REVIEW

on the materials submitted for participation in the competition to
award the academic position "Professor"
in the professional field 4.2 Chemical Sciences (Physical Chemistry)

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candidate: Dr. Habil. Svetlozar Dimitrov Ivanov

Member of Scientific Jury: Prof. Martin Bojinov, DSc

1 Generalities and information on the candidate

Svetlozar Ivanov was born in 1976 in Sliven, Bulgaria. In 2000, he graduated in Chemistry, specialization in Pure and Especially Pure Substances, at the Sofia University "St. Kliment Ohridski". In 2006 he sustained his doctoral dissertation on "Modification of conductive poly aniline coatings by current and currentless deposition of metal particles" at the Institute of Physical Chemistry "Academician Rostislav Kaishev" of the Bulgarian Academy of Sciences under the guidance of Prof. Vesela Tsakova. He has worked consecutively as a research associate at the Institute of Physical Chemistry -BAS (2007-2010), a postdoctoral student at Bar Ilan University, Ramat Gan, Israel (2010-2011) and Ilmenau Technical University (from 2011-). In 2019, he was awarded the title of Dr. Habil. at the same university based on a habilitation thesis entitled "New materials and modern analytical techniques for application in the research and technology of lithium-ion batteries". Svetlozar Ivanov is a leader, co-leader and participant in projects funded by the German Research Society and private contractors. He is a member of the International Electrochemical Society (ISE) and the Electrochemical Society, Inc. (ECS). In 2003 he received an award of the Bulgarian Academy of Sciences for the youngest scientist (up to 30 years old). His teaching activities include lectures and seminars on electro crystallization, electrochemistry and corrosion, lab works in the field of electrochemical energy storage and electroplating, supervision of diploma theses of bachelors and master students, as well as three PhD students.

2 Description of the presented scientific material

Svetlozar Ivanov is a co-author of 60 publications in the period 2001-2025. In addition, over the past 10 years, he has delivered over 15 reports at international scientific conferences. His publications are mainly in prestigious international journals, such as Electrochimica Acta (11), J. Appl. Electrochem. (9), Journal of Power Sources (5), Electrochem. Commun. (3), etc. Prior to his participation in this competition, Svetlozar Ivanov sustained his dissertation for obtaining the educational and scientific degree of Doctor (2006) and was promoted to associate professor (Dr. Habil., 2019). In this sense, only that part of the scientific papers that relate to the present competition for the title of Professor will be reviewed.

Svetlozar Ivanov participates in the competition for professor with 6 articles in journals with quartiles Q1 and Q2, equivalent to a habilitation thesis, and 8 publications in journals with quartiles Q1 and Q2 outside of habilitation work. Two chapters of collective monographs are also presented, as well as two patent applications. The submitted papers have been cited over 60 times, which is a very good indicator, since they have been published in the last 5 years.

Svetlozar Ivanov is the head and co-leader of three PhD students. In general, it can be concluded that its indicators exceed both the minimum national requirements and the specific requirements of the Regulations of Institute of Physical Chemistry-BAS. Given the complexity of the systems studied and the wide range of methods used, a relatively large number of authors often participate in the publications. In a significant part of the publications included in the competition, Svetlozar Ivanov is the first and/or corresponding author. The general review of the works unequivocally shows that Svetlozar Ivanov has a leading participation in the majority of the presented scientific production.

3 Overview of the scientific activities of the candidate

Svetlozar Ivanov's scientific and applied research is in a dynamically developing interdisciplinary field – synthesis and characterization of materials for, and methods for research and testing of lithium and sodium-ion batteries. In the following sections, the main results obtained, their interpretations and the generated ideas and will be briefly reviewed.

3.1 Silicon Deposition from Sulfolane Electrolytes and Ionic Liquids and Coating Applications in Sodium-Ion Batteries

A comparative study of the process of electro-deposition of silicon in electrolytes based on sulfolane and ionic liquids has been conducted. Electrochemical, micro-gravimetric and spectroscopic methods were applied to study the process parameters and properties of the coating. The coating deposited by ionic fluidity is more significantly contaminated with electrolyte decay products compared to the layers deposited by sulfolane electrolyte. It has been found that the substrate plays an important role in the reduction of silicon tetrachloride and significantly affects the properties of the coating, such as the more efficient deposition is observed on metal electrodes due to the accelerated kinetics of the reaction on this type of substrate.

The nucleation and growth of Si on glass carbon in ionic liquids was investigated by an electrochemical method and modeled by a nonlinear procedure. A transition between instantaneous and progressive nucleation depending on the overvoltage has been found. Silicon coatings have been tested as anodes for sodium-ion batteries, and a high specific capacitance has been found in long-lasting fast cycling. The highest electrochemical characteristics were achieved for Si deposited from a sulfolane electrolyte on a porous copper substrate obtained electrochemically.

