

REVIEW

by Prof. Dr. Dragomir Yankov

regarding the materials for the competition for the occupation of the academic position "Professor" in the professional field 4.2. Chemical sciences, scientific specialty "Units operations in chemical and biochemical technology", announced by IИH-BAN in State Gazette, issue 77/10.09.2024.

1. General conditions and brief biographical data about the candidate.

The only candidate in the announced competition for the academic position of "professor" in the scientific specialty "Units operations in chemical and biochemical technology", for the needs of IИH-BAS, is Reader Elena Nikolaeva Razkazova-Velkova, PhD.

Reader Elena Nikolaeva Razkazova-Velkova, PhD completed her higher education in 1995. at University of Chemical Technology and Metallurgy - Sofia with a master's degree in chemical engineering. In the period 1995-1999 she is a full-time doctoral student at IChE, where after a successful defense of her thesis she received a PhD degree. Since 1999 is employed at IChE-BAS successively as: assistant until 2006, and chief assistant until 2012. After successfully passing a competition in 2012 holds the academic position of Reader.

The main scientific interests of Reader Elena Razkazova-Velkova, PhD are in the field of research on packed columns, absorption, adsorption, creation and investigations of environmentally oriented fuel cells.

2. Description of the materials with which the candidate participates in the competition.

Reader Razkazova-Velkova has presented a set of documents on paper and electronic media that fully meet the requirements of the ADASRB, the Regulations for its application and the Regulations for the terms and conditions for acquiring scientific degrees and for holding academic positions at IChE - BAS.

The set of documents contains the applicant's CV according to the European model, a list of the complete scientific output of Reader Razkazova-Velkova, list of publications with which she participated in the competition for "Professor", copies of the publications of the current competition, list of noticed citations of the candidate's publications, list of participations in research projects, report on the implementation of the minimum national requirements for AD "professor" and self-assessment for the main contributions

From the presented lists of publications, it can be seen that in the current competition for Professor Reader Razkazova-Velkova participated with 22 publications, all of which were published after 2013, i.e. after its selection as Reader, which confirms that they were not used in previous procedures. The analysis of the 22 peer-reviewed publications for this competition shows that all are scientific articles published in refereed scientific journals with an impact factor or impact rank, 1 publication is a book chapter published

by IntechOpen, and 2 are patents registered in the Patent Office of the Republic of Bulgaria. Three of the articles were published in refereed scientific journals falling in Q1, 3 - in Q2, 2 - in Q3 and 12 - in Q4. In 6 of the publications Reader Razkazova-Velkova is first, last or corresponding author.

Reader Razkazova-Velkova has participated in 15 research projects financed by various sources (FNI - 10, Seventh Framework Program - 1, ministries and other departments - 2, and other sources - 2). She was the manager of three projects. The funds raised for these projects are BGN 337,057.54.

The submitted report on the fulfillment of the minimum national requirements for "Professor" shows that Reader Razkazova-Velkova has a total of 734 points from all groups of indicators, exceeding the required minimum of 640 points. Group D includes publications for a total of 284 points with a required minimum of 220 points, and for group F – 162 points with only 150 points required. According to group E, the table presents 62 citations with corresponding bibliographic descriptions, carrying 124 items. Assoc. Dr. Razkazova-Velkova is the co-supervisor of a successfully defended doctoral student.

Group	Content	Indicator	Required points	Collected points
A	Indicator 1	Dissertation for awarding the PhD degree	50	50
C	Indicators 3 or 4	Habilitation thesis - scientific publications in Web of Science and Scopus	100	100
D	Sum of indicators from 5 to 10	Scientific publication in Web of Science and Scopus, outside the habilitation work	220	284
E	Sum of points in indicators 11 Citations in Web of Science and Scopus	Citations in Web of Science and Scopus	120	124
F	Sum of indicators from 12 to the end	Management of PhD students, leadership and participation in projects, funds attracted	150	162

3. General characteristics of the candidate's scientific-research and scientific-applied activity.

A real idea of the scientific-research and scientific-applied activity of Reader Razkazova-Velkova can be obtained based on her overall scientific output. More than half of the candidate's articles (47 out of 71) have been published since her habilitation in 2012.

