REVIEW

Considering the competition for the academic position "Associate Professor"
in the area of higher education 4. Natural sciences, mathematics and informatics, professional field 4.2. Chemical Sciences, scientific specialty "Physical chemistry" announced in the State gazette issue 45 dated May 28, 2021, forthe needs of the Institute of Physical chemistry "Acad. R. Kaishev", Bulgarian Academy of Sciences, Department of "Surfaces and colloids".

with candidate in the competition **Res. Assoc. Dr. Kamelia Pavlova Kamburova**

by Prof. DSc Stefka Germanova Taneva, Institute of biophysics and biomedical engineering, Bulgarian Academy of Sciences

1. Brief biographical information about the applicant

Kamelia Pavlova Kamburova graduated in Physics at the Faculty of Physics at Sofia University "St. Kliment Ohridski" in 2001. She was a graduate in the laboratory "Lasers with condensed media", Institute of Electronics "Acad. Emil Dzhakov", BAS, and defended a thesis on "Study of hard human tissues by the method of reflective spectroscopy". She also had specializations in Medical Physics and Meteorology.

During the period 2002-2003 she worked as an assistant operator-weather forecaster in the Meteorological Office, TV-MET, Sofia, then as a physicist in the Institute of Physical Chemistry "Acad. R. Kaishev", BAS.

Kamelia Kamburova was a doctoral student at the IPC-BAS during the period 2004 - 2006. She received the educational and scientific degree "Doctor" after defending a thesis on "Electrical properties and thickness of multilayer films of biopolymers on colloidal particles". From 2009 to 2011 she was a research associate of II degree and since 2011 a research associate of I degree at the IPC-BAS.

She specialized at the Bayreuth Center for Colloids and Surfaces, University of Bayreuth, Germany (2006-2007), where she conducted investigation of the electrical properties of polyelectrolytes, free in solution and adsorbed on colloidal particles, and polyelectrolyte solutions of varying degrees of charge neutralization by means of electric birefringence.

2. General description of the presented materials received

The documents presented by the only candidate for the competition, Dr. Kamelia Kamburova from the department "Surfaces and Colloids", IPC-BAS, are in accordance with the Regulations for Scientific Development of the Academic Staff of IPC-BAS and the criteria for occupying the academic position of Associate Professor. All publications are in the scientific field of the announced competition.

The total number of points on scientometric indicators is **457** points (indicator A - 50, indicator B - 100, indicator D - 235, indicator D - 72) with a requirement of 430 according to the regulations of ZRAS - IPC - BAS for holding the academic position "Associate Professor".

According to the information presented by the candidate, the total number of publications is 27, of which 21 are in refereed journals with impact factor / Q rank (10 with rank Q1, 10 with Q2, and 1 with Q3), 5 are in conference proceedings and 1 in journal without impact factor. 5 of the publications are presented for the doctoral degree. 19 of the scientific papers are cited 176 times (Scopus). According to Scopus, the h-index is 8.
The publications are in prestigious joumals such as Langmuir, Biomacromolecules, Colloids and Surfaces B: Biointerfaces, Colloid and Polymer Science etc.

The works were presented at 14 national (9 lectures and 5 posters) and 31 international (12 lectures and 17 posters) scientific forums, and 13 lectures at the "Alexey Sheludko" Colloquium in the Surfaces and Colloids seminars section

In the competition for associate professor Dr. Kamelia Kamburova participated with a total of 22 publications (16 published in peer-reviewed journals with IF in the period 2008 - 2021, and 6 publications without impact factor). 5 of the publications, all with rank Q2, are included in the habilitation thesis (Indicator B). The publications outside the habilitation work (Indicator D) are 17 (11 with IF/Q rank - 4 with rank Q1, 6 with Q2 and 1 with Q3; and 6 without IF).

Dr. Kamburova is the first author of 4 and the second author of6 ofthe publications, that shows her significant contribution to the published works.

