

REVIEW

by competition: to obtain the academic position "professor" in professional field 4.2. Chemical Sciences, scientific specialty "Chemical kinetics and catalysis", for the needs of the laboratory "New heterogeneous catalysts for clean energy and environmental protection", Institute of Catalysis - Bulgarian Academy of Sciences, announced in State Gazette, no. 24/22.03.2019

Candidate: Assoc. Prof. Dr. Silvia Zhivova Todorova, Institute of Catalysis - Bulgarian Academy of Sciences (IC-BAS)

Reviewer: Prof. Dr. Margarita Dimitrova Popova, Institute of Organic Chemistry with Center for Phytochemistry - Bulgarian Academy of Sciences

1. Personal and professional details of the applicant

Assoc. Prof. Dr. Silvia Todorova is the only candidate in the competition. She graduated in 1987 at the Higher Institute of Chemical Technology at the University of Chemical Technology, Sofia, specialty "Technology of Polymers, Textile and Leathers". In 1999 she was awarded the Doctorate degree after a successful thesis defence entitled "Infrared Spectroscopy of adsorption and interaction of carbon monoxide and hydrogen on supported palladium, ruthenium and cobalt".

Since 1993 she has been working at the Institute of Catalysis, the Bulgarian Academy of Sciences, in succession as a Chemist Specialist, Research Associate II-I degree and Associate Professor from 2010 until now. After defending the thesis, Dr. Silvia Todorova did a one-year specialization in 2001 at the University of Namur, Belgium, and in 2002 she won a NATO scholarship for a three-month specialization at the same University. She was on short-term specializations in Seville, Spain for the period 2006-2009. In 2011 she was elected as the Scientific Secretary of the Institute of catalysis, Bulgarian Academy of Sciences and since 2015 has been the Director of the Institute of Catalysis at the Bulgarian Academy of Sciences. Since 2016 she has been a member of the General Assembly of Scientists at the Bulgarian Academy of Sciences.

Assoc. Prof. Dr. Silvia Todorova is a desirable partner in a number of national and international scientific projects. Over the past 5 years, she has been working very hard on managing and implementing 10 projects funded by the NSF in thematic and bilateral

cooperation competitions, 1 project with the Ministry of Education and 2 projects within the framework of the inter-academic exchange with the Romanian Academy of Sciences.

In the context of bilateral co-operation she is the project leader from the Bulgarian side for joint research with India (2013-2019), Russia (2017-2019), France (2-17-2019) and has participated in a Bilateral Cooperation project with China (2008-2011). She led the implementation by the IC-BAS of a project for the establishment of a Center of Excellence in Mechatronics and Clean Technologies, funded by the Operational Program "Science and Education for Smart Growth" 2014-2020, co-funded by the European Union through the European Regional Development Fund. From the side of IC-BAS she is also the head of a project for distributed Infrastructure/INFRAMAT, contract DO1-155/28.08.2018. She is also the head of the research team of the IC-BAS within the framework of the National Scientific Program "Low Carbon Energy for Transport and Households".

The above-mentioned research projects convincingly show that Assoc. Prof. Silvia Todorova has the capacity to attract funds and to manage research projects.

2. General description of the scientific metrics for the presented materials

For the entire research period, Assoc. Prof. Dr. Silvia Todorova presents 48 publications and in the competition she participates with 27 publications, which do not repeat the ones presented for the position "associate professor", and in 12 of them she is the first author and/or corresponding author.

The results from her scientific work have been published in renowned international journals in area Q1 (WoS or Scopus): Applied Catalysis A, Catalysis Today, Journal of Materials Science, Journal of Alloys and Compounds, Chemical Engineering Journal, Electrochimica Acta.

The publications appearing in the competition are divided into two groups, covering the C and D indicators, in accordance with the Rules of the conditions and order for acquiring academic degrees and for taking up academic positions at the Institute of Catalysis - BAS. In the first group, indicator C - "Habilitation work - scientific publications in journals that are referenced and indexed in world-famous scientific information databases (WoS or Scopus)" are presented 7 (publications 1, 2, 3, 7, 13, 16, 27), which are valued at 127 points, required 100 points. It should be noted that 4 of the publications are in the Q1 area (WoS or Scopus), and in 3 of them, Dr. Silvia Todorova is the first and corresponding author.

In the second group, 20 publications covering indicator D are presented, with a total of 265 points, 220 points required.

