REVIEW

in a competition for the academic position of "Professor" in the professional field "Chemical Sciences" 4.2, scientific specialty "Chemical Kinetics and Catalysis" for the needs of the laboratory "New heterogeneous catalysts for clean energy and environmental protection", in the thematic field "Design of metal and metal oxide systems with application in the energy sector and improving the quality of life", promulgated in the State Gazette, pcs. 82/7.10.2025

Candidate: Assoc. Dimitrinka Alexieva Nikolova MD

Reviewed by: Konstantin Mavrodiev Petrov, PhD, Professor

1. Brief biographical data and characteristics of the candidate's scientific interests

Assoc. Prof. Dr. Dimitrinka Nikolova was born in the city of Vratsa. In 1995 she acquired a Master's degree in Inorganic and Electrochemical Production, specialization in Technology of Inorganic Materials at the University of Chemical Technology and Metallurgy – Sofia. After graduating from higher education, she worked as a Research Chemist at the Institute of Catalysis of the Bulgarian Academy of Sciences (1996–2007). In this period from 1998 to 2001 she was a full-time PhD student at the Institute of Catalysis. where he successfully defended his dissertation in 2005 on the topic: "Influence of potassium supplementation on the activity and structure of NiO-MoO 3-Al2O3 catalysts for the conversion reaction of carbon monoxide with water vapor in the presence of hydrogen sulfide ".

In 2007, Dr. Dimitrinka Nikolova won a competition for Chief Assistant Professor at the Institute of Catalysis in the Laboratory of Synthesis and Activity of Metal Oxide Catalysts.

In 2016, Dr. Dimitrinka Nikolova was elected and appointed to Associate Professor at EC-BAS, where she currently works.

2. General characteristics of the candidate's research and applied research activities

The research activity of Assoc. Dr. Dimitrinka Nikolova is characterized by great thematic diversity and pronounced interdisciplinarity:

(i) Development and research of rhenium-containing catalysts for the production of pure hydrogen through the process of converting CO to CO2 with water vapor in a conventional gas mixture and in a gas mixture with sulphur-containing components;

(ii) Development and research of non-noble electrocatalysts for green energy production through hydrogen fuel cells and green hydrogen for solid oxide fuel cells; alkaline fuel cells; and electrolysis;

(iii) Development and research of nickel-containing catalyst compositions (*built mainly on a hydrotalkite structure*) with application for the process of partial hydrogenation of vegetable oils to high-quality solidified oils and fats as raw materials used in the food industry, as well as for the production of hydrogen and purification of hydrogen gas mixtures by dry reforming of methane, dehydrogenation of ethanol, conversion of CO to CO_2, methanization of CO_2.

(iv) Research on catalysts for the removal of synthetic dyes from industrial wastewater and air purification by catalytic degradation of ozone.
(v) Development of a low-temperature cathode catalyst for green ammonia
(vi) Development of a low-temperature plasma catalyst for nitrogen oxidation
(vii) Development of an anode OER catalyst

Research is focused on optimizing the activity and stability of catalysts for efficient hydrogen production and its transformation into green energy, as well as improving the quality of life.

Along with emphatically fundamental research, Assoc. Prof. Nikolova actively participates in scientifically applied developments. She is a co-author of 2 patents and 1 patent application as a result of a project funded by GenCell Ltd, Petah Tikva, Israel "Development of an anode catalyst from base metals for alkaline fuel cells for GenCell products" in the period 2012-2023. He has gained practical experience in the development and industrial implementation of three catalysts for alkaline fuel cells.

3. Description of the materials presented

Assoc. Prof. Dr. Dimitrinka Nikolova participated in the current competition for Professor Law Firm with a total of 21 publications in scientific journals with impact factor/impact rank with a total impact factor of 65.642, 1 book chapter, 2 patents and 1 patent application. Of the 21 scientific articles submitted, 10 were published in journals from quartile 1, 3 - in journals from quartile 2, 2 in journals from quartile 3 and 6 – in journals from quartile 4. In 7 of the presented articles, Assoc. Nikolova is the first author in 4 and 7 as an author for correspondence, which is indisputable proof of her leading role in these studies.

