

## Preface



Prof. Guangxian Xu  
(Kwang-hsien Hsu)

Prof. Guangxian Xu (Kwang-hsien Hsu), who was born in Shaoxing City, Zhejiang Province on November 7, 1920, is one of the most famous chemists and educators in China and was elected as a Member of the Chinese Academy of Sciences in 1980. He graduated from Department of Chemistry, Shanghai Jiao-Tong University in 1944, and was engaged as a teaching assistant in his Alma Mater two years later. He went abroad in 1946, won his M.S. in 1949 and Ph.D. in 1951, both at Columbia University, U.S.A., and was elected as a member of Phi Lamda Upsilon and Sigma Xi honorary societies. He and his wife Xiaoxia Gao came back together to China for participating in motherland's construction soon. After his return to China he was appointed as an associate professor in Department of Chemistry, Peking University in May, and as a part time associate professor in Department of Chemistry, Yanjing University in September, 1951. He has served successively as an associate professor and as a professor of chemistry in Department of Chemistry and in Department of Technical Physics, Peking University since the autumn of 1952. He has been appointed successively as Director of Radio-Chemistry Division in Department of Chemistry, as a Vice-Chairman of Department of Technical Physics in charge of the Speciality of Nuclear and Radio-Chemistry, as Director of Inorganic Chemistry Division and Director of Rare Earth Research Center in Department of Chemistry, and as Director of State Key Laboratory of Rare Earth Materials Chemistry and Applications as well as Chairman of the Academic Committee of the same State Key Laboratory. It should be emphasized here that the establishment of State Key Laboratory of Rare Earth Materials Chemistry and Applications in Peking University is mainly due to Prof. Xu's great efforts. Since he began his professional career as an assistant in Shanghai Jiao-Tong University in the autumn of 1946, he has dedicated his life in developing education and science undertakings of motherland for more than 60 years.

Prof. Xu's scientific activity field is broad, involving physical chemistry and inorganic chemistry. He has earned brilliant achievements in quantum chemistry and chemical bonding theory, in coordination chemistry and extraction chemistry, in rare earth chemistry and the cascade theory of countercurrent extraction as well as its applications.

When studying at Columbia University, he majored in quantum chemistry, and minored in physics. After he came back to China, he continued the researches on quantum chemistry and chemical bonding theory. He is one of the



With his wife, Xiaoxia Gao, by the Hudson River, New York

founders and trailblazers in the field of theoretical chemistry in China. As early as the late 1940s, when he studied in U.S.A., he proposed a three-center variational function for hydrogen molecule calculation and got results closer to the experimental dissociation energy than those published by Heitler, London or Coulson. In 1955, he extended this three-center model to express the electronic distribution of chemical bonds such as C—H, C—C, etc., and successfully used it to calculate the molecular optical rotatory power of organic molecules. His results were in best agreement with experiments at that time. His article “Vicinal actions in the theory of optic activity” brought to light the dominant role of the quadrupole moment of molecules. During the period from 1948 to 1950, he was engaged in the study of evaluating quantum molecular integrals, especially the exchange integrals. To his great surprise, he found two very important Ph.D. dissertation papers in 1950: one is Roothaan’s paper on self-consistent LCAO method, and the other is Boy’s paper on replacing STO with linear combination of Gaussian functions as basis functions. He promptly used their results to do *ab initio* calculation of the simplest organic molecule  $\text{CH}_4$ , using a punched card machine at Columbia University. In the 1950s he proposed a simple formula to estimate the relative order of atomic orbital levels for filling electrons, with which the elements could be divided into several groups just corresponding to the individual periods in the periodic table of elements. He also studied and clarified the bonding characteristics of many simple inorganic conjugated molecules systematically, and other subjects. By the end of the 1970s, through improving HMO theory, he derived theoretically sine type expresses for the rule of homologous linearity for the energy of molecular orbitals and related properties, which possess higher accuracy than the other empirical formulas

existent at that time and exhibit more reasonable asymptotic behaviors, thus provide the theoretical basis for other empirical formulas of the rule of homologous linearity to a certain extent. His group coded the first *ab initio* quantum chemical program in China, and carried out quantum chemical calculation studies systematically to some extent. In 1982, he extended his three-center model of chemical bonds in combination with the STO-GTO technique to *ab initio* calculations and got satisfactory results.

