



Reading Zolotov: A source of knowledge, inspiration and pleasure—Thoughts and emotions on the eve of the 80th jubilee of Academician Yuri Aleksandrovich Zolotov

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ABSTRACT

Academician Yuri Aleksandrovich Zolotov is a world-wide recognized man in analytical science and chemical analysis. This paper is an appreciation by the author for the long term influence of Professor Zolotov scientific ideas and creative publications on his raising up as scientist during his early studies at Moscow State University and generally on his professional life. The article is a hybrid of personal tribute, historical reminiscence, and a brief tutorial mostly aimed at juniors in science. Paper is illustrated by several photographs and supplemented by references to several of most influential books by Zolotov. Several Bulgarian analytical chemists share their impressions from Professor Zolotov personality and achievements in science.

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Academician Yuri Aleksandrovich Zolotov is a world-wide recognized man in analytical science and chemical analysis. A pleiad of good words will be said and written for Professor Zolotov in this jubilee year and I am completely convinced that he deserves them all. Therefore I was sincerely thankful to the organizers of this Talanta Special Issue in honor of Professor Zolotov for the invitation, the chance (and responsibility) to prepare this text. My contribution will inevitably represent a **hybrid**, since this term for an analytical method introduced by Zolotov some forty years ago [1–4] has impressed and inspired me so much in my junior analytical life as a post-graduate student. Hence I was bound to prepare a **hybrid** of personal tribute, historical reminiscence, and (hopefully) a brief tutorial mostly aimed at young readers. Juniors in science should have a timely chance to have good teachers as I had throughout my life and as Yuri Aleksandrovich had in his professional life.

I know that Professor Zolotov does not like epithets hence I will try avoiding them as far as possible but could a wise man tell me how to do this when I know by experience the paradise and the Hades of an active, successful life in science. During over half a century Yuri Aleksandrovich has devoted his time, efforts, talent, skills, good will, enthusiasm, and inexhaustible energy to our favorite analytics and chemical analysis—as a science, occupation, way of life, destiny.

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I have known Professor Zolotov since 1969 when I was enrolled as a Ph.D. student (1969–1972) at M.V. Lomonosov Moscow State University (MSU). Professor Zolotov was not my direct tutor and most of the time since then we have been spatially separated by over 2000 km (Sofia—Moscow, quite a distance in pre-Internet times and even now). We have something in common with Professor Zolotov that I am very proud of: our dearest teacher and adviser has been Academician Ivan Pavlovich Alimarin [5–8], one of the most prominent analytical chemists in the USSR, representative of a great scientific school, which merited successor in now Academician Yu.A. Zolotov. Because of our involvement with the analytical chemistry, I have read throughout the years and decades many of Zolotov publications (scientific papers, monographs, reviews, editorials etc.), have willingly attended some of his lectures on rare occasion, and have enjoyed our rare personal contacts during conferences and visits. Throughout these decades I have always experienced his considerate friendship and stimulating influence. In this respect I am in the situation of many hundreds and thousands of analytical scientists and Professor Zolotov readers. Most probably each of them has his own ‘Zolotov story’.

Now let me turn back to my early years in science when I was lucky indeed to have very good teachers. To look backwards to wherefrom we have started in order to understand where are we going (hasn’t that been said somewhere by Zolotov!). The Chair of Analytical Chemistry at MSU was one of the best places to grow up an analytical chemist. Although nowadays I am convinced that I have always been an analyst by heart, analytical chemistry happened not to be my major during previous graduate studies at the Higher Institute of Chemical Technology in Sofia

(1963–1965) and the Moscow Institute of Steel and Alloys (1965–1968). In those institutes I was educated as an engineer on chemistry and technology of high-purity metals and semiconductor materials. Fundamental Analytical Chemistry was taught and trained for in Sofia by excellent professors and large curricula comprising much practical work, thanks to my first professors of analytical chemistry B. Sagortschew and N. Elenkova but do we need a narrow professional specializations at early age of our studies? Meanwhile after several thorough competition exams in 1969 I had the lucky chance to be appointed in parallel on a permanent(!) position at the Faculty of Chemistry, University of Sofia (UniSofia) and as a Ph.D. student at MSU. So I was forced by those circumstances to become a real analyst during those three years and to start developing into an analytical scientist!

