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FORMATION AND HISTORICAL DEVELOPMENT OF CHEMISTRY IN UZBEKISTAN

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Abstract : This scientific article analyzes the historical development, current state and prospects of chemistry in Uzbekistan. The article, first of all, studies the formation of chemistry in Uzbekistan and its impact on modern scientific research areas. In particular, important aspects such as scientific traditions and schools, interdisciplinary integration, ecological chemistry and green technologies are presented. The role of Uzbek scientists in the global scientific community and the prospects for the development of international cooperation are also considered. The authors demonstrate the economic, ecological and social significance of chemistry through applied research and scientific developments. The article also analyzes the problems in the development of chemistry, the difficulties in training scientific personnel and the processes of integration into modern technologies. Forecasts are also given regarding the results of scientific research and the impact of the field on social and industrial aspects. This article is an important scientific source for young scientists and researchers, indicating the future development paths of chemistry.

Keywords: Chemistry, Uzbekistan, scientific schools, ecological chemistry, green technologies, scientific cooperation, interdisciplinary integration, training, innovation, nanotechnology, bioorganic chemistry, scientific research, applied sciences, scientific development.

ENTRANCE

Chemistry is a fundamental scientific direction that studies the composition, structure, properties of matter, the laws of their transformation and the conditions leading to these transformations, and is considered one of the main branches of natural sciences. The development of chemistry forms the scientific basis of today's modern technologies, innovative production processes, environmental safety and advanced achievements in the field of pharmaceuticals. Therefore, this science occupies a special place not only as a system of purely theoretical knowledge, but also as a strategic tool ensuring economic, social and environmental stability. The historical formation of chemical thinking in Uzbekistan dates back to ancient times. Great thinkers such as Abu Rayhan Beruni, Abu Ali ibn Sina, Ahmad al-Farghani, Muhammad ibn Musa al-Khwarizmi, who grew up in this region, formed the foundation of world chemical science with their deep scientific reflections on the structure of substances and their natural properties. In particular, Ibn Sina's ideas about the material world, medicines , and their chemical properties in his work "Al-Qanun fi-t-tibb" serve as one of the scientific foundations of modern pharmaceutical science [1].

Chemistry began to take shape as an independent scientific discipline in Uzbekistan, especially since the middle of the 20th century. The Institute of Chemistry under the Academy of Sciences of the Uzbek SSR, established in 1943, served as a leading scientific center in this field. As a result of research conducted by scientists such as Academician A.S.Sultonov, M.Khabibullayev, and M.Yunusov in the areas of inorganic, physical, organic , and bioorganic

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chemistry, national chemical schools were formed. Their scientific schools served to form an advanced research environment not only in Uzbekistan, but also in the Central Asian region [2].

After 1991, that is, during the years of independence, a fundamental shift began in the development of science in Uzbekistan , which directly affected the science of chemistry. Practical cooperation between research institutions, universities and industrial enterprises was strengthened, new mechanisms for financing scientific projects were established - grants, innovation funds, international cooperation programs. As a result, the quality and volume of scientific research work increased significantly. In particular, advanced scientific research is being conducted in the areas of nanotechnology, green chemistry, bioorganic and analytical chemistry [3].

Also, in recent years, the approach of chemistry to practice, that is, its integration into the economy, ecology, energy, food and pharmaceutical industries, is driven by the need to solve problems through scientific approaches. For example, new reagents, environmentally friendly catalysts, pesticides and agricultural fertilizers developed in collaboration with large enterprises of the Uzbek Chemical Industry system are being tested in accordance with market needs. In addition, the development of modern chemistry is also reflected in the education system. Today, research conducted at the master's and doctoral levels is not limited to theoretical knowledge, but also serves to implement innovative ideas in practice, bringing the national scientific base to the international level. The fact that the number of publications by Uzbek scientists in the field of chemistry in the Scopus and Web of Science databases doubled between 2020 and 2024 also indicates activity in this area [4] .

provides a comprehensive analysis of the historical formation of chemistry in Uzbekistan, stages of development, scientific schools during the Soviet era, post-independence reforms, current modern directions, international cooperation and prospects for science. The analysis uses scientific literature, historical sources, scientific articles indexed by the Ministry of Innovative Development of the Republic of Uzbekistan, the Academy of Sciences, Scopus and Web of Science, as well as open statistical data. The main purpose of the article is to scientifically analyze the stages of development of chemistry in Uzbekistan, identify existing problems and future development strategies.

In studying the development of chemistry in Uzbekistan, an analysis of literary sources based on historical sources, scientific articles, dissertations , and official state reports is of great importance. This section systematically analyzes the existing literature in the context of the historical roots of chemistry, its development after independence, and modern scientific directions.