In the early 1980s, a great deal of experimental data had been accumulated in rare earth chemistry, but theoretical researches were relatively scarce. Prof. Xu initiated the study on the electronic structure of rare earth compounds in time. He extended the semi-empirical SCF INDO method for the main group and transition elements to deal with the compounds containing lanthanide elements, and an INDO program including the Ln 4f orbitals in the valence shells was established in his group first over the world. Using this program his group extensively studied the electronic structure and bonding of many mono- and poly-nuclear lanthanide complexes, organometallics and clusters, and the characteristics of the electronic structure and bonding of rare earth compounds were gradually clarified. The major conclusion can be summarized as follows. The bonds between the lanthanide and the ligand atoms in these compounds are of polar covalence in nature, particularly in their organometallics, in contrast with the prevailing concept at that time that the bonding was ionic as that in alkaline metal complexes. The contribution to the covalent bonding between the lanthanide and the ligand atoms is mainly from the interaction between the Ln 5d, 6s and 6p orbitals and the ligand orbitals. The Ln 5d orbitals play the main role, while the Ln 4f orbitals are highly localized in space and they contribute only a little to covalent bonding, in contrast with the actinide elements, where the 5f orbitals contribute significantly to chemical bonding. The 4f electrons of lanthanide only influence indirectly the properties of lanthanide compound due to the fact that the excitation  $4f \rightarrow 5d$  is involved in bonding processes, and the electrons in the open 4f shell would affect 5d and other orbitals through spin polarization. On this basis, the general chemical properties of rare earth elements can be rationalized. Their chemical behaviors are closer to transition metals, particularly in the organometallic compounds, whereas unlike those of alkali earth elements comparatively (their d orbitals do not participate bonding basically), and unlike those of actinide elements (their 5f orbitals take part in bonding

actively). He pointed out that the stability of rare earth coordination compounds follows the “extended eighteen electron rule”. He confirmed this conclusion by demonstrating that the coordination number in lanthanide coordination compounds is 8 or 9 through analyzing all existent structural data of the lanthanide coordination compounds with the new viewpoint that he proposed about coordination number counting. His work brings to light the coordination feature of lanthanides, and clarifies the confused opinions about the coordination characteristics of lanthanides. Many Chinese people also used the INDO program mentioned above to study the electronic structure of rare earth compounds, promoting the theoretical researches of chemical bonding in rare earth compounds in China. In the mid 1990s, a program for relativistic and non-relativistic density functional calculations with high accuracy was developed under his supervision in the State Key Laboratory of Rare Earth Materials Chemistry and Applications and has been used to study a series of lanthanide compounds. The results from these calculations not only further confirm the conclusion obtained from the studies by the semi-empirical INDO method, but also bring to light the influence of relativistic effects on the bonding and properties of lanthanides, and elucidate satisfactorily the stability rule of their compounds. These results clarify some uncertain traditional viewpoints, and deepen people’s cognition on the characteristics of electronic structure and bonding of rare earth compounds, thus are quite helpful for understanding the chemical behaviors of lanthanides.

In 1982, Prof. Xu proposed a new definition for atomic covalence and its quantum chemistry definition based on summarizing and analyzing experimental data and quantum chemical calculation results. In scrutinizing the theory of covalence, he found that Pauling’s and Mayer’s definitions of covalence are satisfactory in organic chemistry, but encounter difficulty in inorganic, organometallic and cluster chemistry. For example, what is the covalence of an atom in simple inorganic molecules such as CO, NO, NO<sub>2</sub>, O<sub>3</sub>, FO, etc.? The organometallic compounds and transition metal clusters are usually covalent compounds, then what is the covalence of a metal atom in these compounds, for example, Be(Cp)<sub>2</sub>, Ni(CO)<sub>4</sub>, Fe(Cp)<sub>2</sub>, CH<sub>3</sub>Mn(CO)<sub>5</sub>, etc.? To solve such issues, he proposed a new definition of covalence, which states that the covalence  $V$  of an atom in a molecule is equal to the number of effectively sharing valence electrons it accepts during formation of covalent bonds with the neighboring atoms. It is also equal to the

