listened with such complete attention that there was not a murmur to be heard in the class of three hundred fifty students" (23). For his war service, he was made Chevalier la Legion d'Honneur in 1918 and Commandeur in 1933. In 1921 he was elected to the Académie des Sciences. He was an Honorary Member of the Chemical Society of London and Corresponding Member of the National Academies of Belgium, Spain, and the USSR. He served as president of the French Chemical Society, Société de Chimie, and Société de Minéralogie.

Urbain was also a musician who played the piano and composed. Some of his compositions included, *A la veillée, Chanson d"Automne, Sur l'herbe,* and *Magagnose et Dyonisos*. In 1924, he wrote the book *Le Tombeau d"Aristoxéne. Essai sur la musique*, in which he applied the scientific method to the study of music (25). In addition, he was a painter and sculptor.

In 1879 Lars F. Nilson separated Marignac's ytterbia into scandia and a new ytterbia, which Urbain then separated into neoytterbia and lutecia (ytterbium and an unknown element) in 1907. In the same year, K. Auer von Welsbach reported the spectra and atomic weights of two elements in ytterbia, which he named after the stars aldebaranum and cassiopium. Urbain named the element lutecium (Roman name for Paris), which was later changed to lutetium. Between 1895 and 1912 he worked on the rare earths and performed more than 200,000 fractionations to afford the elements samarium, europium, gadolinium, terbium, dysprosium, and holmium. In 1911 Urbain had studied element number 72, which he called celtium. The discoverers, D. Coster and G. von Hevesy, however, named it hafnium in 1923. He also discovered the law of optimum phosphorescence of binary systems and carried out research in isomorphism. He converted an analytical balance into a thermobalance before Kotaro Honda and discovered the law governing efflorescence of hydrates in a dry atmosphere. He also served on the International Commission on Atomic Weights.

Urbain wrote several books dealing with various chemical topics, spectrochemistry, 1911 (26), chemistry of complexes with A. Sénéhal, 1913 (27), chemical reactions, 1925 (28), and a general chemistry text with P. Job, G. Allard, and G. Champetier, 1939 (29).

Urbain died on November 5, 1938.

Emil Votoček, Organic Chemist-Composer (1872-1950) (8, 31-32)

Emil Votoček was born in Arnau (Hostinné nad Labem), Bohemia, on October 5, 1872. After graduating from the gymnasium, he attended the School of Commerce in Prague where he developed an interest in chemistry. So, he transferred to the School of Chemistry (now the Prague Institute of Chemical Technology) of the Czech Technical University. In 1893 he received a diploma with the degree of Ingenieur (33). Then he continued his studies in Germany, first at Mulhouse in Alsace-Lorraine, and a year later at Georg-August University in Göttingen. He returned to the Czech Technical University as an Assistant in 1895 and was promoted to Docent in 1905. One year later he was appointed Extraordinary or Associate Professor of Organic Chemistry and was promoted to Ordinary (Full) Professor of Inorganic and Organic Chemistry in 1907. He served as Rector of the University during 1921-1922, and in February, 1939 he was forced to retire by a decree from the Department of Education. However, he enrolled as a student so that he could continue his research. After the conquest of Czechoslovakia by the Germans, the universities were closed by order of the German occupation officials on November 17, 1939, until the country was liberated in 1945.

Emil Votoček as Rector of the Czech Technical University from (32)

Although he was regarded as a learned and respected professor, he was often hot-tempered and irritable. His research laboratory was known as "Devil's Island," which represents the appearance and the mood in the laboratory (32). He lectured in both inorganic and organic chemistry and wrote textbooks in both fields. K. Preis and he wrote the inorganic text with Jaroslav Heyrovský (34). In the organic text (35) he introduced a new classification of organic chemicals dependent upon whether a compound was derived from the original hydrocarbon by substitution on one, two, or more carbon atoms. He also wrote a laboratory manual and a book of exercises in organic chemistry (36).

Votoček received honorary doctorates from the Czech Technical Universities of Prague, 1948 and Brno, 1927, the Universities of Padua, Nancy, and Toulouse, 1929, and from the Sorbonne. He was an honorary member of the Polish, Italian, Spanish, and Romanian chemical societies, the Société de Chimie Industrielle, and the Société Chimique de France, which awarded him the Le Blanc Medal; and he was named Officier de la Légion d'Honneur and Officier de l'Instruction Publique. Other honors included the Ordine Corona d'Italia and Commander of Poland's Order of Polonia Restituta, 1932. He was nominated for the Nobel Prize in Chemistry in 1933, a year in which it was not awarded (32). However, one of his students, Vladimir Prelog, received the Nobel Prize in 1975 for his research into the stereochemistry of organic molecules and reactions, which he shared with John Cornforth for his work on the stereochemistry of enzyme-catalyzed reactions. On the centenary of his birth, 1972, a commemorative medal was minted and is awarded by the Rector of the Prague Institute of Chemical Technology as the highest recognition of scientific activity,