From the presented **Table for the fulfillment of the minimum national requirements** for Professor, it is evident that Assoc. Prof. Nikolova scored a total of 1615.63 points with a required minimum of 640 points.

4. Main scientific and applied scientific contributions

In the habilitation work of Assoc. Prof. Dr. Dimitrinka Nikolova, **under indicator B**, the publications after occupying Associate Professor Law Firm are thematically related and united in two main research areas, and what unites them is that they are focused on various aspects of the design, research and optimization of catalysts for the production of hydrogen and catalysts for its conversion into electricity. highly pure hydrogen in the efficient conversion of CO to CO2 into hydrogen-containing gas streams through the CO Water Vapor Conversion Reaction (COVP) and further enrichment with the hydrogen produced during the reaction. The second strand concerns electrocatalysts for hydrogen fuel cells and electrolysis. Included are publications, 9 in number, in which the applicant is indicated as the first author in 4 and the author for correspondence in 6. The habilitation work also presents 1 patent and 1 patent application from indicator G, which reflect the design and development to technological readiness of catalyst systems entirely based on non-noble components with application as anodes in alkaline fuel cells.

As the most significant in the individual thematic areas, I can highlight the following scientific contributions:

- Design of oxide Re(Mo) catalysts promoted with potassium and cobalt for conversion of CO with water vapour (*Publication No 14).*
  1) The potential of the CoRe configuration to achieve a near-equilibrium conversion of 94% CO at a reaction temperature of 260 °C and an industrial volumetric velocity of 4000 h^{-1} has been demonstrated.
  2) Two requirements for increasing activity for further research have been defined:

- Modeling the catalyst composition to achieve an optimized balance in the active redox structures $Re^{4+}/Re7^{+}$, $Co2^{+}/Co3^{+}$ and $Mo4^{+}/Mo6^{+}$, as well as their associated electronic properties;
- Finding suitable conditions for activation, such as the choice of reducing agent, optimal duration and temperature, is considered necessary for the further development and increase of catalytic activity.

- Development of new catalyst formulations, Ni-Al layered double hydroxides promoted with rhenium and cerium, for conversion of CO with water vapor for low-temperature regime (*Publication No. 15).*
  1) Re-containing CeO 2-modified Ni-Al was found to exhibit slightly increased activity against the cerium-free catalyst system.
  2) The Re-containing CeO 2-modified Ni-Al catalyst demonstrates resistance to deactivation under various reaction conditions.
  3) It is defined that an improvement in catalyst behavior can be achieved by adjusting the ratio in the Re^{4+}/Re7+ redox pair, as well as optimizing the catalyst composition.
- Design of specialized, sulfide Re-based catalysts promoted with potassium, cobalt and nickel for conversion of CO with water vapor in the presence of sulfur impurities in the reaction mixture (*publications No. 7 and 8*).
  1) A trimetallic KCoRe catalyst composition has been developed and provides high activity and stability in the presence of sulfur impurities in the technological infrastructure, which defines it as a sulfur-resistant catalyst for effective purification of hydrogen-containing gas streams from CO and for obtaining additional amounts of hydrogen.
  2) It has been found that uniform application of K–Co–Re components to the surface of the carrier provides maximum access of the reagents to the active sites.
  3) It has been found that a balance is needed between sulfide ReS_2 and oxide ReO_{xSy} forms of rhenium (the ratio $Re4^{+}/(Re7^{+}+Re6^{+})$)
  4) It has been found that the simultaneous presence of potassium, cobalt and rhenium provides an optimal ratio between the sulfide and oxide forms of rhenium, a ratio of $^{Re\ 4+}/Re7^{+}$ close to 2, to achieve high catalytic activity and stability of the KCoRe catalyst.
  5) The resistance of the KCoRe catalyst to potential emergency conditions of deactivation caused by the absence of sulphur in the gas mixture has been confirmed.