3. General description of the research and applied research activity of the candidate

Dr. Kamburova's research activity is focused in two directions: (i) design, build-up and functionalization of colloidal particles with multilayer polyelectrolyte coatings for building up composite materials - polymer nanocontainers and nanoparticles containing a corrosion inhibitor, and encapsulation of drug particles for controlled drug delivery; and (ii) exploring the electro-optical phenomena to determine the electrical characteristics (electric dipole moments and polarizabilty) of colloidal systems; the size and dispersion of inorganic, organic and biological particles and the influence of charged polymers on the electrical properties of colloidal particles.

A number of techniques were explored for measuring the electric properties of colloids and their stability in suspension; to control the formation, the size and aggregation of nanocontainers; the surface morphology; the protective properties and the corrosion behavior of the composite coatings – electro-optical (electric light scattering, electric birefringence), microelectrophoresis, measuring of ζ-potential, cyclic voltammetry, potentiodynamic polarisation, polarisation resistance measurements, scanning electron microscopy, X-ray diffraction, X-ray photoelectron spectroscopy.

The habilitation work summarizes research on the incorporation of corrosion inhibitors (publications №15, 17, 22, 26) and drugs (publication №18) in nanocontainers/nanoparticles. Publications outside the habilitation work (№19,20,21,23,24,25,27) are also related to the design and characterization of nanocontainers with built-in corrosion inhibitor. The rest of the publications (№6,7,9,10,11,12,13,14) are related to electro-optical investigations of colloid-polyelectrolyte suspensions and colloid particles functionalized with multilayer polyelectrolyte films and lipid nanotubes (№16), and one publication (№1) presenting spectral analysis and an algorithm for determining the state of tissues and detection of lesions.

The research is of a fundamental nature, but some results would have practical application. A successful strategy is presented for construction of nanocontainers and nanoparticles with a built-in corrosion inhibitor to protect metal surfaces from corrosion and for sustained release of the encapsulated inhibitor, that may have important applications. The main advantages of the electro-optic technique were demonstrated: the ability to obtain simultaneously information about the electrical characteristics and the thickness of polyelectrolyte multilayer films deposited on anisometric colloidal particles; and to follow the mobility of counterions of the adsorbed polymers, to discriminate between free and condensed counterions and to help understanding the overcompensation of particle charge. The construction of polyelectrolyte coatings is important for biomedical applications, and the research on the complexation of polyelectrolytes and oppositely charged colloidal particles is of interest for potential application in gene therapy.

Dr. Kamburova participated in 18 research projects related to the main areas of her research work (8 projects funded by State Funds and the Ministry of Education and Science, 4 projects under European and international programs and funds, 4 are COST-Action, and 2 projects on

international cooperation in the framework of inter-academic treaties and agreements (EBRD)). She was coordinator of 1 of the projects.

Expert activities Dr. Kamburova was a reviewer of thesis and wrote reports for the evaluation of projects for textbooks in physics (6 issues printed edition and electronic version of the MES, 2018), for the evaluation of a project textbook in physics and astronomy (5 issues printed edition and electronic version to the Ministry of Education and Science, 2019) and for evaluation and approval of a draft textbook for specialized training for XI grade in physics and astronomy (3 issues printed edition of the Ministry of Education and Science, 2020).

During the period 2011 - 2020 she was a member of the following scientific organizations: International Association of Colloid and Interface Scientists (IACIS), European Colloid and Interface Society (ECIS), European Colloid and Interface Society (ECIS), Affiliate membership of IUPAC.
She was a member of the organizing committee of 7 consecutive national forums on physical chemistry for young scientists and doctoral students (2012 - 2018).

Teaching activity Since 2019 Dr. Kamburova has been a part-time lecturer in physics at the Technical University, Sofia.
She conducted laboratory exercises in Physics at the Faculty of Applied Mathematics and Informatics of the Technical University, Sofia, in 2019/2020 and 2020/2021, and on Non-standard electro-optical equipment for characterization of nanostructures under the Pilot program for training of young specialists in 2007.