A total of 51 participations in international and national scientific forums were presented,

included in the materials for this competition, of which 7 oral presentations were given at prestigious international forums.

Evidence of the international recognition and significance of the scientific results of the research by Assoc. Prof. Dr. Silvia Todorova is the large number of citations of her works. In the attached documents there are 296 citations in WoS or Scopus and 53 references in other sources - dissertations, patents and other international publications, presented, with which, according to indicator D, Assoc. Prof. Silvia Todorova receives 645 points, with the requirement being 120 points for the position Professor in accordance with the Rules of the conditions and order for acquiring academic degrees and for taking up academic positions at the Institute of Catalysis - Bulgarian Academy of Sciences.

According to indicator E, including supervisor of PhD students, implementation and management of national and international projects and attracted funds, Assoc. Prof. S. Todorova has 461 points, the required being 150 points, according to the aforementioned rules. The scientific indicators in the presented materials, with which Dr. Silvia Todorova participates in the competition, convincingly show that she significantly exceeds the requirements imposed on the candidates for the position of professor.

I would also like to point out that all the materials are very well and neatly arranged, which greatly facilitates the work of the reviewer.

3. Assessment of the applicant's research activity

The scientific work of Assoc. Prof. Dr. Silvia Todorova is in extremely modern directions of the heterogeneous catalysis, related to the environmental protection and development of efficient technologies for obtaining ecologically clean fuels. Her topics are within the direction Mechatronics and clean technologies - development of new nanostructured materials with application in ecology, alternative fuels, waste materials utilization and medicine; technologies for the protection of air and water purity, formulated in the National Strategy for the Development of Scientific Research 2017-2030.

The contribution of the candidate in the presented studies to clarify the relationship between the catalytic activity and the state of the applied active components in the developed catalysts is unquestionable. The interactions between different active phases, between the active sites and the carrier, as well as the influence of the carrier type and the catalyst preparation method on the distribution and dispersion of the active phase on the surface of the carrier, having a direct effect on their activity in the investigated processes, have been studied in depth.

4. Assessment of the applicant's teaching activities

The teaching activity of Assoc. Prof. Silvia Todorova is mainly related to the training of students, graduates and doctoral students. She was a mentor of 5 students from the UCTM under the OPERATIONAL PROGRAM "HUMAN RESOURCES DEVELOPMENT" 2007 - 2013 under project BG051PO001 - 3.3.07-0002 "STUDENT PRACTICES" and project BG05M20P001-2.002-0001 "Student Practices - Phase 1" 2018. She was a scientific supervisor of a successful graduate in 2013 and a PhD student in 2017.

She has participated in a lecture course on project BG051PO001-3.3.06 - 0050 "Creation of highly qualified specialists on novel materials for environmental protection: from design to innovation" on "Catalysts for the cleaning of waste gases from organic substances" and before Saudi Basic Industries Corporation with "Infrared Spectroscopy in Heterogeneous Catalysis".

The expert activity of Assoc. Prof. Dr. Silvia Todorova includes preparation of reviews of project proposals for the Romanian National Council for Research and Development and the National Science Fund.

Assoc. Prof. Dr. Silvia Todorova has participated in the preparation of reviews in 13 procedures for promotion to the academic positions as associate professor and professor, as well as in procedures for the defence of the educational and scientific degree Doctor.

5. Evaluation of scientific and applied research contributions.

The scientific and applied scientific contributions from the works of Dr. Silvia Todorova can be summarized in three main directions:

1. Development of supported oxide systems as catalysts for total oxidation of volatile organic compounds and CO (publications 1, 2, 3, 7, 13, 16, 27).
2. Development of catalysts based on a combination of oxides and precious metals (Pd, Pt) for oxidation of VOCs and methane (publications 4, 6, 9, 10-12, 14, 15, 17-19, 21, 23, 24, 26).
3. Development of catalysts for fine purification of hydrogen-rich mixtures from CO (publications 5, 13, 20, 22).

In the first direction studies directed at processes for complete oxidation of VOCs and CO based on transition metal oxides used as catalysts are presented. The selected catalytic processes are important for maintaining air purity. Justification of the choice of model compounds for VOCs (methane, propane, n-hexane, ethyl acetate) in view of their toxicity and existing processes for generating these harmful emissions has been made. Catalysts based on Cu, Mn, Co and Ni oxidation systems have been developed as catalysts for complete

oxidation of volatile organic compounds and CO, with manganese- and cobalt-containing catalyst based systems being particularly promising for realization because of their relatively low price and high activity in the oxidation of CO and VOCs.