In the author's reference for the scientific contributions **under indicator G,** the publications after the occupation of Assoc. Prof. Dimitrinka Nikolova, PhD, are thematically related and united in the development and research of nickel-containing catalyst compositions (*built mainly on a hydrotalkite structure*) with application for the process of partial hydrogenation of vegetable oils to high-quality solidified oils and fats as raw materials used in the food industry, as well as for the production and purification of fuels and the production of clean energy (dry methane reforming processes, ethanol dehydrogenation, CO to CO 2 conversion, CO 2 methanization, alkaline fuel cells). Studies on the development and research of effective catalysts for clean and safe industry (processes for the removal of synthetic dyes from industrial wastewater and air purification by catalytic degradation of ozone) are also presented.

- Development and research of effective nickel-containing catalysts for partial hydrogenation of vegetable oils *(publications No. 3, 17 and scientific paper No. 22*).

- Development and research of catalysts for the conversion of CO from water vapor to CO2 and H2.

1) NiAl and NiMgAl layered double hydroxides (LDH) promoted with different amounts of gold were studied. It was found that hydrogen production was significantly influenced by the nickel content, the presence of magnesium and the amount of gold in the catalysts. NiAl-based catalysts containing the highest amount of gold (2.4 t.t.) demonstrated the best catalytic performance due to the greater number of active sites. optimization of the composition by precisely adjusting the Ni–Mg–Al ratio, with the magnesium content of LDH proving to be key to achieving balanced catalytic activity in terms of CO activation and$_{H2O}$ dissociation. 3 and 5 t.t.% of S&D$_2$). ***Publications 10,11.***
2) A gold-deposited catalyst was investigated as being designed with a carrier TiO2 modified with cerium (Ce-TiO2), synthesized by two approaches: **(i)** by the sol-gel method; **(ii)** mechanochemical mixing; in the amount of cerium 1, 3 and 5 t.% CeO2 (***Publication 18***). Catalysts modified with cerium have been found to show significantly better performance compared to analogous Au/TiO2 without cerium and achieve a maximum CO conversion of 90-93 % at a low reaction temperature of 180 $^{\circ}C$ compared to 75 % for unmodified. The increase in activity is related to the interactions between Ce-Ti and the modification of structural and electronic properties that favor the dissociation of water.

- Development and research of catalysts for dry methane reforming (**Publication No 16**)

1) Nickel-containing catalysts with a hydrotalkite-like structure NiAl-HT have been investigated in the dry methane reforming (DRM) reaction to produce a synthesis-gas mixture of H2 and CO in a molecular ratio of 1:1 by converting CO2 and CH4. It has been concluded that any synthesis method that provides a stable attachment of gold in the catalyst structure and inhibits its surface segregation could be promising for obtaining a catalyst with better DRM activity.

- Development and research of catalysts for methanization of CO_2 (Publications No 4)

1) An assessment of the effect of the divalent metal type (Ni or Co) on the structure, phase composition, thermal stability and reducibility of layered double hydroxides as

precursors of catalysts for methanization of CO_2, co-located Ni-Al LDH and Co-Al LDH. The methanizing activity was analyzed when the operating conditions changed: the *in situ* activation-reduction temperature at 400, 450, 530, and 600 °C, the reaction temperature (220–400 °C) and volumetric velocity (3000 to 22000 h^{-1}) in a CO2/H2/Ar reaction gas mixture (0.65/34.35/65 vol.%). It has been found that the Ni-Al LDH catalyst is more active due to the formation of easily reducible Ni^{2+}-O structures.