She participated in a practical course for the Fourth training seminar "Methods and equipment for research in liquid media and surface phenomena, including opportunities for application in ecology", 16.04.2014 - 17.04.2014, in the Laboratory of Electro-Optics and Microelectrophoresis, IPC - BAS. She supervised 2 students from the Faculty of Biology, Sofia University "St. Kliment Ohridski", in the period December 9, 2019 - March 31, 2020.

4. Main scientific and applied scientific contribution

The main contributions from the research work of Dr. Kamburova can be summarized as follows:

Encapsulation of the corrosion inhibitor benzotriazole (BTA) in nanocontainers and nanoparticles

The positively charged corrosion inhibitor BTA is incorporated in nanocontainers (NC) of "core-shell" type, constructed by encapsulation of rod-shaped hematite particles, kaolinite and zinc oxide nanoparticles, using layer-by-layer (LbL) deposition of a pair of oppositely charged polyelectrolytes: (poly (acrylic) acid) (PAA) and poly (diallyldimethyl) ammonium chloride (PDADMAC)); and (poly (acrylic) acid and poly (ethyleneimine)) on the surface of the nanoparticles.
- The nanocontainers (hematite and kaolinite particles) are incorporated into a matrix of zinc coating on steel by simultaneous or sequential electrodeposition with zinc from zinc sulfate solutions. It has been found that (1) the formation of stable suspensions of nanocontainers and the incorporation of inhibitors is controlled by the ionic strength and pH of the medium and the polymer solutions; (2) The presence of NaCl and the increased thickness of the polyelectrolyte coatings on the particles increase the amount of entrapped inhibitor compared to nanocontainers formed in the absence of NaCl; (3) the corrosion inhibitor is released from the nanocontainers by changing the pH of the medium, lowering the pH leads to decrease in the dissociation of the negatively charged polyelectrolyte and consequently to its electrostatic interaction with the positively charged polyelectrolyte, respectively.

- It has also been demonstrated that the top adsorbed polymer layer controled the PAA / PDADMAC film behavior. The positively charged PDADMAC as a top layer of the coatings allowed electrophoretic deposition on the cathode. The BTA molecules were found to

incorporate mainly in the negatively charged layers of PAA, as well as in small amounts in PAA or PAA / PDADMAC coatings when the top layer is PDADMAC. By increasing the number of adsorbed polyelectrolyte layers, the BTA content in the PAA / PDADMAC coating is increased. The inhibitor may be released by the nanocontainers in response to changes in the medium pH.

Incorporation of the corrosion inhibitor Safranin

The same design was applied to incorporate the corrosion inhibitor Safranin into a matrix of zinc oxide (ZnO) nanoparticles and ZnO-based nanocontainer coatings. Protective zinc composite coatings were obtained by a two-step procedure - nanoparticles and nanocontainers are deposited at pH 7.5, while zinc is applied to steel substrates from zinc sulfate acidic solution (pH 4.5-5.0), which leads to the formation of homogeneous zinc coatings. The pH and the concentration of NaCl in the immersion polymer solutions proved to be important for the formation of stable NC and for incorporation of safranin, that can be released from NC under neutral conditions. The ZnO-based nanocontainers impregnated with safranin show improved protective characteristics of mild low carbon steel against corrosion for a long time and almost uniform distribution of NC in the hybrid zinc coatings maintaining size close to that of NCs in stabilized suspensions before electrodeposition.

Modified nanoparticles embedded in zinc coatings

Suspensions of positively charged carbon spheres and positively charged colloidal polymer-modified particles of polyaniline silica (PANI-SiO_2) sterically stabilized against aggregation were obtained by adsorption of Pluronic F127 triblock amphiphilic copolymer on the surface of the particles.

- The inclusion of polymer-modified particles in zinc / composite zinc coatings improves the corrosion resistance and the protective ability of the hybrid zinc coatings (in 5% NaCl medium), which is due to the formation of a mixed layer containing zinc corrosion products and carbon sphere particles acting as an additional physical barrier against the penetration of corrosion agents.