3.2 Nickel fiber synthesis and application as anodes for lithium-ion batteries

Nickel nanofibers with a structured surface are obtained by a chimie douce process, meeting the requirements of green chemistry (one-pot reaction). At lower reaction temperatures, Ni/NiO structures with a lower concentration of defects were obtained, maintaining a higher reversible capacity and good stability during long-term cycling.

3.3 Electrical and Electrochemical Properties of the Lithium/Electrolyte Interface

Electrochemical impedance spectroscopy is employed to investigate the influence of soluble polysulfides and lithium nitrate on the characteristics of the passivating layer (solid-electrolyte interface, SEI) formed spontaneously on the surface of Li before cycling. The studied individual additives increased the resistance at the SEI, while their combination reduced it. When cycling in DME-based electrolytes without additives, no significant changes in the morphology of the passivating layer were observed, whereas the presence of polysulfides and lithium nitrate coarsens and heterogenizes the morphology. The formation of SEI in electrolytes modified with diphenyl octyl phosphate and vinyl carbonate was followed in real time by electrochemical quartz microbalance (EQCM). Rapid SEI formation is observed in an electrolyte containing diphenyl octyl phosphate, while in vinyl carbonate-modified and non-modified electrolytes, growth is slower. The formation of SEI has also been studied by in-situ electrochemical dilatometry. It has been found that the addition of vinyl carbonate reduces the irreversible expansion of the graphite anode, while in the absence of this additive, a large irreversible expansion of the electrode occurs. Impedance analysis reveals that the formation of SEI in the presence of VC limits ion transport in the porous anode.

3.4 Corrosion processes in lithium-ion batteries

The Taguchi (TM) method was used to determine the relative influence of experimental parameters on the rate of corrosion process in lithium-ion batteries. It has been shown that the properties and structure of lithium salt have the strongest influence, followed by the temperature and composition of the solvent mixture. Using the combined in situ ZRA (Zero-Resistance-Amperometry)-QCM method, the corrosion of lithium in contact with a copper substrate (Cu-Li) was investigated. This combination allows a gravimetric signal of deposition or dissolution to be measured in parallel with the galvanic current. The process of Cu-Li contact corrosion was investigated in a sulfolane-based electrolyte, whereby it was found that an adsorbed layer of polyethylene oxide (PEO) on the copper surface can be applied to inhibit corrosion. The mechanisms of corrosion of aluminum in lithium-ion batteries, methodologies for analyzing the process and ways to effectively inhibit it are also considered. Relevant examples of the influence of important factors such as electrolyte composition, temperature and electrochemical parameters are presented to clarify the mechanism of corrosion of aluminum in these environments. The analysis summarizes the possible pathways for inhibiting corrosion by adjusting the electrochemical system and optimal operation of the positive electrode of the batteries.

3.5. Fundamental electrochemical investigations

An overview of the different types of charge storage mechanisms in electrochemical energy storage systems is presented. A definition of pseudocapacitance and a quantitative framework for distinguishing it from (diffusion-limited) processes of storage of Faraday charge are formulated. A methodology on how to identify and quantify Faraday, pseudocapacitive, and capacitive charge storage using conventional electrochemical methods is developed. A description of typical examples of electrochemical energy storage systems is presented, which combine the characteristics of a battery, a capacitor and a pseudocapacitor. An updated critical review of the main strategies for structuring 3D copper substrates such as current collectors, methodologies for analyzing these structures and approaches for effective control of their properties is also presented. The methods are described in the context of their practical application. The relationship between the properties of current collectors and the functional parameters of intercalation electrodes is also discussed.

4 Main scientific contributions

As a whole, the scientific research of the candidate is quite homogeneous and covers research in the field of basic and accompanying processes in lithium and sodium-ion batteries, as well as works related to the improvement of the methodology of studying and testing related electrochemical systems. The analysis of the scientific production of Svetlozar Ivanov makes it possible to make a summary of the main scientific and scientific-applied contributions, as follows:

4.1 Enrichment of existing knowledge and theories

4.1.1 For the first time, an electrolyte based on sulfolane was used for electrochemical deposition of silicon. The selected experimental conditions allow the formation of thin Si layers with low roughness and minimal inclusion of organic pollutants. More efficient deposition is observed on the metal electrodes (copper, nickel) in both electrolytes due to the accelerated kinetics of the reaction on this type of supports.

4.1.2 A theoretical model for three-dimensional nucleation has been applied, taking into account the propagation and overlap of diffusion zones, for the interpretation of electrochemical nucleation and growth of silicon on vitreous carbon in an ionic liquid. In addition to the established methodology for analyzing current maximums in dimensionless coordinates, an interpretation of the entire germination process was carried out by a nonlinear procedure.