number of vacancies in the valence electron shells of the atom, i.e.,  $V = 2s - i$ , where  $s$  is the number of valence orbitals, and  $i$  the number of valence electrons. Thus for a dative covalent bond  $A \leftarrow B$ , the covalence of  $A$  is  $V_A = 2$ , because it accepts 2 electrons from the donor atom  $B$ , while that of  $B$  is  $V_B = 0$ , because it accepts no electrons from  $A$ . The bond strength of  $A \leftarrow B$  is equal to  $(V_A + V_B)/2 = 1$ . According to this definition, the covalence of C, N, O, F, Be, Ni, Fe, and Mn atoms in the above-mentioned molecules is 4, 3, 2, 1, 6, 8, 10, and 11, respectively, which are more reasonable comparatively. He proposed the quantum chemistry definition of atomic covalence as  $V_A = \sum_{B \neq A} B_{AB} + Q_A - N_A$ , where  $Q_A$  is the electron population on atom  $A$  in molecule  $AB$ ,  $N_A$  is the number of the valence electrons on atom  $A$  in its free state, and  $B_{AB}$  is the Mayer bond orders between atoms  $A$  and  $B$ . The definition that he proposed solved satisfactorily the problems in Pauling’s and Mayer’s definitions. The universal applicability of the new definition has been confirmed through evaluating and analyzing the calculated atomic covalences in a series of compounds.

In order to make a systematic study of more than 20 millions of molecules synthesized up to the mid 1980s, Prof. Xu claimed that it is helpful in study of the structure of matter to insert two levels, molecular fragments and structural units, between about 100 kinds of atoms and many millions of molecules. The concept of molecular fragments was first proposed by Hoffmann in connection with the famous isolobal principle. Prof. Xu’s contribution is to define the covalence of fragments and to propose a  $[nxc\pi]$  formalism for characterizing the structural type of molecules, where  $n$  is the number of fragments and  $c$  the number of cycles in a compound, and  $x$  is a number specific to the structural type of the compound and can be calculated from the number of valence electrons of the compound, and to propose a structural rule with the formula  $c + \pi = n + 1 - x/2$  to predict the geometric structure and stability of various compounds or clusters. When the formula is satisfied for a molecule, it would be stable generally, otherwise it would lose or gain electrons or change its structural type to become stable. He also proposed a periodical table of molecular fragments, which is quite helpful for predicting new compounds. The above-mentioned structural rule has broad applicability. It not only provides a new method to classify all inorganic and organic molecules, and sets up a bridge to join inorganic and organic chemistry, but

also can be used to predict new molecules and clusters and their possible synthesizing approach, guiding related experiments. Many of the predicted compounds have been synthesized.

In the field of coordination chemistry Prof. Xu is a forerunner in China in the researches of the coordination interaction in solution. In the forefront of the 1950s the coordination chemistry in solution was vigorously developing. He realized keenly that it would become an important branch of inorganic chemistry, and caught the opportunity to initiate the researches in this field in time. Through improving the experimental apparatuses, he improved the accuracy of polarographic and pH titration methods for determination of stability constants by one to two orders of magnitudes, combining with the new method he proposed to treat the experimental data, he obtained more accurate results than others. He determined the stability constants of many weakly coordinated complexes such as those of alkali and alkaline earth metals, earlier than others over the world. Sillen and Martell highly appreciated these determinations and collected the results in their *Handbook of Stability Constants of Complexes*. Based on the similarity between the weak coordination and adsorption equilibria, he proposed an adsorption theory of equilibria of complexes, which is useful to depict processes of weak coordination equilibria in solution. After the 1980s, he extended the research area in the field of coordination chemistry. His group synthesized a series of novel solid coordination compounds, particularly, the multi-nuclear or hetero-nuclear coordination compounds containing rare earths, for example, synthesized firstly a series of tetra-nuclear rare earth coordination compounds containing peroxide radicals with special structure and oxygen-carrier function, and determined the crystal structure as well as carried out spectroscopic studies of these compounds.