The publications of Reader Razkazova-Velkova are extremely diverse in terms of topics - research and design of packed columns, study of kinetics and modeling of mass transfer processes, purification of flue gases from sulfur dioxide, research of catalytic processes, construction and research of fuel cells for removal of various pollutants. They

have both a fundamental and a scientific-applied nature, as evidenced by the 2 patents registered in recent years.

4. Main scientific and scientific-applied contributions of the candidate

The 22 publications described above, presented in a separate list, are subject to review within the framework of this competition. The main contributions in them, according to the candidate's self-assessment, are thematically separated in several directions, but essentially, they are related to obtaining new knowledge, enriching existing knowledge and finding possible applications of various processes and devices and ecological orientation.

The main scientific and scientific-applied contributions according to the attached publications can be divided by topic into four groups:

- I. Contributions related to packed columns;
- II. Contributions related to the purification of flue gases from sulfur dioxide;
- III. Contributions related to research on catalysts and electrocatalysts;
- IV. Contributions related to the construction and research of fuel elements with an ecological orientation for the disposal of various wastes.

Contributions related to padded columns

- 7 sizes of Raschig Super-Ring (RSR) metal packings were tested. Based on the experimental determination of the hydraulic resistance of the packings, the obtained equations are of sufficient accuracy for engineering purposes. The equations are common to all investigated packing sizes and reflect the influence of their geometry and the reloading of the apparatus (publ. 6 from the attached list).

- Metal Raschig Super-Ring (RSR) and Intralox Metal Tower Packing (IMTP) packings were investigated. Based on experimental data on the dynamic retention capacity of 4 size IMTP and 7 size RSR, dimensionless criterion equations were proposed for both types of packing to calculate their dynamic retention capability for modes below the retention point (publ. 15).

Contributions related to the purification of flue gases from sulfur dioxide

- An integrated absorption-adsorption method for capturing sulfur dioxide from flue gases was investigated. The method involves physical absorption of SO_2 with water and chemical absorption of HSO_3^- from the aqueous solution by an ion exchange resin. It is carried out in two steps and is integrated into one apparatus - a bell plate column (publs. 2, 17, 21 and 22). This method is regenerative, and the regeneration is done with ammonium hydroxide solution. The method enables the utilization of the obtained $(\text{NH}_4)_2\text{SO}_3$ and NH_4HSO_3 to produce concentrated SO_2 (gas) and NH_4NO_3 (solution). The

most suitable ion exchange resin was selected, the absorption-adsorption process was modeled and a CFD simulation of the flow on the bell dish was made. An experimental bell plate column was designed and built using 3D printing.

Contributions related to research on catalysts and electrocatalysts

- The photocatalytic oxidation of a model pollutant azo dye (Acid Black 194.) with TiO_2 incorporated on activated carbon was investigated. 4 samples were tested - two of them: activated carbon + TiO_2 and the other two - only activated carbon. The samples were obtained by an original pyrolysis method with simultaneous activation (publ. 3).

- Various catalysts (Co_3O_4 , Mn_3O_4 , Fe_2O_3 , ZrO_2) were investigated for the oxidation of sulfides from model seawater systems. Catalysts are metal oxides incorporated on activated carbon and are obtained by pyrolysis with simultaneous activation upon application of a catalyst precursor. A comparison was made of the catalytic activity of activated carbon obtained under the same conditions, in fuel cells and outside them. Oxidation in a fuel cell has been shown to occur at a higher rate and is independent of the amount of catalyst. Of the investigated catalysts, ZrO_2 gave the best performance. For it, detailed studies were carried out on the kinetics of oxidation under two modes of operation - continuous aeration and stirring (publs. 1, 4, 5 and 14).

- A new method for simultaneous purification of sulfur dioxide and hydrogen sulfide was proposed, and the conditions for simultaneous reduction of sulfur dioxide and oxidation of hydrogen sulfide were found (publs. 7 and 9).

- The possibility of using electrocatalysts for sulfites and nitrates based on manganese deposited on fullerenes and carbon nanotubes is considered. They have been studied for the oxidation of SO_3^{2-} to SO_4^{2-} and the reduction of NO_3^- to NO_2^- and N_2 , thereby creating an environmentally friendly SO_x/NO_x fuel cell and generating electrical energy (pubsl. 10 and 20).