The application of carriers (conventional SiO₂ and mesoporous MCM-41 and SBA-15 silicas), on which, by various methods: impregnation, precipitation and the two-solvent method, cobalt oxide, manganese oxide and manganese oxide modified with CeO₂ are supported, allows for highly efficient catalysts to be obtained. Regularities of the influence of the nature of metal oxide particles, the presence of mixed oxide oxides, their reducibility, dispersion in the studied processes of complete oxidation of methane, propane, n-hexane, ethyl acetate and CO are found. An approach to overcome one of the major drawbacks of transition metal catalysts associated with agglomeration of the active phase is proposed by applying new methods of active component loading, using various precursors, new carriers (mesoporous silicas with different structure), etc.

In the second direction, studies in the reactions of total oxidation of VOCs and CO based on a combination of oxides and precious metals (Pd, Pt) are presented. Catalysts have been developed on the basis of palladium, applied on nanosized oxides (Mn₃O₄, Co₃O₄ and Fe₃O₄) as well as Pt supported on titanium modified SBA-15, KIT-6 and nanoporous Fe₂O₃ for CO oxidation and complete combustion of n-hexane and methane. Research has been carried out to develop catalysts based on a combination of precious metal oxides (Pd, Pt) and other transition metal oxides (Co, Ce, Ni) supported on different carriers (Al₂O₃, La₂O₃-Al₂O₃, La₂O₃-Al₂O₃) for methane oxidation.

Through in situ diffuse-reflecting infrared spectroscopy information about the type of the active sites and the mechanism of the oxidation reaction of CO on Pd/Fe₂O₃ and Pd/Co₃O₄ has been obtained. Promising results for CO and n-hexane oxidation on catalysts based on iron-containing biogenic materials obtained in the presence of 0.3% Pd/mesopore Al-Si-O are shown.

In the third direction, catalysts for fine purification of hydrogen rich mixtures of CO by its selective oxidation (PROX process) are presented. The PROX process is an efficient CO purification method present in hydrogen-rich mixtures that are used in fuel cells. The requirements for the catalysts for this process have been set: high CO conversion (about 99.9%) to achieve CO values below 10 ppm in the fuel mixture, operation over a wide temperature range (50-150°C) and stability with respect to the presence of CO₂ and H₂O.

It has been established that the silver catalysts obtained through impregnation of different carriers (SiO₂, CeO₂ и MnO₂), are effective in a PROX process, with Ag/SiO₂, pretreated in

pure oxygen, showing the best results, which is due to the redistribution of the surface of the silver particles in the oxidative pretreatment.

A series of nanosized Fe, Pt and Fe-Pt supported on active carbons have been investigated in a selective CO oxidation reaction in hydrogen-rich mixtures, which have shown high activity due to the high phase dispersion and formation of a different type of active sites. It has been shown that the use of active carbons as carriers of ferrites ($\text{CuFe}_2\text{O}_4/\text{ACP}$, $\text{MnFe}_2\text{O}_4/\text{ACP}$, $\text{ZnFe}_2\text{O}_4/\text{ACP}$) results in very low activity in the PROX process. For mono-component and two-component Co-Mn catalysts deposited on a SiO_2 carrier with a different molar Co/Mn ratio, high catalytic activity was found, the highest being for the mono-component cobalt catalyst.

The presented scientific contributions in the publications of Assoc. Prof. Dr. Silvia Todorova are a novelty in science and have significant applied potential.

Concluding remarks:

From the review of the submitted documents for the announced competition it is concluded that Assoc. Prof. Silvia Todorova is an authoritative scientist with an undisputed contribution as a leading author in the scientific teams.

The results from her research activities have had a significant scientific and applied scientific contribution to clarifying the relationship between catalytic activity - active centers on the basis on classical and modern experimental approaches in processes for reducing atmospheric pollution emissions, as well as in processes related to the use of low-emission energy sources.

Based on the above, I strongly recommend to the honourable members of the scientific jury to vote positively for the award of the academic position "professor" in the professional field 4.2. Chemical Sciences, scientific specialty "Chemical kinetics and catalysis" to Assoc. Prof. Dr. Silvia Zhivova Todorova.

27.06.2019

Reviewer:

(Prof. Margarita Popova)