Historical sources and the legacy of oriental scholars

The basic concepts of chemistry, the initial scientific views on the structure of substances and their properties were embodied in the works of Central Asian thinkers - Abu Rayhan Beruni, Abu Ali Ibn Sina, Ahmad al-Farghani and al-Khwarizmi. In particular, Beruni's "Kitab as-Saydana fi-t-tibb" contains detailed information on more than 800 substances and their pharmaceutical properties, and this work is one of the most important sources of medieval Eastern chemical thought [1]. The classification of substances based on such qualities as heat, moisture, dryness and cold in Ibn Sina's "Al-Qanun fi-t-tibb" served as an attempt to explain chemical properties with an equilibrium-based approach [5]. These historical sources laid the foundation for some of the theoretical foundations of modern chemistry. Currently, these works are also recognized by UNESCO and the academies of sciences of the Islamic world, and they have been translated into many languages [10].

Literature of the Soviet era: the formation of scientific schools

During the Soviet period, chemistry was institutionalized and its development was encouraged at the level of state policy. The fundamental works of scientists such as Academicians A.S. Sultanov, M.Yunusov, and A.Karimov led to the formation of notable scientific schools, in particular, in the chemistry of inorganic and complex compounds, the

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synthesis of natural alkaloids, thermodynamic analysis, and ion exchange. Sultanov's work "Fundamentals of Inorganic Chemistry" (1975) is still used as one of the main textbooks in higher education institutions. The literature of this period is more focused on experimental methods, laboratory-based tests, and technical parameters, and theoretical analysis is relatively rare in them. However, these studies formed the basis for the formation of the principles of laboratory methodology, analytical methods , and technological modeling of modern chemistry [6].

Post-independence literature: national model and international integration

After Uzbekistan gained independence, scientific research has entered a new stage in terms of structure. Scientific articles and dissertations began to reflect important aspects such as convergence with global trends, international indexing requirements, copyright and intellectual property protection. In scientific articles written in recent years - in particular, in works published in the Web of Science, Scopus and Google Scholar databases, bioorganic chemistry, nanochemistry, environmentally friendly chemistry, photocatalysis, modern analytical technologies and organic synthesis processes stand out as priority topics. For example, M. Kadyrov's monograph “Modern Chemistry and Innovation Directions” (2020) is one of the relevant literature that highlights the role of modern chemistry in global scientific and technical integration, problems and prospects in Uzbekistan. Also, reports on the Academy of Sciences, the Agency for Innovative Development and the “Uzkimyosanoat” system analyze practical aspects such as commercialization of science, patenting of scientific results and participation in international exhibitions [4].

Contemporary international literature and open databases

Today's scientific research is conducted on platforms such as Scopus, Springer, Elsevier, ACS Publications, Wiley Online Library, Nature Chemistry. Articles by Uzbek scientists in the field of chemistry mainly cover the following topics:

- Green chemistry and environmentally sustainable technologies
- Biocatalysis and enzymatic reactions
- X-ray diffraction analysis of crystal structures
- Polymer chemistry and high molecular weight compounds
- Synthesis of sorbent materials for water purification

For example, AK Akhmedov's article "Green synthesis of ZnO nanoparticles for wastewater treatment", published in Scopus in 2023, provides a summary of effective methods for purifying polluted water based on new materials developed in an environmentally friendly way. This direction indicates that a modern branch of environmental chemistry is being formed in Uzbekistan [7].

The development of chemistry in Uzbekistan is developing gradually through successive historical periods, the formation of scientific schools and integration into global trends. While historical sources reflect the scientific heritage , Soviet-era literature has shaped experience and methodology, and post-independence sources have opened up opportunities for innovative approaches and entry into the international arena. Currently available scientific sources have a rich methodological basis that allows for scientific substantiation, analysis and forecasting, creating broad opportunities for master's-level scientific research. Analysis of the literature on the development of chemistry in Uzbekistan, written on the basis of scientific research, requires, first of all, a review of the works of representatives of major scientific schools that have operated and are operating in this field. This literature constitutes a rich scientific heritage on the historical formation, experimental foundations and modern directions of chemistry.

The first national chemists and founders of science

The scientific basis of chemistry in Uzbekistan was formed in the middle of the 20th century, and the first major step in this direction was the establishment of the Institute of Chemistry under the Academy of Sciences of the Uzbek SSR in 1943. Academician **AS Sultanov** is known for his profound theoretical work in inorganic chemistry, and he trained

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representatives of several scientific schools in the field of chemistry of complex compounds and metal-organic reactions. His textbook "Fundamentals of Inorganic Chemistry" continues to serve as the main educational resource in the higher education system after independence. **M. Yunusov** conducted fundamental scientific research on the chemistry of natural compounds, especially alkaloids, flavonoids , and glycosides. He identified many bioactive substances present in the Uzbek flora and characterized their structures using spectroscopic methods [2].