The scientific and educational environment at the Chair of Analytical Chemistry at MSU represented a perfect institution for this endeavor. There were long traditions and an established scientific school headed by Academician I.P. Alimarin. This happy medium was a natural amalgam of teaching, research, and thorough practical training, everybody was so friendly, and I had the unique chance to learn from the best. After some discussions with my dearest scientific advisers I.P. Alimarin and N.I. Tarasevich (MSU) and the Head of the Chair of Analytical Chemistry in my University Professor N.P. Pentchev (UniSofia) my topic was indicated by two keywords: Atomic absorption spectrometry (AAS) and Liquid/liquid extraction (LLE). This was quite a logical selection at that time since the AAS was an emerging promising analytical method in its boom years of an instrumental technique, while extraction methods were attractive, well taught and extensively applied at the MSU school. I had an expectation that a lot could be learned about LLE and about their combination with the AAS (with flame atomization at that period). Now the great reading and learning began! I was eagerly absorbing every word about extraction and extracting all available information (scarce at those times though) about the prospective AAS. I remember gratefully lectures delivered by I.P. Alimarin, V.M. Byrko, I.M. Gibalo, A.P. Golovina, N.V. Melchakova, A.I. Kamenev, I.V. Sokolova, N.I. Tarasevich, Yu.A. Zolotov, as well the contacts and seminars by distinguished visitors (R. Belcher, D. Dyrssen, D. Jagner, H. Kaiser); the warm attention and consultations by many staff members (P.K. Agasiyan, A.I. Busev, V.M. Byrko, I.F. Dolmanova, V.I. Fadeeva, V.M. Ivanov, G.V. Kozyreva,

V.M. Peshkova, G.V. Prokhorova, K.A. Semenenko, L.N. Simonova, A.A. Zheleznova); thousands of read pages in Russian on atomic spectroscopy by N.P. Ivanov, B.V. L'vov, N.S. Poluektov, A.K. Rusanov, A.N. Zaidel, and the scarce early books on atomic spectroscopy by J.A. Dean and Th.C. Rains, G.D. Christian and F.J. Feldman, R. Mavrodineanu, M. Pinta, E. Pungor, J. Ramirez-Munoz.

Professor Zolotov monographs, papers and reviews have been an essential reading for me ever since those great times of growing up as an analyst, a future teacher by itself, and a scientist. In early 1970's Professor Zolotov was not actually a staff member of the Chair but his name was often heard—could after all extraction and preconcentration be studied, thought, practised and researched without reading and referring to Zolotov! Nowadays I guess how unbelievably busy might have been he in those years at the Vernadsky Institute of Geochemistry and Analytical Chemistry (GEOKHI). In those times I had an impression that Professor Zolotov was a kind of legend, especially for youngsters like me because of his already well-recognized and popular achievements in science, impetus career and promising future. Colleagues were referring to Zolotov in their publications, and more impressively, in their lectures! My tutor Academician I.P. Alimarin obviously liked Yuri Aleksandrovich as his gifted student, with a wise view to continuity. Professor Zolotov was young at his 37 years and appeared even younger on the background of his remarkable scientific achievements yet already full professor, Ph.D., D.Sc., Corresponding Member of the Academy of Sciences of the USSR. It was at later stage however that we have heard about his prestigious awards, orders, and state prizes.

Professor Zolotov ideas about preconcentration and separation, mechanisms, effects of concomitants, rational combining, hybridizing and integrating analytical steps, his timely book on chelate extraction [4] and early reviews on combined and hybrid methods of analysis [1,3] were willingly adopted by me in my research on group preconcentration and flame AAS investigation of hexamethylenammonium hexamethylendithiocarbamate-n-butylacetate extraction system, that resulted in successful defending my Ph.D. thesis in 1972 [9].

Irresistibly, I attended Professor Yu.A. Zolotov lecture course on “Application of extraction in analytical chemistry” for the Faculty of Staff Qualification at MSU by end-1971. A couple of scanned pages from my lecture notes at that time (Fig. 1) reveal a