Contributions related to the construction and research of fuel elements with an ecological orientation for the disposal of various wastes

Various fuel cells have been constructed and studied: with salt bridge, cylindrical membrane, a battery of two fuel cells with different capacities of the cathode and anode compartments and graphite plates as electrodes, a membrane less fuel cell. For some of the fuel element designs, the disposal of various pollutants has been studied:

- A fuel cell based on sulfide oxidation was investigated. It provides exchange of OH^- anions across the membrane using hydrogen sulfide in natural seawater (publ. 11).

- To overcome the limiting process of oxidation of sulfides in a fuel cell reaction of reduction of oxygen at the cathode, a gas diffusion electrode was used and by highly efficient saturation with oxygen in a venturi tube ejector. Two types of purging were investigated - Venturi and direct oxygen purging. The electrodes are pure graphite, cobalt spinel coated graphite and zirconium dioxide (publ. 18).

- Different anode catalysts for HS⁻ oxidation were tested: graphite, cobalt phthalocyanine (CoPc) and perovskite (La_{1.3}Sr_{0.7}NiO₄). No catalytic poisoning by oxidation products (sulfite and/or sulphate) has been observed. Perovskite and CoPc were found to be suitable catalysts for this system. Fuel cell characteristics based on hydrogen sulfide oxidation were tested with optimized HS⁻ anodes and previously developed oxygen (air) cathodes (publ. 8).

- A fuel cell is designed for simultaneous oxidation of sulfides and reduction of nitrates. The results for biological and chemical denitrification in the cathodic compartment are compared. The influence of different concentrations of sulfides and nitrates on the electric power of the fuel cell, as well as their simultaneous neutralization, was investigated. The electrodes used in the anode compartment are graphite rods and pyrolyzed and activated cotton wool (publ. 12).

- Fuel cells with microbial sulfide oxidation and chemical denitrification and a microorganism-assisted process were investigated for both reactions. A comparison between microbial and chemical fuel cells under the same conditions is also presented. A new type of pyrolyzed activated carbon electrodes were used to immobilize the bacterial strains. *Pseudomonas putida* 1046 was used for sulfide oxidation and *Pseudomonas denitrificans* as a model strain for denitrification (publ. 16).

- A membrane less fuel cell was investigated for the remediation of polluted streams. The core of the fuel cell is a cylindrical tube of activated carbon, acting as both an electrode and a non-selective membrane. Compared to a classical membrane fuel cell, it shows comparable characteristics. The advantage is the elimination of the expensive and difficult to operate polymer membrane. Additional advantages are the ability to work at elevated temperatures and relatively cheap production and operating costs. Both abiotic conditions and microbial fuel cells were investigated for the neutralization of polluted streams with different initial concentrations of sulfide and nitrate ions, as well as their electrical power output. *Pseudomonas putida* 1046 is used in microbial fuel cells for sulfide oxidation (publ. 19).

- A fuel cell for sulfite oxidation was investigated. It has been found that the use of sodium sulfite produces higher outputs than the use of calcium sulfite, and that the use of catalysts improves the performance of the fuel cell. Nickel-plated graphite fibers show both the best oxidation rate and the lowest production cost, but also have very low wear resistance. The use of a more powerful oxidizer increases the oxidation rate of sulfite ions and, accordingly, the power output. Of the oxidants studied, nitrates show the best results (publ. 13).

The applied scientific contributions of the candidate are revealed mostly in the two patents, on which Reader Razkazova-Velkova is a co-author, and the main contributions in them are the following:

- Patent Reg. No. 66721 - method for oxidation of hydrogen sulfide in a fuel cell. The material containing hydrogen sulfide and sulfide ions is fed as an anolyte into the anode space of a fuel cell, which consists of two separate chambers connected internally by a salt bridge. The anolyte in chamber A has a neutral or alkaline reaction and is an aqueous solution of sulfides or hydrogen sulfide in an environment of chloride ions. Oxygen or another gaseous oxidizer is passed through the catholyte containing an electrolyte solution containing salts of strong acids of the alkali or alkaline earth metals (chlorides, sulfates, nitrates, etc.).