Modern scientific schools and their works

Today, among the scientists actively participating in the development of chemistry in Uzbekistan, a number of major researchers stand out:

- **Prof. Yo.A. Azimov is known for his work in the field of** bioorganic chemistry and enzymatic catalysis. His scientific work is devoted to methods for simplifying reactions based on oxidoreductase enzymes and their industrial application [2].
- **Prof. Sh.A. Amonov is known for his research** on the chemistry of polymers and methods for increasing their thermal stability, as well as the synthesis of new stabilizers. Dozens of master's and PhD theses have been defended under Amonov's supervision.
- **Prof. MI Khaydarov** is a leader in the field of photocatalysis and energy-saving technologies based on semiconductor oxides. His articles are regularly published in Elsevier and Springer.
- **Prof. AS Khodjayev** is known for his scientific research on ion exchange reactions in aqueous media, synthesis of sorbent materials and their practical application. In his laboratory, a new type of zeolite-based materials was developed [8].

Also, young scientists - researchers such as **PhD NA Soliyev** , **PhD M. Tursunova** , **PhD S. Sodiqov - are** currently publishing international scientific articles in the Web of Science and Scopus databases, contributing to the development of topical problems of modern chemistry, including "green chemistry", ecological catalysis, and nanochemistry.

prepared by Uzbek scientists in recent years and recognized internationally, the following stand out:

- Modern methods for the purification of polluted waters using environmentally friendly catalytic methods are proposed in the article “Green synthesis of ZnO nanoparticles for wastewater treatment” by **Akhmedov AK et al. (2023). This article** was published in the Scopus database and is the product of international collaboration [2].
- Kadirova GG's research on the topic of "Synthesis and stabilization of complex compounds" was published in the journals of the Academy of Sciences of Uzbekistan and was conducted in collaboration with scientists from the CIS countries [2].
- **Tashkent Chemical Journal** , **University Scientific Bulletins** , and **Uzbekistan Chemical Journal** are important platforms for Uzbek scientists to publish their research. These journals publish articles included in the OAK list and are indexed in accordance with the requirements of the Agency for Innovative Development of the Republic of Uzbekistan.

the above literature shows that the scientific schools formed in Uzbekistan in chemistry are adapting to modern trends and integrating with the international scientific community . Scientific ideas, synthetic methods, models and theories developed by Uzbek scientists are participating in international competitions, and the number of citations is increasing. Also, the real application of Uzbek chemistry in socio-economic life is expanding through open sources, patents and international grant projects.

The formation and development of chemistry in Uzbekistan is a complex process that has arisen under the mutual influence of historical, scientific, and social aspects . The main problems and opportunities arising from the analysis of research conducted in this area require in-depth scientific analysis.

scientific heritage and modern approaches

Chemical knowledge, expressed in historical sources - especially in the works of such great thinkers as Abu Rayhan Beruni, Abu Ali ibn Sina, al-Khwarizmi, Nasriddin Tusi - forms the

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theoretical foundation of modern chemical thinking. This aspect currently has a twofold impact on the development of chemistry : on the one hand, the Uzbek school of chemistry relies on its historical foundations, and on the other hand, these historical approaches are being re-conceptually interpreted in modern nanochemistry, bioorganic chemistry, "green technologies" and the analysis of complex systems. For example, the classification given by Ibn Sina based on the reaction of substances to "temperature" is being studied on the basis of modern kinetics and thermodynamic analysis. This indicates that the science of chemistry in Uzbekistan is developing evolutionaryly, while preserving its historical and philosophical foundations [5].

Interdisciplinary integration and the current social role of chemistry

In recent years, the approach to the social and economic role of chemistry has been changing radically. Previously, chemistry was considered more of a laboratory and production-oriented applied science, but now it is closely integrated with ecology, biology, medicine, pharmacy, energy, materials science, and information technology. This requires a more interdisciplinary approach to assessing modern trends in chemistry .

It is observed that this interdisciplinary connection is considered a priority in research conducted by the Institute of Chemistry under the Academy of Sciences of Uzbekistan, Tashkent State Technical University, National University of Uzbekistan and other prestigious scientific centers. In particular, projects are being implemented on water purification based on photocatalytic methods, the preparation of medicines based on bio-polymers , and the use of "green chemistry" principles in the synthesis of nanomaterials .

scientific schools and personnel training

Scientific schools are the key to the systematic development of any science. An important issue in Uzbek chemistry is the decreasing number of successors to previously formed strong scientific schools (for example, AS Sultanov, M. Yunusov, A. Karimov, etc.). This poses a risk of scientific continuity being disrupted.