In 1957 Prof. Xu was appointed Vice-Chairman of Department of Technical Physics, in charge of the Speciality of Nuclear and Radio-Chemistry. His research emphasis was partly shifted to experimental studies on coordination and extraction chemistry of actinide elements and nuclear fuels. At that time, the separation and purification of nuclear fuels were one of the key problems related to chemistry in nuclear industries. He awakened to the connection between extraction processes and complex equilibria in solution as well as the possibility and merits of using extraction method in separation technology, thus initiated immediately the study on extraction chemistry of nuclear fuels. In that period of time, the extraction chemistry was at



Giving the plenary lecture titled "New concept of atomic covalence" at the IUPAC 16th International Conference of Chemical Education, Bangkok, Thailand, 1992

the primary stage, the classification of extraction systems was quite inconsistent, and the interpretation of extraction mechanisms was very confused too. These situations influenced people to find out the regularity of extraction processes. He realized that correct classification of extraction systems would promote the development of extraction theory. Based on the experimental data of more than ten thousand different extraction systems collected from the literature and analyzing the extraction mechanism of some typical examples, he proposed a new classification of extraction systems according to their extraction mechanism in 1962. In his classification, not only the properties of the extracting agents were considered, but also the properties of the complexes formed in the extraction processes were taken into account. He classified extraction systems into 6 classes, that is, simple molecular extraction (D), neutral ligand coordination extraction (B), chelation extraction (A), ionic association extraction (C), synergistic extraction and high temperature extraction. The synergistic extraction was further classified into several types such as  $A+B$ ,  $A+C$ ,  $A+B+C$ ,  $A+A'+B$ , and  $A+B+B'$ . On the basis of correct classification, he studied a series of different extraction systems in a deep going way, clarified the extraction mechanism of many typical systems, and achieved several general rules about extraction processes. He also studied a series of synergistic extraction processes, and found a few regularities, which could be applied to predict and elucidate synergistic extraction phenomena. His classification is now extensively used in solvent extraction chemistry.

In the 1960s, the study of extraction mechanism was mainly through determination of equilibrium constants of

extraction processes and related thermodynamic function. He proposed several improved and new methods for determining the constants of complex equilibria in solution and extraction equilibria, and used them to determine the stability constants of many complexes and the extraction equilibrium constants of a lot of important extraction or synergistic extraction systems in nuclear fuel chemistry. For example, the two-phase titration method proposed by Jensen to study extraction equilibria was improved, and was used to study the mechanism of chelation extraction as well as the mechanism of chelation and neutral coordination synergistic extraction, and to determine, accurately and efficiently, the constants of complex or synergistic extraction equilibria. He also improved the method to determine the equilibrium constants of neutral extraction systems.

The microscopic structure of extracted complexes has to be known for deeper clarifying the extraction mechanism. Since the 1980s, Prof. Xu has carried out systematically structural chemical studies on extracted complexes, and has determined the crystal structure of a series of typical extracted coordination compounds. Based on structural data, in combination with extraction data and synergistic extraction phase diagrams, he has obtained the direct proofs of the mechanism of many extraction and synergistic extraction processes.