- Patent Reg. No. 66967 – a method for separating hydrogen sulfide and sulfur dioxide from fluids, applicable to the purification of wastewater, industrial waste gases, harmful pollutants in the atmosphere and natural sources of pollution. The method involves the simultaneous feeding of two fluids through a catalytic mass consisting of teflonized highly dispersed carbons and/or carbon soot, which are a support for an applied catalyst representing chelates of metals, such as iron, cobalt, vanadium, manganese, etc.

5. Personal contribution of the candidate, and a vision for the development of the theme of the competition in the next 5 years.

Knowing the candidate's work closely, I have no doubt that the presented results are the personal work of Reader Razkazova-Velkova. They were achieved under her leadership or in equal contribution with her co-authors.

The presented vision for the development of the subject of the competition in the next 5 years is well-founded, represents a further development of the previous studies and includes:

- bio-electrochemical systems for cleaning dyes and phenol in fuel elements.
- continuation of research on the integrated absorption-adsorption process for waste-free purification of gases from sulfur dioxide.
- research on membranelles fuel cells will continue for various systems, as a catalyst will be inserted into the electrodes according to the purpose of the research.
- 3D printing methods will be used to create new fuel element designs.
- different microbial strains and/or consortia will be isolated from the waters of different thermal springs for use in a fuel cell. The oxidation/reduction ability of the isolated bacteria will be investigated on different substrates.

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

Considering the fact, the various topics of the research of Reader Razkazova-Velkova, the reflection of her scientific publications by the world scientific community is very good. The list of citations submitted by the candidate for participation in the competition includes 62 citations to a total of 21 publications out of the 22 presented. The total number of citations of the applicant is 162 to 37 publications, which indicates that the applicant's

work is of interest not only to leading scientists in the field, but also for scientists at the beginning of their professional career.

7. Significance of the candidate's contributions to science and practice.

The significance of the candidate's contributions to science and practice is undeniable both in terms of content and as reflected in the scientific literature. The publications presented cover diverse aspects related to packed column research, flue gas cleaning, catalyst and electrocatalyst research, and the design and research of fuel cells for the disposal of various pollutants. The obtained results are met with interest by the scientific community.

8. Critical notes and recommendations to the candidate's scientific works

I have no critical comments on the candidate's scientific works submitted for the competition, which have been published in reputable scientific journals with an impact factor. Although diverse in thematic terms, they are all united by a common goal related to the development and finding real applications of innovative methods with an ecological focus for the removal of various pollutants. I would recommend the candidate to publish his future results primarily in scientific journals with a high impact factor from the Q1 and Q2 quartiles.

9. Personal impressions of the reviewer about the candidate

I have known the candidate since 1995, when he started his doctoral studies at IChE. As a colleague, I have direct observations on the scientific research of Reader Elena Razkazova-Velkova, what are distinguished by their competence and precision. Reder Elena Razkazova-Velkova is distinguished by her active activity as a participant in various projects and works extremely effectively in a team. She is highly respected by her colleagues for her respectability, correctness and collegial attitude towards everyone.

CONCLUSION

In terms of volume and quality, the science-metric indicators of Reader Elena Razkazova-Velkova exceed the minimum national requirements described in the Act on the Development of the Academic Staff in the Republic of Bulgaria, the Regulations for the Application of the ADASRB and the Regulations for the Terms and Procedures for Acquiring Scientific Degrees and Holding Academic Positions in the Bulgarian Academy of Sciences, as well as the additional requirements for holding Professor degree from the IChE-BAS Regulations for acquiring scientific degrees and holding academic positions.

For me, the high scientific qualification of the candidate for holding academic position "professor" Reader Elena Razkazova-Velkova in the field of unit operations in chemical and biochemical technology is indisputable. She is a fully formed scientist who has the


qualities of a researcher with an affinity for both fundamental and applied scientific research.

Based on all of the above, with full conviction I give a positive assessment to the candidate in the competition for the academic position of professor in professional field 4.2. Chemical sciences, scientific specialty "Unit operations in chemical and biochemical technology" and I will vote "Yes" for the esteemed jury to propose to the Scientific Council of IChE to appoint Reader Elena Razkazova-Velkova, PhD for the academic position "Professor".

Sofia

01/04/2024

Reviewer:

 /prof. Dr. Dragomir Yankov/