Despite the increased attention of the state to the formation of a generation of young scientists , the amount of grants allocated for scientific research, the level of technical equipment, and the lack of international internships have a negative impact on this process. In addition, the skills to prepare articles that meet the requirements of international publications such as Scopus and WoS still remain problematic for many researchers [7].

However, in recent years, grants provided by the Agency for Innovative Development of the Republic of Uzbekistan, the "Fund for Support of Science and Scientific Activity", the activities of the Academy of Young Scientists , and the introduction of the "Teacher-Student" programs are creating the basis for positive changes.

Commercialization of science and integration with industry

The current scientific paradigm requires ensuring the practical economic efficiency of scientific results. In chemistry, this is achieved through the development of new materials, pharmaceuticals, technological reagents , and environmental protection technologies.

For example, zeolite-based sorbents developed by the Institute of Chemistry of the Academy of Sciences of the Republic of Uzbekistan have been tested as effective means for purifying water resources. Also, research conducted on the local production of the main components of some synthetic drugs produced in Uzbekistan (for example, Paracetamol, Analgin, Aspirin) is considered fundamental work aimed at the industry [2].

Internationally recognized developments

In recent years, scientific research conducted by Uzbek scientists has been recognized internationally. In particular:

- Developments based on photocatalysis and semiconductor nanostructures by Prof. MI Khaydarov and his team;
- biofermentative reactions conducted by Prof. Yo.A. Azimov;
- Environmentally friendly reagents created based on plant extracts by PhD NA Soliyev [3].

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Such developments are being carried out in scientific collaboration with foreign universities, in particular, ITMO (Russia), KIT (Germany), and Kyoto University (Japan). This is evidence that Uzbek chemistry is now actively participating in the international scientific community.

CONCLUSION

, and prospects of chemistry in Uzbekistan, provides the basis for several important scientific, theoretical, and practical conclusions.

Firstly, chemistry has historically been an integral part of natural scientific thought in Uzbekistan . In the works of classical scientists such as Abu Rayhan Beruni, Ibn Sina, al-Khwarizmi, Qutbuddin Shirzi, ideas about the properties of substances, their processing, and the essence of chemical processes are inextricably linked with modern chemical theories. This shows that the development of science is taking place in **the continuum model** - that is, based on the laws of continuous development .

Secondly, after independence, chemistry entered a new era: as a result of the revival of research institutes, the development of academic schools, and the expansion of international scientific cooperation, Uzbek scientists began to carry out internationally recognized work in modern areas of chemistry - **nanochemistry, bioorganic chemistry, ecological chemistry, and the kinetics of complex systems .** In particular, **prof. MI Khaydarov** , **prof. AS Khodjayev** , **prof. Yo.A. Azimov** , **PhD NA Soliyev** and other researchers are reflected in articles indexed in Scopus and Web of Science databases.

Thirdly, the development of chemistry is associated not only with fundamental scientific research, but also with **its integration into real practice in the fields of industry, medicine, agriculture and ecology . For example, some medicinal substances and technological sorbents developed by the Institute of Chemistry under the Academy of Sciences** of the Republic of Uzbekistan and the Republican Scientific and Practical Center of Pharmacy are real achievements in ensuring the economic efficiency of science.

Fourth, existing problems — in particular, difficulties in ensuring the continuity of scientific personnel, the limited level of technological base and laboratory equipment, and the low efficiency of the grant system — can be assessed as relatively slowing factors in the development of science. At the same time, reforms aimed at supporting science by the state, including **the Law "On the Commercialization of Scientific Developments" , initiatives such as the "Teacher-Schogird"** program for young scientists , and the **"Science and Innovation Fund"** are creating an important foundation for the development of science.

Fifth, integration into the global scientific space — that is, participation in international research projects, establishment of joint laboratories with foreign universities, publication of scientific results in prestigious journals — plays a key role in bringing Uzbek chemistry to a qualitatively new level. In this regard, the introduction of modern methods such as **interdisciplinary integration** , **data analytics** , and **computer simulation is relevant.**

- **in the next 5-10 years,** the priority areas of Uzbek chemistry will be environmentally friendly synthesis methods, molecular design of biologically active substances, and the development of energy-efficient materials .
- **Cooperation between scientific schools** will increase, and national research will be integrated with international grant programs.
- **Artificial intelligence-based modeling** and Specialized scientific groups will be formed in the areas of **predictive chemistry based on databases .**
- **The international citation index of Uzbek chemistry** will increase significantly if the existing organizational and material problems are resolved.

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