When Prof. Xu performed the mini-scale technological test to produce high purity yttrium oxide by extraction separation with naphthenic acid, it was found that the organic phase kept clear and transparent, even though its volume had increased by 20%. Further study showed that the organic phase was a kind of microemulsion of water in oil type (w/o) instead of some kind of true solution containing water. The size of particles of microemulsion is about 100 nm of magnitudes, and they do not scatter light, and thus the appearance of solution is clear and transparent. It is the first time that there is microemulsion formation in the extraction process of some systems was proposed. More extraction systems with microemulsion formation were found later. It was also found that the microemulsion of oil in water type (o/w) may form in the water phase in some extraction systems, which brought to light another way of extracting agent losing through water phase, and resulted in a scheme proposed to improve the extraction separation technology. It has been demonstrated by means of various spectroscopic techniques that the essence of microemulsion formation is hydration of the polar groups in extracting agents, and the microquantity water in microemulsion or

inverse micelles possesses special structure and property of super concentrated water solution. The study on microemulsion has gradually attracted more people's attention only after 1988. Now it has become a hot research topic in extraction chemistry.

A part of Prof. Xu's important harvests in the field of extraction chemistry has been summarized in two monographs *Principle of Extraction Chemistry* and *Solvent Extraction of Rare Earths*. His researches in the field of extraction chemistry have pushed the development of this discipline in China. He is the exploiter and guide.

In 1972, Prof. Xu returned to work in Department of Chemistry, Peking University, his research field was shifted to rare earths and their extraction chemistry. China is richly endorsed with rare earth resources. Fifteen lanthanide elements, except Pm, usually coexist with Sc and Y in nature. They are called rare earth (RE) elements. Their chemical properties are very similar; therefore, it is quite difficult to separate them by extraction techniques to individual elements in high purity. Especially, the composition of RE elements in natural ores is very diversified, and the abundance of some elements, such as Eu, Tb, Dy, Ho, Er, Sc, etc., is very low, but they are very valuable, and should be recovered in very high purity (over 99.9%) with high yield (greater than 99%). It is a great challenge for chemists to establish a theory and technique to meet this demand.

The first mission he was assigned was to separate praseodymium (Pr) and neodymium (Nd). In Latin, praseodymium means 'the green twin'; neodymium 'the new twin'. They were the most inseparable 'twins' by extraction at that time. They were separated by the ionexchange method, which is much more expensive in cost.

The separation factor between Pr and Nd,  $\beta(\text{Pr/Nd})$ , in most extractant systems is less than 2. Bauer in the US Bureau of Mines invented a "pull-push system" to increase  $\beta(\text{Pr/Nd})$  to near 4, but failed to use it in a counter-current extraction system of 20 stages to separate a mixture of Pr/Nd, thus considered it useless for multistage extraction to get pure products.

However, Prof. Xu found that a pull-push system with  $\beta(\text{Pr/Nd}) = 5.8$  could be composed by using quarternary amine N263 plus dimethylbenzene as the extractant and diethylene-triamine-pentacetic acid (DTPA) as the complexing agent. More importantly, he found that when the RE loaded extractant was used as the organic phase the multistage counter-current extraction could be realized in this system, and succeeded in getting pure products. In

September 1974, in an industrial test to treat the Pr-Nd and other RE concentrates with 80 stages of mixers and settlers, the following products, 99.4%–99.6% Nd, 99.0%–99.4% Pr, 99.4%–99.8% La and more than 50% Sm and higher RE elements, were successfully obtained. It is the first time that multistage counter-current extraction in a pull-push system for rare earth separation was realized. In 1980, he attended an International Solvent Extraction Conference (ISEC) held in Belgium and presented the result of separation of Pr and Nd in 99.9% purity, which attracted many participants' attention, particularly the scientists of Rhodia, the most famous RE separation enterprise in the world.

In this series of experiments, Prof. Xu found that the concentrations of the mixed RE in various stages of both phases are constant, therefore he proposed a new concept of "mixed extraction factor  $E_M$ ", which equals the product of the ratio of concentrations of the mixed RE in both phases and the phase ratio. He used two hypotheses of "constant  $E_M$  in various stages of the extraction section and constant  $E_M$  in stripping section" with constant separation factor  $\beta(A/B)$  to replace the hypothesis of constant extraction factor of individual elements  $E_A, E_B$  in Alder's book *Liquid-liquid Extraction Theory* and established a new "Cascade Theory of Counter-current Extraction". Extensive experimental tests of the hypothesis showed that the constancy of  $E_M$  is much better than the constancy of  $E_A, E_B$  in most acid and amine extractant systems without using a complex agent in the aqueous solution. Another but the most important advantage of the new theory is that  $E_M$  can be related to the ratios of flow rates of the feed/extractant/stripping solutions, thus making the latter calculable by the new theory, while Alder's theory has no formula to calculate these parameters, which have to be determined by a tedious time-consuming "shaking funnels" method. He proposed a logarithm purity diagram method to calculate the stage number, and further converted it to an analytical formula giving the number of stages.

