

OPINION

according to the competition of the Institute of Engineering Chemistry at BAS - Sofia for a professor in a professional field 4.2. Chemical sciences (Processes and devices in chemical and biochemical technology) for the needs of the laboratory "Transfer processes in multiphase media", promulgated in the State Gazette no. 66/16.10.2022 with candidate Assoc. Dr. Maxim Ivanov Boyanov from the same institute

Prepared the opinion: Prof. Dr. Veneta Ivanova Groudeva, University of Sofia, Faculty of Biology, Department of General and Industrial Microbiology, retired

1. Brief biographical data about the candidate.

Maxim Ivanov Boyanov was born in 1973. He began his secondary education at 114 AEG - Sofia and graduated from the "Marie Curie" High School in the city of Chicago. In 1990, he began his studies as a physics student at the Illinois Institute of Technology. He completed his higher education in 1999 at Sofia University, Faculty of Physics, specializing in solid state physics.

From January 1997 to March 2003, he was a graduate student at the University of Notre Dame, Indiana in the Department of Solid State Physics and Microelectronics. He defended his doctoral dissertation (PhD) in 2003. In the period 03.2003 – 04.2006 he was a post-doctoral fellow at the Institute of Environmental Studies, Argonne National Research Laboratory, Illinois, where he worked on adsorption, reduction-oxidation processes, and X-ray spectroscopy of solvated U and Fe to surfaces of metal oxides and polymer microspheres and determination of the elemental composition of single biological cells by X-ray micro spectroscopy. From 04.2006 to 04.2006 he specialized in the Institute of Molecular Ecology and where he studied the adsorption of solvated Cd to cell surfaces by X-ray spectroscopy. From 03.2007 to 06.2007 he was a physicist at the Laboratory of Engineering Chemical Physics, Faculty of Chemistry, Sofia University, and from 07.2007 to 12.2008 - assistant professor in the Department of Solid State Physics and Microelectronics, Faculty of Physics, Sofia University. From 02.2014 to 01.2015 he was chief assistant in the Laboratory of Transport Processes in Multiphase Media, Institute of Engineering Chemistry, BAS, Sofia. In 01.2015 he was elected as an associate professor, Laboratory of Transfer Processes in Multiphase Environments at the same institute where he currently works

2. General characteristics of the research and applied activity of the candidate

The candidate's scientific research activity is related to studies of chemical and biological transformations of various metal ions in soils and waters and opportunities to apply technologies to clean ecosystems polluted with these metals. The scientific research activity of the candidate has a decidedly fundamental nature with serious contributions to science in the fields of physics, chemistry, microbiology, biogeochemistry. At the same time, however, this fundamental research represents a real potential for the development of technologies for the removal of metal pollution in soils and waters, as the applicant has also been doing. He managed and participated in 4 national projects, 3 international, was the supervisor of two doctoral students, has active expert activity, participation in a large number of scientific seminars, reviewer of more than 200 articles in renowned journals, member of editorial boards and others.

3. Evaluation of the presented materials

To participate in the competition for professor the candidate submits a book chapter and 25 scientific publications. The book "Redox Processes Affecting the Speciation of Technetium, Uranium, Neptunium, and Plutonium in Aquatic and Terrestrial Environments", of which the candidate is a co-author, is of a high scientific level and is of interest to students, doctoral students and scientists working in the field of molecular biogeochemistry and environmental pollution.

The 25 publications presented are in renowned scientific journals with a high impact factor, 17 of them published in Q1 journals. The citations of the papers are 765 in scientific publications and 242 in dissertations and others. The candidate has supervised two PhDs, worked on several national and international projects, with the total amount of funds received in ICT exceeding BGN 2,000,000.

It is obvious that the applicant fully meets the minimum state requirements under the law for the developed of the academic staff as well as the additional requirements of the ICT and exceeds them to a considerable extent. The presented materials are in good condition and meet the requirements

4. Basic scientific and scientific-applied contributions.

The scientific research work of the candidate for professorship is a continuation of the direction started 25 years ago, namely chemical and biological transformations of various metal ions in soils and waters and possibilities of applying technologies for cleaning up ecosystems polluted with these metals.

The analysis of the candidate's scientific output shows that a significant part of his research activity is related to research on transformations (physical and biological) of uranium in soils and subsoil and technologies for removal of uranium in contaminated ecosystems (papers No No: 2,10, 13,15,16, 18,20,22 from the list for participation in the competition). Another important direction of the candidate's scientific activity is related to transformations of other elements, representing a danger of environmental pollution. (papers 1,4,5,6, 11,14, 3, 9, 12,17,19)

The candidate's more significant contributions include:

- Through the use of X-ray synchrotron spectroscopy the first observation of the so-called molecular U^{4+} phases in environmental systems (microbes and minerals) was made in which the reduced uranium is not in the form of UO_2 , and the individual U^{4+} atoms are connected in complexes or adsorbed on the surfaces.
- Molecular U^{4+} phases have been found to be predominant in reduced subsoil systems as a result of anaerobic respiration by the local microflora.
- Retention mechanisms of U^{6+} in uranium-contaminated soils have been investigated and it has been found that those rich in iron oxides found in moist conditions form reactive ferro-oxides with a layered structure, which play the main role in the partial reduction of U^{6+} to U^{4+} as the reduction product are molecular U^{4+} phases, not UO_2 .
- Studies have been carried out on stimulated microbial reduction in purification technology. Nutrient solutions (emulsions) were injected into underground wells in order to stimulate the local microflora, reducing the passing U^{6+} and the formation of reduced U^{4+} in the solid phase.
- The effect of the nano-porosity inherent in natural minerals on the ability to reduce U^{6+} adsorbed in these pores was investigated and it was found that uranium adsorbed on macro-porous minerals is easily reduced to UO_2 , while uranium adsorbed on micro-nano-porous structures, is not reduced under the same conditions,

• Nanomeric U^{6+} -phosphate bio mineralized on the surface of one bacterium was found to be reduced to molecular U^{4+} by another, metal-reducing bacterium, with the degree of solubility of the U^{6+} -phosphate phase influencing the degree of reduction.

• Magnetite and alumina surfaces have been found to stabilize adsorbed U^{4+} in mononuclear surface complexes and prevent UO_2 formation.

• The bacterium *Orenia metallireducens* strain Z was isolated for the first time, which is halophilic and grows in a wide pH range, reducing iron oxides such as goethite and hematite to $Fe^{2+}CO_3$ and/or $Fe^{2+}(PO_4)_3$ depending on the conditions in which it develops.

• Through X-ray spectroscopy, the different iron phases were quantitatively determined, which is not possible with other methods due to the amorphous nature of some of them and the formation of several phases at the same time, some of which are transient.

• The smooth transition from one structure of Re to the other and the possibility of electron transfer to the perchlorate in the different structures are quantitatively described.

• The structure of As, Zn, Pb, and Fe in underground environments with metal pollution was achieved as well as the form in which the corresponding element is found, which is important for its toxicity and mobility in the environment, were determined.

• Reduction-oxidation processes were studied during the adsorption of Se and Te and on thiol groups from bacterial cell wall structures and has been confirmed directly that thiol groups ($R=SH$) are the target sites for the binding to the bacterial wall.

• The retention mechanism of ReO_4^- as a safe structural analogue of the radioactive pollutant TcO_4^- in cation-modified zeolites studied for the purpose of developing a purification technology was investigated and it was found that ReO_4^- is adsorbed as an internal complex. Both mechanisms imply a strong interaction and stabilization of the pollutant, which is suitable for the use of the modified zeolite for the purification of polluted waters.

The candidate's contributions are very important for molecular biogeochemistry and molecular biochemistry as they enrich existing knowledge and theories, but at the same time there are also original contributions and new information about the mechanisms of transformation of metal ions in different ecosystems. This is essential for the implementation of biotechnologies to clean up polluted ecosystems. The candidate's leading position as a specialist in synchronous X-ray spectroscopy makes him a desirable partner worldwide and his presence as a professor at ICT will allow him to develop in the future molecular biogeochemistry and biochemistry at the institute and will increase its authority as a leading unit in this direction as well as the authority of Bulgarian science in general.

5. Reflection of the candidate's scientific publications in Bulgarian and foreign literature.

The candidate's scientific publications have found an enviable reflection in the literature. This is confirmed by the available metrics overview of the candidate: publications - 84, citations - 3578, h-index 34 (Scopus) and over 4000 (Scholar). According to the number of citations, the candidate has an enviable position in the direction of the competition.

6. Personal impressions of the reviewer about the candidate.

I do not know the candidate personally. At the same time, however, as a specialist who has worked for many years in the field of biology of bacteria performing anaerobic respiration with terminal electron acceptors in their respiratory chains metal ions and biotechnologies for the removal of metal pollution, I am thoroughly familiar with the candidate's scientific output. I believe that the contributions of the candidate are essential to the elucidation of the mechanisms of the phenomenon of anaerobic respiration in bacteria. I am filled with respect for the quality of the

candidate's research activity, his multifunctional expertise in several scientific fields - physics, chemistry, biology biotechnology.

CONCLUSION

The candidate for professor in the announced competition is a proven specialist in the field of the competition, an established expert in synchronous X-ray spectroscopy, expertise in several scientific fields - physics, chemistry, biotechnology, enviable metrics overview, extensive experience in the development of projects with both fundamental and applied character. This is an excellent opportunity for the development of the direction of molecular biochemical technology in ICT, it will significantly increase the authority of the institute and Bulgarian science.

With complete conviction, I recommend to the honorable scientific council of ICT to award associate professor Maxim Boyanov the academic title of professor.

December 15, 2022

Prof. Veneta Groudeva