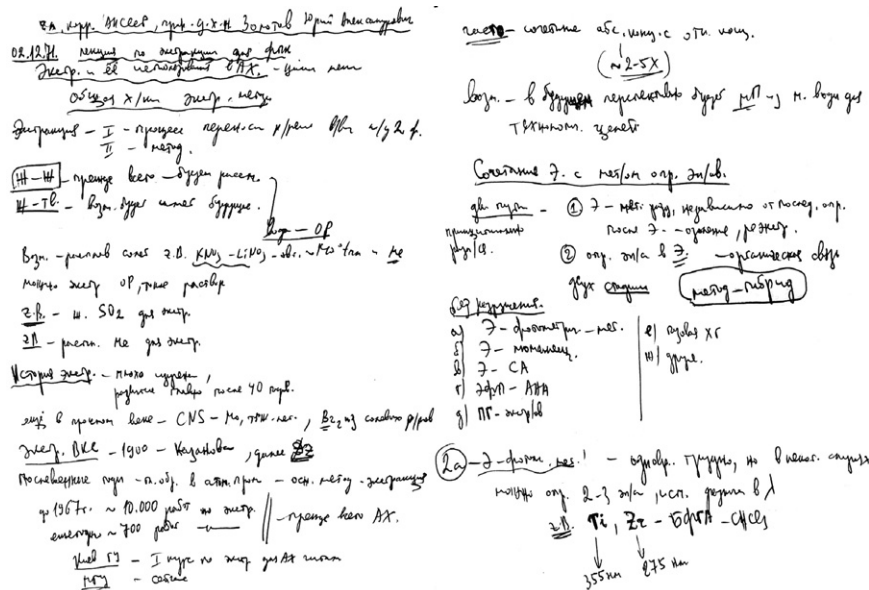


Fig. 1. A couple of pages from lecture notes taken by the author when attending Professor Yu.A. Zolotov lecture course on “Application of extraction in analytical chemistry” at Moscow State University in 1971—a wealth of knowledge and inspiration for further achievements.



Fig. 2. Selection of books written/edited by Yu.A. Zolotov—essential reading and a benchtop reference in our laboratory.

wealth of information and inspiration for further studies. On the left page Professor Zolotov has commented that the Solid phase extraction (SPE) might have promising future; on the right page he introduced the concept of “*hybrid method*”. Nowadays hybrid methods are widely accepted with the English names such as hyphenated or elsewhere coupled techniques. New hyphenations have been added and old hyphenations have been omitted (just a few illustrative examples, cf: HGAAS vs. HG-AAS, FI-HGAAS, FI-UV-HGAAS, FI-MWD-CVAAS, HG-HPLC-UV-HGAAS, etc.). The general concept of a rational combination of pre-instrumental steps of sample pretreatment and/or preconcentration with instrumental quantification is widely adopted. For a junior scientist these ideas have proved stimulating and forming the basics of analytical methodology and analytical way of thinking.

Reading Zolotov books and reviews [1,2] has challenged me to try analyzing extracts with inappropriate chlorinated solvents by aerosol drying [10] or by pulse nebulization [11]; of course these environmentally unfriendly solvents became obsolete and abundant after one or two decades. My own extraction-flame AAS interests have gradually subsided and research was directed to other relevant topics: scaling down, microcolumns, electrothermal AAS [12], vapor generation AAS (VGAAS) (a hybrid method by itself) [13], flow and flow injection analysis, on line treatments [12–15], speciation analysis, and further hybrid methods [14–16].

Whenever possible I have consulted publications by Zolotov in preparing my own specialized courses for Bachelor (B.Sc.) or Master degrees (M.Sc.): ‘Contemporary problems of chemical analysis’, ‘Environmental analytical chemistry’, ‘Introduction to instrumental analysis’, ‘Combined and hybrid methods of analysis’, etc.

It is interesting to have a retrospective look on the early book by Zolotov entitled ‘Essays on analytical chemistry’ [20] considered by him as a ‘kind of hybrid of a monograph, popular science and a handbook’. In the Forward, the author refers to the science as a ‘fantasy, flight into the future’. So let us excerpt part of impressive points, raised by Professor Zolotov some 35 years ago (!) and how important they look nowadays as an almost uncombed, alphabetic

list; no comment! [since terminology is changing some current terms are given in brackets]:

- Analytical chemistry of organic compounds
- Automation, especially in environmental analysis
- Decisions to be made on the basis of analysis
- Economic aspects of analysis
- Economic role of accuracy
- Flow analysis
- Great future of computers in analytical chemistry
- Hybrid methods
- Metrological aspects of chemical analysis and their importance
- Metrology in teaching analytical chemistry
- Organizational problems of chemical analysis
- Calibration free methods of analysis [Primary methods]
- Problems and role of certified reference materials
- Prospective inorganic mass spectrometry
- Prospects of AAS
- Prospects of X-ray fluorescence
- Qualification [Continued education]
- Representative sampling
- Trends: automation, instrumentalization, mechanization, miniaturization
- Standardization and unification [of procedures]
- Terminology
- The role of high precision coulometry
- The role of scientific journals

I am willingly looking forward to each new Editorial by Yu.A. Zolotov (‘The page of the Editor-in-Chief’) commencing each issue of Zhurnal Analiticheskoi Khimii (Zh. Anal. Khim.) with impressive regularity since mid-1990, with simultaneous English edition (J. Anal. Chem.) after 1994, briefing the readers with comments, enlightenment, ideas, insights.

