

Opinion

by Prof. Dr. Silvia Todorova, Institute of Catalysis - BAS

regarding the contribution of the works of assistant professor Ivan Bogoev Ivanov, PhD, for participation in a competition for "associate professor" in the professional degree 4.2. "Chemical sciences", scientific specialty 01.05.16 "Chemical kinetics and catalysis" for the needs of the laboratory "Catalysis for energy and environmental protection", in the thematic direction "Catalytic systems for new energy sources" (announced in Bulgarian State Gazette No. 55 of 27/06/2023)

General presentation of the candidate.

Assistant professor Ivan Bogoev Ivanov, PhD, is the only candidate in the competition for the academic position of "associate professor". The candidate meets all the conditions of the regulations for the terms and conditions for acquiring scientific degrees and for holding academic positions at the Institute of Catalysis - BAS.

To participate in the competition, Dr. Ivanov submitted the necessary documents: curriculum vitae, diplomas for completed higher education and for the educational and scientific degree "Doctor", a list of publications for participation in the competition with copies of the same, author's reference for contributions from scientific publications, list of participations in national and international conferences and congresses, list of citations noticed in the literature, list of participations in international and national projects. For the entire creative period, the candidate co-authored 37 publications, and participated in the competition with 17, all of which were in journals with an impact factor. 11 of them are in the Q1 category, of which 1 is in Q1, leading the ranking; 5 in Q2 and 1- Q3. In 1 of the publications, the candidate is listed as the first author, 3 - second, in the others - third and next. This indicates a substantial contribution of the candidate to the development of scientific research. All the publications of assistant professor I. Ivanov are in one of the most renowned journals in the field of catalysis (*Applied Catalysis A*, *Applied Catalysis B*, *Catalysis Science and Technology*, *International Journal of Hydrogen Energy*, *Catalysis Today* p *Catalysis Letters*). The quality of research is assessed by the specialists in the field by the number of citations. According to the data of the SONIX system, 206 citations of the works with which he participated in the competition were noticed.

The total number of observed citations according to Scopus without self-citations of all authors is 1006, of which 794 are for the last 15 years. Total number of points achieved

according to indicator B.4 125, according to indicator D.7 – 265 and according to criterion D-420, which significantly exceeds all the minimum national requirements provided in the Law on the Development of Academic Staff in the Republic of Bulgaria, as well as the additional criteria of IC-BAS for the academic position of "Associate Professor". Assistant Professor Ivan Ivanov, Ph.D e participated in 8 national projects - 4 with the Scientific Research Fund and 4 within the framework of international ones collaborations of BAS. The results of scientific research Assoc. Dr. Ivanov have been presented at 23 scientific events, 10 national and 13 international forums and 4 oral reports and 25 posters respectively. The candidate's Hirsch index (H) without self-citations according to the Scopus database is 14.

Scientific contributions.

The main scientific contributions of Dr. Ivanov, presented in the habilitation thesis, are in the field of a modern and very promising direction, namely the production of pure hydrogen for use in fuel cells. For this purpose, two reactions are used: the water gas shift reaction (WGSR) and the selective oxidation of CO in hydrogen-rich gases.

The publications are aimed at studying the influence of the method of deposition of the active phase, the method of preparation of the support and doping of the support with different elements on the activity and stability of the catalyst in the above-mentioned reactions. Au, Pt and Cu were used as the active phase. The carrier used is mainly based on CeO₂ modified with various additives Mn , Fe , Sn , Y.

When studying the influence of the method of preparation and the nature of the additives on the catalytic activity in the WGSR of gold-supported catalysts on transition metal- doped cerium oxide, it was found that the mechanochemically activated (MA) ones were more active than the co-precipitated ones, because the mechanochemically treated lead to higher dispersion and more number of active centres on the surface, responsible for activation of CO and dissociation of water - namely Au nanoparticles and Ce³⁺ ions. In co-precipitated catalysts, the modification of CeO₂ is in the bulk, and not enough active centres are formed. The deposition of gold on cerium oxide modified with Fe and Mn leads to an increase in activity, which is attributed to an increase in the mobility of carrier oxygen.

It was established that the preparation methods of gold catalysts supported on CeO₂ doped with different Fe content, namely MA or impregnation of carriers, affect the catalytic behaviour in the reactions of WGSR and PrOX in a different way. In the latter reaction, the preparation method was found to be of no significant importance, while in the WGSR reaction, the mechanochemically activated ones demonstrated higher activity. The Au₅FeCeMM catalyst shows the highest activity and this is consistent with the presence of a

Fe₂O₃ phase with improved reduction properties. According to Mössbauer data, hematite transforms under WGS conditions into a magnetite phase with a high degree of non-stoichiometry.

Publications which are not included in the habilitation thesis are 12. Thematically, they are related to the previous one and also relate to the development and research of nanoscale cerium-oxide catalysts for low-temperature conversion of CO with water vapour in order to obtain pure hydrogen.

So e.g. investigated a series of gold catalysts supported on CeO₂-Al₂O₃, promoted with ZnO, are found to be suitable catalysts for the purification of hydrogen by means of WGS. The addition of ZnO significantly increases the activity of Au/CeO₂/Al₂O₃, which is mainly related to the increased oxygen storage capacity of the Zn-promoted systems. Not only high activity but also good stability makes these catalysts a promising alternative for their CO scavenging applications.

Within the framework of the opinion, it is difficult to note all the scientific contributions of the candidate. Different physicochemical methods for catalysis characterization have been used in the research (IRS, XPS, TPR, Determination of the specific surface area and pore size distribution, HTEM, Mössbauer spectroscopy, catalytic activity test, etc.). The interpretations of the experimental data are convincing for the stated hypotheses. Characteristic of all the publications is that they thoroughly analysed the relationships between structural and catalytic properties and sought evidence for the clarification of the nature of the active centers and the mechanism of the catalytic reactions.

Conclusion

The scientific research of Assistant Professor Ivan Ivanov, Ph.D fully correspond to the subject matter of the announced competition for awarding the scientific position of "associate professor". The publication activity and the citations on the published results prove that Dr. Ivan Ivanov fully meets all the requirements in the IC - BAS Regulations for awarding academic positions and scientific degrees. Therefore, I strongly recommend to the members of the respected Scientific Jury and the respected Scientific Council of IC-BAS to award assistant professor Ivan Ivanov, PhD, the academic position „associate professor " in professional direction 4.2 "Chemical Sciences" and scientific specialty "Chemical Kinetics and Catalysis".

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Sofia

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