He played the double bass in addition to being a musicologist and composer. Among the 70 songs and works for piano and ensembles he wrote are *Allegretto grazioso*, 1932, *Thema con variazioni for piano and Soprano Voices*, 1934, *Trio for Piano, Violin, and Violoncello*, 1938, *Serenade for French Horn and String Quartet*, 1943, *Czech Polka*, 1944, *From Dawn to Dusk of Life*, 1945, and *The May Fairy Tale*, 1949. In 1946 he published the book, *Musical Dictionary of Foreign Expressions and Phrases* (37).

Among his many literary achievements were several chemical dictionaries for different languages: *Shorter German-Czech and French-Czech Chemical-Technical Dictionary* with B. Setlík, 1906 (38); *Czech-German-French-English-Italian-Latin Chemical Dictionary*, 1941 (39). He also published several for other sciences: *Czech-French-Terminological and Phraseological Dictionary for Chemistry, Physics and Related Sciences*, 1924 (40); *Polish-Czech Chemical Dictionary with Partial Regard to Mathematics, Physics, Geometry and Mineralogy,* 1931 (41). Two dictionaries dealt with the Czech and French languages: *Czech-French Conversation and Phraseology*, 1939 (42) and 1924 (40). He published two volumes containing all postmarks used in Bohemia up to 1918 (43). In 1929 he started the journal *Collection of Czechoslovak Chemical Communications* with Jaroslav Heyrovský, who received the Nobel Prize in Chemistry in 1959 for work in polarography. They also served as the editors until the journal ceased publication in 1939. When the journal resumed publication after World War II in 1947, Heyrovský continued as sole editor (44).

Votoček's research on artificial dyestuffs, carbohydrates, and analysis of natural products was published in 300 articles. One of his main research interests was saccharides, especially methylpentoses. This interest was developed during his stay in Göttingen, where he worked with Bernard C. G. Tollens, who was noted for his research of the chemistry of saccharides. He studied the derivatives of rhammose, L- fucose and its D-isomer, which he named rhodeose. To describe two sugars that can be converted into each other, he invented the term epimers and the term epimerization for the reaction. He introduced the use of nitrous acid in the oxidation of sugars and synthesized a number of saccahrides and saccahride acids and alcohols. Some of his efforts were devoted to nomenclature in carbohydrates and (with Alexander Sommer-Batěk) in inorganic compounds. He also served on the IUPAC Commission on the Nomenclature of Organic Chemistry. One of his studies on the derivatives of carbazole led to its application as an analytical reagent (Votoček's reagent) for the determination of sulfite in the presence of thiosulfate and thionate. He also introduced the use of sodium nitroprusside as an indicator in mercurimetric titrations. A more comprehensive account of his chemical work can be found in Ref. 32.

On February 17, 1906, he married Libuše, the daughter of an Austro-Hungarian minister; they had two sons and a daughter. He died October 11, 1950 in Prague.

Contemporary Chemist-Composers

The tradition of chemist-composers continues to the twenty-first century as illustrated by the activities of three contemporary chemist-composers, E. L. Bearer, Morris Kates, and Carlo Botteghi.

E. L. Bearer, Biochemist-Composer (8, 45)

Elaine L. Bearer was born on April 1, 1949 in New Jersey. Her early education began at age 6, and by age 9, the first performance of one of her compositions took place. After studies at Juilliard Prep School, she matriculated at Carnegie Institute of Technology, where she studied both music and computer science. Composition studies were with Carolos Surinach, Virgil Thompson, Don Wilkins, and Nicolai Lopatniff. She left Carnegie Tech after two years to travel to Paris, where she worked with Nadia Boulanger, the famed composition teacher. Returning to New York, with an interest in computer "algorhythms" to generate sound, she completed a B. Music in 1970 from the Manhattan School of Music. From 1970 to 1973 she was an instructor in music history and appreciation at Fairleigh Dickinson University. Then she was recruited to San Francisco by Lone Mountain College as an Assis-

Elaine L. Bearer

tant Professor of Music in 1973, after having withdrawn from the Ph.D. program at NYU, which awarded her an M. A. in Musicology in the same year. After teaching composition at Lone Mountain, SF State University, and the San Francisco Conservatory, she decided to attend medical school. While preparing at Stanford University, she was a postgraduate research assistant in neuroscience with John Nicholls and a teaching assistant for Donald Kennedy. She was the first graduate from the M.D.-Ph.D. program at University of California, San Francisco in 1983. Then she served a residency in pathology there for two years. After a year at the Centre Medial Universitaire, University of Geneva, Switzerland, she returned for a postdoctoral fellowship in biochemistry with Bruce M. Alberts. In 1991 she joined the Department of Pathology and Medicine of Brown University as Assistant Professor. One year later she was appointed Adjunct Assistant Professor in the Department of Music. After six years, she was promoted to Associate Professor in both departments and Professor in 2004 in the Department of Pathology and Medicine and in 2005 in the Department of Music and in 2006 in the Division of Engineering. Since 1993 she has served as Director and Codirector of The San Lucas Health Project, which provides the indigenous Maya of the San Lucas Toliman, Guatemala region with free year-round primary health care.