- Development and research of catalysts for ethanol dehydrogenation (Publication No. 9)
  1) Studied Cu catalysts promoted with Ni and maintained on metal-modified calcined hydrotalkite in order to improve the stability of Cu catalysts. A one-step synthesis approach has been proposed for the production of two-metal Cu–Ni catalysts based on the single-stage formation of layered double hydroxides containing Cu, Ni, Mg and Al. Two deactivation modes have been established: rapid deactivation in the first hours of operation, during which selectivity to acetaldehyde increases, followed by slower deactivation.
- Development and research of catalysts for the removal of synthetic dyes from industrial wastewater (**publications No 19, 21**)

Co-Al2O3 oxides obtained by the sol-gel method have been extracted for the degradation of textile dyes in industrial wastewater. Oxide Co-Al_{2O3} catalysts have been found to be effective in the degradation of dyes: Methylene Blue, Basic Blue 41 and Remazol Brilliant Blue R, and can also be used for simultaneous degradation processes of Orange G in binary dye mixtures.

- Development and research of catalysts for air purification by catalytic degradation of ozone (**publications No. 1, 6**)

1) Research is focused on the development of coherent Ni-Cu-Al catalysts for the decomposition of ozone to oxygen in the gas phase as substitutes for classical Pt-containing catalysts. **Publication 1**
2) In catalytic degradation of ozone, the applied MnO_x/Al2O3 system was also investigated. It was found that a catalyst with the highest percentage of MnOx (15 t.%) reached the highest degree of conversion of $O_{3.70\%}$. **Publication 6**

5. Electrochemical research

Under the projects "Low Carbon Energy for Transport and Households" (EPLUS), NSF "Innovative Rechargeable Carbon-Free Zinc-Air Cells" and "Research on the Mechanisms of Conductivity and Reversibility in Innovative Design of Solid Oxide Fuel Cells", IMOOD, coordinated by IEES, Assoc. Prof. Dr. Dimitrinka Alexieva Nikolova entered the Electrochemical Topic. As the head of the Hydrogen Energy Systems Department at IEES, I had direct observations of the work and. She quickly mastered the basics of electrochemistry, in particular electrocatalysis, which allowed her to competently conduct electrochemical measurements and process and interpret the data, and with enviable diligence.

A special period of her scientific and applied activity was her work in the company "Gencell", Israel. I have also consulted at this firm and am a direct witness to its research in the development and research of catalysts for non-platinum electrocatalysts for anodes in alkaline fuel cells **(No 23 Patent US 10,522,844 B2/12/31/2019**). I have to admit that it started timidly

– after all, it is a leading company in the world. Her rich experience and knowledge in the field of catalysis and her perseverance began to bring results, and with it self-confidence.
I think that her work at Gencell has taken her to a new, I would say world level.

This leads to the current competition!

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

The achievements of the candidate are greatly reflected in scientific works abroad, with over 100 (hundred) citations noted, which shows the significance of the scientific work of Assoc. Prof. Dr. Dimitrinka Alexieva Nikolova.

7. Critical remarks and recommendations to the candidate's scientific works

I have no critical comments. My recommendation is to slow down a little and focus on one or two directions.

CONCLUSION

The high scientific qualification of the candidate for the position of Associate Professor Assoc. Prof. Dr. Dimitrinka Alexieva Nikolova in the field of catalysis and electrocatalysis is indisputable for me. She is a fully built scientist who has successfully combined the qualities of a researcher with an affinity for both scientific-fundamental and applied research. including in the field of electrochemistry, allowing it to plan and conduct interdisciplinary research at the highest level.

In terms of their volume and quality, the scientometric indicators of Assoc. Prof. Dr. Dimitrinka Alexieva Nikolova far exceed the minimum national requirements, as well as the additional requirements for occupying a professor in the Regulations of EC-BAS for acquiring scientific degrees and occupying academic positions.

Based on all of the above, I strongly support the candidacy and recommend to the members of the esteemed Scientific Jury at the Institute of Catalysis – BAS to propose to the Scientific Council of the Institute to elect Assoc. Prof. Dr. Dimitrinka Alexieva Nikolova to the academic position of Professor.

Sofia, 22.10.2026 Reviewer:

(Prof. Dr. K. Petrov)