Time is running, books by Zolotov [17–22] persistently continue occupying their well deserved place on our benchtops and libraries as an essential reference—well worn from permanent,



Fig. 3. A pleasant meeting of D.L. Tsalev and Yu.A. Zolotov (left to right) during the International Congress on Analytical Sciences (ICAS-2006), June 25–30, 2006, Moscow, Russia.

frequent use (Fig. 2). As one of the numerous correspondence students and fellows of Yuri Aleksandrovich, I am publishing by myself scientific papers, reviews, monographs, bibliographies, dictionaries, and teaching aids, some of them accepted well by the analytical community. Our book on AAS [23] has been successfully translated into Russian (with thanks to all kindly involved!) and enjoys apparent success in laboratories of the huge country and in the teaching programs of some universities. Contacts with other successful students and collaborators of Zolotov are taking place (no space for the long list though!). Some of my own students are becoming professors—optimistically, better than me. Occasionally I got myself cited by Professor Zolotov and his co-workers (blissful fellow—20 citations by Zolotov!). Our brief meetings with Yuri Aleksandrovich at the 31st International Congress of Pure and Applied Chemistry, July 13–18, 1987, Sofia, Bulgaria and at the International Congress on Analytical Sciences (ICAS-2006), June 25–30, 2006, Moscow, Russia were inspiring and joyful. I count on my favorite scientific writer for continued reference on latest trends in chemical analysis and analytical sciences [21,24]. Eventually Professor Zolotov attended my invited keynote lecture in Moscow where I dared taking about ‘More chemistry in instrumental methods’ [15], something adopted from him many years ago! Remember the youngsters from the early 1970s, including the fascinated post-graduate from Room 259, admiring Professor Zolotov achievements—nowadays established scientists by themselves (Yu.A. Barbalat, T.N. Shekhovtsova, O.A. Shpigun, D.L. Tsalev, N.B. Zorov).

There is a catch-phrase that one will never read a book if he/she could talk for a half an hour with the author (or so). As many generalizations this one proves rather to be not true—depending on the quality of books and the author. Personally, I have been fortunate to enjoy both reading and meeting our hero of an anniversary (Fig. 3).

At this point I am self-critically asking myself: Am I not too enthusiastic and pathetic? Why not – Zolotov merits this! May be my passion is a kind of resonance between our perceptions – obviously? May be the good writer has just matched a thankful reader? Doesn't our satisfaction stem from the successful and renewed reproduction of the chain ‘teacher–student–teacher’ admired by Zolotov in his recent text [21]. Should I somehow validate or at least verify my appraisals and does positive attitude really need validation?

I have therefore interviewed several Bulgarian colleagues of mine who are by themselves established scientists, authors and educators in the field of analytical chemistry and have known for years Academician Zolotov and his creative works. Their responses are given below as an expression of their esteem, gratitude and salutation to Professor Zolotov on the occasion of his jubilee. No ‘analytical bias’, the emotional one well allowed! Inevitably, our appreciation and kind feelings are in coherence.

Academician Panayot R. Bontchev, Member of Bulgarian Academy of Sciences (BAS): “I recall one of my most impressive visits to the Vernadsky Institute of Geochemistry and Analytical Chemistry of the Academy of Sciences of the USSR (GEOKHI) in 1976, when Prof. Zolotov was Head of Laboratory and Deputy Director of that Institute. In 1970s we had an intensive cooperation between the Departments of Analytical Chemistry and Inorganic Chemistry at the University of Sofia and the MSU, with exchange of education programs, textbooks, teaching aids, visiting scientists, etc. After one of our working meetings, Professor Zolotov invited me to pay a visit to the Institute and attend the opening of a container with extraterrestrial material brought from the Moon surface. Looking at the cherished specimen with appearance of a fine greyish dust powder, manipulations by means of robotized appliances and remote sub-sampling has been such an exciting and unforgettable experience that I was wholeheartedly thankful to Prof. Zolotov for this gesture of friendship and surprising encounter”.