One musical composition, *The Nicholls Trio: A Musical Biography of a Scientist***,** is dedicated to her mentor, John Nicholls (45, 46). The final movement was inspired by electrical patterns in the neurons of leeches, which Nicholls studied. The piece was premiered at the annual meeting of the Society for Neuroscience in 1994. Her *Magdalene Passion* (45, 46), an hour-long oratorio for chorus, orchestra, and five soloists, was premiered in 2000 by the Providence Singers under Julian Wachner

In her research in molecular biology of actin-cytoskeleton, Bearer investigates dynamic cellular behavior. Presently, she uses a range of microscopic imaging and molecular techniques to understand the mechanisms of these dynamics by using model systems, including squid giant axon, transport of Herpes simplex virus, and human blood platelets. Some of her recent studies address fundamental questions pertaining to learning and memory. She has published 45 papers on her research and is the editor of *Cytoskeleton in Development* (47) and co-editor of *Nature and Nurture* (48).

Carlo Botteghi, Industrial Chemist-Composer (1938-2002) (49,50)

Carlo Botteghi was born in La Spezia, Italy, on March 5, 1938. In 1963 he graduated in chemistry from the University of Pisa. He continued there as a Lecturer of Organic Chemistry in the Faculty of Engineering until 1968. Then he took a research position at ETH (Polytechnic Institute) in Zürich, Switzerland, as Forschungsassistent and Oberassistent. He was also Lecturer in Organic Chemistry in the Faculty of Engineering and Director of the high pressure laboratory. In 1975 he became Professor of Industrial Chemistry at the University of Sassari, Italy, and Director of the Institute of Applied Chemistry. After ten years he became Professor of Industrial Chemistry at the Università Ca' Foscari di Venezia (University of Venice), Italy. In addition to teaching various courses in the area of industrial chemistry, he served as Director of Department of Chemistry for two 3-year terms.

Carlo Botteghi from (50)

He studied piano and music composition privately and has been registered in the Music Section of the Italian National Register of Authors since 1960. As a musicologist, he concentrated mainly on Pietro Mascagni (1863-1945), who was one of the important Italian composers at the turn of the 20th century, best known for his first masterpiece *Cavalleria Rusticana*. He was a noted Mascagni scholar or Mascagnano and the head of the Centro Studi Mascagnani of Livorno. In 1995 he wrote the music for the song *Mascagni* with words by Luigi Biagioni. It may be found on a CD entitled *Cieli* *di Toscana* (Tuscan Heavens) performed by the popular Italian singer, Andrea Bocelli. In 1981 Carlo Botteghi wrote *Magari tu and Una giornata senza te* with words by Antonio Strinna. His book, *Le Suggestioni della Musica* (The Splendor of Music) was published in 1992 (51). In 1997 he published an essay on the opera, *Parsina*, entitled *Parisina –il dramma musicale di Gabriele D'Annunzio e Pietro Mascagni* (Parisina-the musical drama by Gabriele D'Annunzio and Pietro Mascagni) (52).

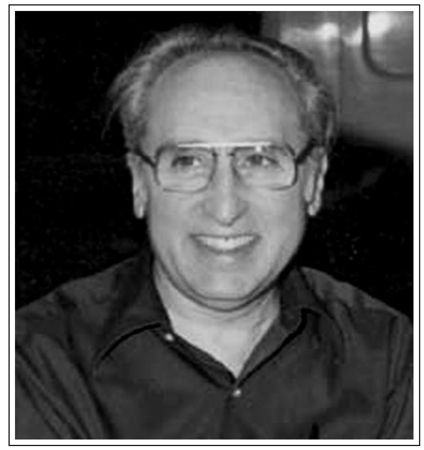
Botteghi published 150 papers in organic chemistry, homogeneous catalysis, hydroformylation, and carbonylation. One of his interests was conservation of buildings, and he did research in the synthesis of polymeric materials for this use. From 1995 to 1998 he also taught Conservation of Materials in Historical Buildings at the Architecture University Institute in Venice.