Later, Prof. Xu and his coworkers further established a model to simulate the tedious "funnel shaking" experiments by a computing method for the dynamic equilibrium of the multi-components counter-current extraction system, and worked out a "One-step Enlargement Expert System". When someone wants to establish a new RE extraction separation factory, he just needs to offer the composition of the raw material and the purities and yields of the products he required, the "Expert System" will provide him all the

optimized parameters within a week.

This theory and the Expert System have been widely used in the rare earth separation enterprises of China in the last two decades with great successes, lowering the cost significantly, rendering the RE separation factories in Japan and US closed, Rhodia in Europe reducing 90% of their production. Since 1995, China has held over 90% share of the total world production and foreign trade of individual RE products in high purity. This situation has brought a great shake on the world RE industries and is known as "China Impact".

Prof. Xu always pays attention to exploiting continually new research field along with the development of the discipline. In recent years he has continued to guide his assistants and students to carry out systematical studies in the field of functional materials chemistry and bioinorganic chemistry related to rare earths, and important results have been achieved.

In scientific practice of many years, Prof. Xu has established the guiding thought of himself for scientific researches. He always has national aims in mind and keeps a close watch on the developing trend of disciplines, and combines these two aspects cleverly and neatly to promote development of disciplines and to solve important problems to the country at the same time. He thinks that the basic researches should have middle and long-range applied prospects for winning the support from society to get strong vitality, while the applied researches need the results from basic researches as supporters in order to surpass others in competition, entering into the advanced range in the world. Basic and applied researches can be combined together, developing in parallel and promoting each other. He always pays attention to and is good at joining the theory and experiment, analyzing experimental data to find regularities and to abstract theoretical problems to study, and bringing the theoretical guidance into play in experimental exploration.

In the past years, Prof. Xu has published more than 500 reviewed articles in the fields of quantum chemistry and chemical bond theory, coordination chemistry and extraction chemistry, rare earth chemistry, cascade counter-current extraction theory and its applications, and two monographs. Besides, he has compiled a comprehensive reference book of rare earth science and technology (in three volumes) and three proceedings of international rare earths conferences (in two volumes for each) in 1985, 1991 and 1995 as editor-in-chief. He has won many distin-

gished scientific awards due to outstanding achievements in scientific researches, particularly, the achievements on the rare earth cascade counter-current extraction separation theory and its industrial practice as well as its extended application, which have played very important role in realization of the development of Chinese rare earth separation industry with a leaping over mode, such as National Science Congress Award (1978), National Natural Science Awards (1987, 1987), National Science and Technology Progress Awards (1991, 1999), Ho-Leung-Ho-Lee (HLHL) Foundation Science Progress Award (1994) and the HLHL Science Achievement Award (2005), particularly, the State Top Scientific and Technological Awards (2008).

