

Anniversary



Prof. Christo Balarew's 90th anniversary

Prof. Christo Balarew, PhD, DSc, has turned 90. He is an eminent scientist, lecturer, public figure, member of organizational and scientific committees of international scientific forums, guest professor and lecturer at foreign universities, such as the University Claude Bernard in Lyon, France, the University of Valladolid, Spain, the Mining Academy Freiberg and the University of Siegen, Germany, the University of Colorado in Boulder, USA, the McMaster University in Hamilton, Ontario, Canada, the University of Witwatersrand, Johannesburg, South Africa, etc. During the period 1997-2001, he was Deputy Minister of Education and Science.

He has been a president of the National Committee at the International Union for Pure and Applied Chemistry for the period 1998/2022.

He was born on June 23, 1934 in Sofia. In 1957, he graduated in chemistry from the Faculty of Physics and Mathematics of Sofia University. He worked for 2 years as a high school teacher, then in 1959 entered the then Chemical Institute of the Bulgarian Academy of Sciences. In 1967 he was elected Associate Professor at the newly established Higher Chemical-Technical Institute - Burgas where he headed the Department of Inorganic Chemistry. In the meantime, as a part-time doctoral student, he defended his PhD thesis at the Mining Academy Freiberg, Germany (1969). In 1972 he returned to Sofia as Associate Professor at the Institute of General and Inorganic Chemistry of the Bulgarian Academy of Sciences, and in 1988 he was elected Professor and Head of the Laboratory of Inorganic Salts at the institute, in which scientific activity he still participates today. During the years 1976-1978 he was a scholarship holder of the Alexander von Humboldt Foundation. In 1983 he defended his

Doctor of Chemical Sciences thesis on the topic "Regularities of the equilibrium formation of mixed crystals and double salts from three-component water-salt systems".

The scientific studies of Prof. Chr. Balarew are in the field of solubility and crystallization processes of salts in multicomponent model and natural systems. In aqueous solutions, the ions of salts are always hydrated, forming complexes with each other. The latter are grouped into complex associates of different sizes depending on the composition of the solutions, the concentrations of the salts and the temperature. Balarew's contribution is in the application of Pearson's concept of "hard and soft" Lewis acids and bases with a view to determine which are the preferred metal-ligand bonds in a given system. On this knowledge, by applying Pauling's rules for building coordination polyhedra, Balarew predicted the composition and structure of the complexes prevailing in the respective solution. Postulating that the kinetics of both nucleation and crystallization depend on the structural analogy between the complexes and fragments of the structure of the crystallizing phase prevailing in the solution, Balarew explained a number of phenomena, e.g., the kinetics of nucleation, and the oversaturation ability of the solutions. The classification of the latter according to this characteristic, explains Ostwald's Rule of Stages for the crystallization of metastable phases, throws light on the difference in the sequence of crystallization upon evaporation of the water from multicomponent salt solutions under natural or laboratory conditions, from the sequence required by thermodynamics, and offers explanations for the structure of mineral evaporite deposits.

Again on the basis of Pearson's concept of "hard and soft" Lewis acids and bases, Balarew, together with R. Duhlev, explained the formation of double salts and developed a procedure for predicting their composition and structure, a problem that no one had tackled before them.

A significant contribution of Balarew is his theory of isomorphic and isodimorphic co-crystallization. Balarew's proposed formula for the distribution coefficient of salt 1 and salt 2 between the solid and liquid phases ($D_{2/1}$) during co-crystallization is:

$$D_{2/1} = \left[\frac{M_{1,0}}{M_{2,0}} \right]^2 \cdot \exp \frac{a \cdot f \left(\frac{\Delta R}{R} \right) + b \cdot \varphi(\Delta \epsilon) + c \cdot \psi(\Delta s)}{RT}$$

where M_1 and M_2 are the solubilities of salt 1 and salt 2 in pure water at the corresponding temperature, while

$$a \cdot f\left(\frac{\Delta R}{R}\right) \quad b \cdot \varphi(\Delta \varepsilon) \quad \text{and} \quad c \cdot \psi(\Delta s)$$

take into account the changes in Gibbs free energy that occur during co-crystallization due to changes in the crystal structure, changes in the energies of the metal-ligand bonds, and as a result of the stabilization energy in the crystal field.