Botteghi died suddenly on September 19, 2002 and was survived by his first wife, Maria Grazia Bacci, and their two sons and his second wife, Vera Bellagamba, and their son.

Morris Kates, Biochemist-Composer (53,54)

Born in Galati, Romania, on September 30, 1923, Morris Kates was brought to Ottawa, Canada, one year later. He received a B.A., 1945, M.A., 1946, and a Ph.D., 1948 from the University of Toronto. After receiving his doctorate, he continued at the University as a postdoctoral fellow and then moved to the National Research Council of Canada, where he was first a Postdoctoral Fellow (1950-1951), and then a research scientist until 1968. In that year, he transferred to the Department of Biochemistry, University of Ottawa, as Professor, where he remained until he retired in 1989 as Professor Emeritus. During his tenure at the University of Ottawa, he served as Chairman of the Department of Biochemistry (1982-1985) and Vice-Dean (Research), Faculty of Science and Engineering. In 1995 he was named the Morton Lecturer, an award by the Biochemical Society to a lecturer who has made an outstanding contribution to lipid biochemistry. He also received the Supelco Award for lipid research from the American Oil Chemist Society in 1981. An issue of *Biochemistry and Cellular Biology* in 1990 was dedicated to him in honor of his valuable contributions to biochemistry in Canada (55).

Kates developed his twin passions for science and music during his youth and began studying violin at the age of 11. By the time he was in high school, he began composing music and exploring the world of laboratory science. During his university studies he took courses in music harmony, counterpoint, and composition and played in the University of Toronto Orchestra. When he was at the National Research Council, he played in orchestras and string quartets in Ottawa. His first formal composition in 1946 was *Theme and Variations for Piano*, which was revised for strings in 1964. In 1990 he composed *Columbus* for baritone and full orchestra, and two years later, *Festive Suite for Brass Quintet and Strings*. His composition for choir and string quartet *Water—Source of Life* was released in 2000. He is an Associate Composer with the Canadian Music Centre and a member of the Canadian League of Composers.



Morris Kates from (53)

Kates has published about 220 articles on the analysis, structure determination, biosynthesis, and membrane function of cellular phospholipids, the nutritional value of lipids, and the production of biodiesel fuel. One of his research projects was the discovery and study of a new class of glycerol-diether lipids in bacteria named *Archaea* that live in extreme environments. He is currently associated with the Ottawa Biodiesel Research Group in the Department of Chemical Engineering at the University of Ottawa, whose "main objective is to produce biodiesel in a cost-effective way by overcoming several barriers to biodiesel profitability"(56).

His books include *Techniques of Lipidology: Isolation, Analysis, and Identification of Lipids*, which is now in the second edition (57). In 1980 he and Arnisa Kuksis edited *Membrane Fluidity: Biophysical Techniques and Cellular Regulation* (58), and four years later, with Lionel A. Manson, he edited *Membrane Fluidity – Biomembranes*, Vol. 12 (59). In 1990 he edited *Glycolipids, Phosphoglycolipids, and Sulfoglycolipids*, which is volume 6 of the *Handbook of Lipid Research* (60). Three years later he coedited *The Biochemistry of Archaea (Archaebacteria), New Comprehensive Biochemistry*, Vol. 26, with D.J. Kushner and A.T. Matheson (61).

Kates is married to Pirkko Helena Makinen, and they have three children and seven grandchildren.

Observations

The chemist-composers described above are experimental chemists; two amateur chemist, two biochemists, an industrial chemist, an inorganic chemist, two organic chemists, and a polymer chemist, but none is a physical or theoretical chemists. In performing experimental work, one sometimes involves "hunches" in solving problems, which may be more similar to the brain processes used in composing music than the abstract reasoning needed in solving problems in physical or theoretical chemistry. This does not apply to chemist-performers because some are physical chemists (e.g., Wilhelm Ostwald). Nor does it apply to several of the scientist-composers who are also mathematicians and physicists (62). It may be that the sample of nine chemist-composers is too small to derive any correlation between the area of chemistry pursued by the chemist-composers and their music.

ACKOWLEDGMENT

I thank Professor Elaine L. Bearer for her comments and picture, Professor Morris Kates for his comments, Professor Giorgio Strukul for the information on Carlo Botteghi, Professors Sarah Lowengard and William H. Brock for their comments and for bringing George Berg to my attention, and Ms. Eva Feiglova, Professors Frantisek Jursik and Jan Rocek, and Dr. Michal Hocek for their comments on Emil Votoček.

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* Presented at the Symposium on "Chemist-Composers: Their Chemistry and Music" cosponsored by the Division of the History of Chemistry, The Chemical Heritage Foundation, and the Chemical Society of Washington at the 231st American Chemical Society National Meeting, Atlanta, GA, March 26-29, 2006, HIST 030.

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