Professor D.Sc. Sonja Arpadjan (UniSofia) shares her impressions: “I attended Professor Zolotov lectures on solvent extraction at the Faculty of Qualification at the Moscow State University in 1981. At first glance I was surprised: ‘Is that the great Zolotov?’—He was so humanly simple and modest! His lectures were at a very high scientific level and I have got so much! This was a real school and Academician Zolotov is a world leader in his field. Students were figuratively fighting for the great luck of becoming his Ph.D. students. I have used many of Zolotov books and I consider ‘Extraction of Chelate Compounds’ [4] to be the best, unbelievably useful monograph!”.

Prof. D.Sc. Stoyan Alexandrov (UniSofia) added: “I have widely used publications by Zolotov starting from 1970’s during my Ph.D. studies on radiochemistry at the Moscow State University, and later in preparing my lecture courses and writing textbooks on ‘Analytical chemistry’ and especially on ‘Methods for dissolution, separation and preconcentration in analytical chemistry’. The monographs by Zolotov on ‘Preconcentration of microelements’ [19] and ‘Extraction preconcentration’ [2] have proved most helpful in my teaching and research. Academician Zolotov very kindly and timely stimulated me to prepare my D.Sc. thesis on ‘Separation and preconcentration by using some low soluble inorganic sulfides, chlorides and oxides in development of combined and hybrid methods for analysis’ (Sofia, 1989). Although our meetings and discussions have been scarce, I have best impressions from Yuri Aleksandrovich as a virtuous man and a great scientist. Our trip to the Rila Monastery in Bulgaria has been an unforgettable human contact”.

“With pleasure, with great pleasure”, Professor D.Sc. Vasil Simeonov (UniSofia) said: “I have discussed with Professor Zolotov on several occasions in the early years of chemometrics. In the 70’s chemometrics was not unanimously accepted as an important branch of analytical chemistry. Prof. Zolotov comforted me (a young chemometrician at that time) in my doubts with his futuristic remark that the future of analytics is closely related with methods assessment and optimization and with intelligent data treatment (actually, the fundamentals of chemometrics!). This gave me the confidence to carry on my research without fear to be an analytical ‘outlier’. Since then I am always quoting the idea of Prof. Zolotov about the information nature of analytical

chemistry where data collection and data treatment should go parallel in order to describe not only the sample but all aspects of analysis—sampling, pretreatment, signal measurement and estimation, and analytical data interpretation.”

Prof. DSc. Elisaveta Ivanova from the Institute of General and Inorganic Chemistry of the Bulgarian Academy of Sciences (IGIC-BAS) says: “The analytical chemists of our institute are personally acquainted with Prof. Zolotov during their long-term scientific collaboration (1970–1990) in the field of the analysis of high-purity substances, environmental samples and the chemistry of platinum metals”. The books of Zolotov, particularly those on trace element preconcentration and separation, e.g., ‘Preconcentration of microelements’ [19], ‘Extraction of metals by acylpyrazolones’ [18], a.o., have helped me a lot in my analytical work. These excellent monographs have a permanent place on my desk. The main analytical reagent in my Ph.D. work and in subsequent studies was 1-phenyl-3-methyl-4-benzoyl-2-pyrazolin-5-one (PMBP) [18] after all!

My friend and colleague Assoc. Prof. Dr. Ivan Havezov (IGIC-BAS) kindly encouraged my efforts to prepare a balanced, felicitous text: “I imagine what a hard endeavor is to write about Academician Zolotov but who else if not you! Personally I value mostly his book “Essays on Analytical Chemistry” [20] wherein he has given the complete picture of analytical chemistry—in the USSR and in the world. Yuri Aleksandrovich was telling me that instrumental methods virtually constitute a great orchestra and if only one instrument is out of tune then the whole piece of music is ruined. Academician Zolotov is a person with an incredible broad view on analytical chemistry and its place among sciences. Few people exhibit such an insight!”

And a final touch: this Spring I read over a couple of Zolotov books – “Assays...” [20] and “About chemical analysis ...” [21] – In Russian of course, just for pleasure! That is it all about: the joy from science and the happiness in science!

Thank you so much, dear Yuri Alexandrovich, for your generous devotion to our beloved analytical sciences, for creating and spreading of precious knowledge, for continued inspiration, for the joy of scientific reading, scientific writing and vice versa! Many happy returns of the day!

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