Prof. Xu has distinguished contribution to Chinese education undertakings. Soon after his return in 1951, he taught the course *quantum chemistry* for postgraduate students at Yanjing University for the first time in China. Since then he has taught a series of courses for undergraduate and/or postgraduate students, such as *physical chemistry*, *structure of matter*, *statistical mechanics*, *introduction to nuclear physics*, *molecular spectroscopy*, *quantum chemistry*, as well as *coordination chemistry*, *extraction chemistry*, *nuclear fuel chemistry*, *advanced inorganic chemistry*, and others, at Peking University. In particular, the undergraduate course *structure of matter*, which he began to teach at Peking University in 1952, consists of chapters on introduction to quantum chemistry, the nature of chemical bonds, molecular spectroscopy and other experimental methods of structural chemistry, etc. Based on his lecture notes, he published a textbook *Structure of Matter* in 1959, which was deeply welcome by numerous teachers and students, and designated as a standard textbook of Chinese universities by the national education administration, and used by nearly all chemistry departments of Chinese universities for more than a quarter of a century. This book was reprinted many times up to over 200,000 copies. In 1988 this book was awarded a Supreme Class Prize of Excellent Textbooks by the State Educational Commission, which is the only one awarded so far among all chemistry textbooks. In the 1980s, based on the lecture notes of the postgraduate course *quantum chemistry*, a three-volume monograph *Quantum Chemistry: Fundamental Principles and Ab Initio Methods* was published, which has also been reprinted, and has won good evaluations from many readers. These books have been invited to publish the revised second edition (2007–2009).

Prof. Xu supervised the first postgraduate student in

quantum chemistry during the period from 1951 to 1954. Since then he has supervised 99 postgraduate students and many visiting scholars doing researches in the field of theoretical chemistry and inorganic chemistry. His students are found all over China, and among them many have become outstanding academic leaders or backbones in universities, institutes and industrial enterprises in China. When he worked in Department of Technical Physics as Vice-Chairman in charge of the Speciality of Nuclear and Radio-Chemistry, many distinguished scientists and academic leaders in nuclear fuel extraction and radio-chemistry in China were educated in the 1950s and 1960s at Peking University. He also went to institutions of scientific researches and industrial bases to give classes, training many high-level engineers and technicians. As a teacher, he not only actively imparts students with experience of pursuing one's studies, and encourages them to explore assiduously and innovate boldly, but also pays attention to moral education, particularly to cultivate students' spirit dedicating to the nation and society.



Having a discussion with his students in the laboratory

Prof. Xu has been active in both international and domestic academic activities. He was the Director of the Division of Chemistry, the National Natural Science Foundation of China (1986–1994), the President of the Chinese Chemical Society (1986–1990), the Chairman of the Federation of Asian Chemical Societies (1989–1995), and the Vice-President (1980–1999) and Honorary Vice-President (1999–) of the Chinese Rare Earth Society. During his term of office, he organized a series of international and domestic academic activities, for example, he was the Chairman of the 25th IUPAC International Coordination Chemistry Conference (1987), the Chairman of the 4th Congress of Asian Chemical Societies (1991), the

Vice-Chairman of the 1st, 2nd and 3rd International Conference of Rare Earth Science, Technology and Applications (1985, 1991, 1995), and so on. He was a member of the International Editorial Board of the International Journal of Quantum Chemistry (1982–1990), Lanthanides and Actinides Research (1991–1995), and has served as the Editor-in-Chief or Vice Editor-in-Chief of many domestic scientific journals, for example, *Chinese Journal of Rare Earths*, *Journal of the Chinese Rare Earth Society*, *Journal of Molecular Science*, *Science in China*, *Chinese Science Bulletin*, *Chemical Journal of Chinese Universities*, *Chemical Research in Chinese Universities*, *Chinese Journal of Inorganic Chemistry*, and so on, for more than two decades, and now he is still serving as the Editor-in-Chief of *Chinese Journal of Rare Earths* and *Journal of the Chinese*

*Rare Earth Society*.

Prof. Xu has diligently served people for more than 60 years. He has made great contributions to China. Many people are impressed by his spirit of keeping forging ahead and keeping on fighting in spite of all setbacks, his working attitude of diligence, assiduity and never slacking, as well as his distingue style of condescension, pure-heartedness, and finding it pleasure to help others. He is strict with himself and broad-minded towards others, cultivates ardently young generation, guides and supports juniors. Thus he is deeply loved and esteemed by many teachers and students as well as colleagues in chemical circles.

This special issue is respectfully dedicated to Prof. Xu in honor of his 90th birthday to glorify his brilliant contribution to society and the country. We sincerely wish him living in longevity with good health.

*Lemin Li*

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