Encapsulation of drugs for controlled drug release

- Nanocapsules with polysaccharide (chitosan and pectin) coatings containing the anti-inflammatory drug indomethacin (IMC) have been found to prolong the release time of the drug, the amount of the released IMC and the release rate depend on the concentration of ions (NaCl and CaCl2). A procedure for optimizing the coating thickness of the capsules (which increases linearly with the number of layers applied) for controlled drug release was developed.

Electro-optics of colloid-polyelectrolyte suspensions

Ferric oxide (β-FeOOH) particles were explored as a model to study the electrical properties and stability of colloid-polyelectrolyte suspensions and their dependence on the charge density and charge distribution in the chain of fully ionized polyelectolyte chain.

- The electro-optic behavior of β-FeOOH suspension shows that the maximum of particles´ aggregation in suspensions coincides with the charge neutralization point; the concentration of polyelectrolyte, needed to neutralize the particle charge decreases with increasing the polymer charge density, with exception of the most highly charged polyelectrolyte, explained with reduction of the effective charge density due to condensation of counterions. A theoretical model for the counterions condensation is proposed that explains the increase in the length of the weak polyelectrolyte chains with increasing their charge.
- Estimation of the condensed counterions in highly charged polyelectrolyte free in solution and adsorbed on poorly charged particles applying the theory of Sens and Joanny, and Manning's theory, respectively, is indicative of insignificant effect of the adsorbed polymers on the electric properties of the particles.

Functionalized colloid particles with multilayer polyelectrolyte films

- The layer-by-layer technique for building up multilayer polyelectrolyte coatings from biopolymers and synthetic polymers has been modified for performing electro-optical measurements.

- The findings that the electrical polarizability and the thickness of weakly charged particles covered with highly charged polyelectrolyte increase with the ionic strength, that is related to a significant increase in the adsorbed amount of polyelectrolyte chains, while the electrophoretic mobility of the particles remains unchanged, indicate that higher quantity of mobile counterions is imbedded in the polymer matrix. It was demonstrated that polarization of counterions along the chains of the last-deposited polymer layer governs the behavior of the whole multilayer film.

Evidences are given that the film thickness can increase: (i) exponentially with the number of the deposited layers even in the absence of salt when a fully charged polyelectrolyte is combined with a weakly charged one, or (ii) linearly that is explained by the desorption of complexes from the film surface. The adhesive characteristics of multilayer films are directly related to their swelling and hydrating properties.

Electric polarization of lipid nanotubes

Electro-optic characterization of self-assembled lipid (galactosyl ceramide) nanotubes (LNTs) mimicking the lipid bilayer of biological membranes has shown that the electric polarization was dependent on the electrokinetic charge. This approach could be applied to investigate the physicochemical properties of other organic nanotubes as well as to characterize accommodation of proteins or other substances in the lipid nanotubes.

5. National and international recognition of the scientific publications of the candidate

19 of the scientific publications were cited 176 times (according to Scopus) that is an evidence for the international recognition of the research work of Dr. Kamburova.
Recognition of Dr. Kamburova's achievements are her awards for:
- scientific achievements in the field of physicochemistry with the Award "Acad. Rostislav Kaishev" (2007);
- the most important scientific and applied achievement of IFH - BAS for 2013 and 2016;
- the most significant scientific achievement of IFH - BAS for 2020.

CONCLUSION

The scientific production and scientific indicators of Dr. Kamelia Kamburova meet the recommended requirements for occupying the academic position of "Docent" according to the Act for the Development of the Academic Staff in the Republic of Bulgaria (ADASRB) and the Regulations for the Application of ADASRB in the IPC-BAS. The significant contribution of the scientific production of Dr. Kamelia Kamburova and the prospects for future research gives me a confidence to support her nomination for the academic position "Docent" and to recommend to the Scientific Jury and to the Scientific Board of IPC-BAS to elect Dr. Kamelia Pavlova Kamburova for the academic position "Docent" in professional field 4. Natural sciences, mathematics and informatics, professional field 4.2. Chemical Sciences, scientific specialty "Physical chemistry".

Sofia
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/Prof. DSc Stefka Germanova Taneva/