4.1.3 The simultaneous addition of polysulfide and lithium nitrate has been demonstrated to reduce the electrical resistance of the passivating layer of the lithium/electrolyte boundary (SEI), even if the effect of the individual additives is in the opposite direction. An interpretation of this synergism has been proposed based on the abrupt alteration of the morphology of the interphase boundary layer in the presence of both types of additive. Through a combination of in-situ methods, the effect of vinyl carbonate and diphenyl-octyl sulfate additives on SEI has been demonstrated, the former improving the stability of the passivating layer by limiting ion transport through it, while the latter destabilizing the SEI due to the inclusion of weakly bound particles.

4.2 Applied scientific contributions

4.2.1 Electro-deposited silicon layers on a copper substrate have been tested as anodes for lithium and sodium-ion batteries, and the results show high specific capacitance, long-term electrochemical stability, retaining a capacity of 540 mAh g^{-1} for at least 400 galvanostatic cycles at a cycling current of 150 mA g^{-1}. It has been proposed that the reversibility of the material in the sodium-ion electrolyte is due to the joint contribution of carbon and silicon redox centers, while the stability of the capacitance is due to their improved mechanical stability and accelerated transport of sodium ions in the porous structure of the anode.

4.2.2 Nickel microfibers synthesized by a low-temperature chemical reaction have been tested as anodes for lithium-ion batteries without binder, and the influence of the reaction temperature on the values of reversible capacity and cycling stability has been established.

4.2.3 An innovative method for the study of contact corrosion in the Cu-Li system, based on a combination between ZRA and QCM, has been proposed. In the case described, the ZRA measures the galvanic current in the system when immersed in an electrolyte, and the QCM quantifies the deposition of products of the reduction decomposition of the electrolyte on the copper surface. The application of the method leads to the identification of polyethylene oxide as a possible corrosion inhibitor.

3 International significance of the scientific papers of the candidate.

Svetlozar Ivanov is a co-author of 60 publications in the period 2001-2025, cited over 1250 times (without self-citations), with his Hirsch index being 19. A number of his works (9) have been cited over 50 times, and three of them – over 100 times: Electrochimica Acta 412 (2022) 140072 (179, included in this competition), Journal of Power Sources 378 (2018) 235 – 247 (122) and Journal of Power Sources 342 (2017) 939 – 946 (101 times). In a significant part of the citations, the candidate's works have been commented on, and the quantitative characteristics of the micro- and nanostructure of a number of classes of materials, obtained in a number of his papers, have been used for the interpretation of experimental results or in the development of new approaches for obtaining comparable compounds with applications in a number of important fields of science and practice. It can be concluded that the candidate's publication activity has its significant place in the literature on inorganic materials science and in particular materials for lithium-ion and sodium-ion power sources.

CONCLUSION

- The problems in which the main scientific and scientific-applied results of Svetlozar Ivanov have been achieved are leading and promising for science and technology. The synthesis and characterization of thin films with optimal properties for a number of important applications open up wide opportunities (some of which are unique) for fundamental and applied research, and in the last few decades this scientific field has emerged as a rapidly developing branch of inorganic materials science.
- The scientific development of Svetlozar Ivanov is harmonious. He successively went through scientific degrees and titles, which allowed him to form himself as a mature scientist. At the current stage of his activity, he is already an established leader of younger scientists who embark on the path of scientific research.
- Svetlozar Ivanov has made an in-depth analysis of a number of problems in the field under study and has systematically focused on solving them. In the process of his research work, the teams in which he has a leading participation generate new tasks and ideas.
- Svetlozar Ivanov's scientific contributions are significant and have received a very good international assessment. These results have been achieved through a significant volume of complex studies conducted at a very high level on complex systems and phenomena. His scientometric indicators are very good, which is a criterion for the level of research carried out and the results obtained. At the same time, Svetlozar Ivanov has a significant teaching and scientific popularization activity, which makes him suitable for a leader in a scientific field.

In view of the above, there is no doubt in my mind that we have before us the successful work of a fully formed and profound scientist. His scientific and educational activities, international events, contributions, scientometric indicators (number of publications in prestigious journals and citation index) fully meet the high requirements of the

Regulations on the terms and conditions for occupying academic positions at the Institute of Physical Chemistry at the Bulgarian Academy of Sciences.

Based on these facts, I strongly recommend to the Honorable Scientific Jury to award the scientific title of PROFESSOR in the professional field 4.2 Chemical Sciences (Physical Chemistry) to Svetlozar Dimitrov Ivanov.

Date: 21.05.2025 г. Member of the Scientific Jury:

(Prof. Martin Bojinov, DSc)