In isovalent-isomorphous cocrystallization, the numerator in the exponential term can be assumed to be 0 and the formula simplifies to:

$$D_{2/1} = \left(\frac{M_1}{M_2}\right)^2$$

The numerator in the exponential term represents the change in Gibbs free energy upon transition of component 1 with crystal structure I to crystal structure II (GI→II). Using this formula, Balarew also proposed a method for determining this free energy from experimental data for the distribution coefficient in the immediate vicinity of the eutonic points of the solubility diagrams of the corresponding ternary systems.

The scientific achievements of Christo Balarew are published in over 200 scientific papers, most of which in renowned international journals. Prof. Balarew is also the author of 5 books and monographs and several dozen popular science articles. Balarew's applied research, based on the obtained fundamental results, led to the development of a dozen technologies for obtaining chemical products with reagent purity, for the synthesis of new materials, for the recovery of useful components from natural raw materials and industrial waste products by hydrometallurgical means. He participated in the implementation of over 30 international, European and national projects. He created an Experimental and Production Base in Burgas for the utilization of the chemical resources of the Black Sea, which even today enables chemists to conduct pilot studies for testing and implementing environmentally friendly technologies. He himself has developed technologies and original methods, protected by 19 copyright certificates and 1 patent. During the period 1972-1994, he organized a series (7 in total) of national scientific conferences in Sunny Beach on the utilization of the chemical resources of the Black Sea. In July 2002 in Varna the 10th International IUPAC Symposium on Solubilities with the participation of over 200 scientists from 30 countries from five continents, was held under the chairmanship of Prof. Balarew.

In the field of inorganic chemistry education, Prof. Balarew has left a remarkable trail. He managed to create in his students love for chemistry, taught them honesty and dedication to science. His students at the Chemical-Technical Institute-Burgas, the Chemical-Technical Institute -Sofia, the Plovdiv University and the Faculty of Chemistry of Sofia University defined his lectures as some of the most interesting ones. On the basis of his scientific ideas he has guided the scientific development and growth of 13 successfully defended PhD students. To this day, he pays special attention to the younger generation. To encourage young researchers in their early careers, he established two annual awards - the national award of the Union of Chemists in Bulgaria "Prosperous Young Scientist in the Field of Inorganic Chemistry" and the award of the International Union of Pure and Applied Chemistry (IUPAC) "Young Scientist Working in the Field of Solubility and Equilibrium Data".

For his achievements in the field of science and education, Prof. Balarew has been repeatedly awarded prestigious Bulgarian and foreign awards, including: the honorary badge of the Bulgarian Academy of Sciences, the anniversary medal of the Chemical-Technical Institute-Burgas, the honorary medal "Acad. N.S. Kurnakov" of the Russian Academy of Sciences, the honorary medal of the University of Valladolid, Spain, the honorary badge (1st degree) of the Institute of General and Inorganic Chemistry-BAS, the honorary badge of BAS "Prof. Marin Drinov", a gold badge from the Federation of Scientific and Technical Unions in Bulgaria, the order "St. St. Cyril and Methodius" first degree, the order "St. St. Cyril and Methodius" with a necklace, the title "Honorary Citizen of Sofia", an honorary member of the Union of Chemists in Bulgaria.

The international chemical community celebrated the anniversary of Prof. Christo Balarew with a special article entitled "A Tribute to Christo Balarew" in the IUPAC journal *Chemistry International* and with a special issue of the *Journal of Solution Chemistry* dedicated to the jubilee. The Institute of General and Inorganic Chemistry of the Bulgarian Academy of Sciences celebrated on June 24, 2024 the ninetieth birthday of Prof. Balarew in the crowded hall "Prof. Marin Drinov" of BAS.

Be alive and healthy for many more years, Prof. Balarew! We wish you to realize a lot of new creative ideas!

Laboratory "Salt Systems and Natural Resources - IGIC – BAS