REVIEW

On a Competition for academic position " Professor", Scientific direction 4.2., Chemical sciences, Speciality Physical Chemistry at the institute of Physical Chemistry, Bulgarian Academy of Sciences, published in SG number 41/20.05.2025

CANDIDATE: Assoc. Prof. Viktoria Milkova Nakova, PhD

Reviewer: Krastanka Georgieva Marinova, PhD, Professor at the Faculty of Chemistry and Pharmacy, Sofia University "St. Kliment Ohridski"

1. General characteristics and brief curriculum vitae about the candidate.

The materials presented by the only candidate in the competition Assoc. Prof. Viktoria Milkova, PhD, meet the minimum national requirements of the Act of Development of Academic Staff of the Republic of Bulgaria and the Regulations for its implementation, as well as the Rules of the Bulgarian Academy of Sciences (BAS) and the Regulations on the terms and conditions for obtaining scientific degrees and holding academic positions in the Institute of Physical Chemistry (IPC) of BAS. Mrs. Viktoria Milkova graduated MSc degree in Chemistry in 1998 (Specialization Chemical Physics and Theoretical Chemistry) in Sofia University „St. Kliment Ohtidski", Faculty of Chemistry. In 2000 she started full-time doctoral studies at the Institute of Physical Chemistry, BAS, and received the educational and scientific degree of "Doctor" in the specialty "Physical Chemistry" in 2006 with a thesis entitled „Electro-optical investigation of the structure and the electrical properties of the polyelectrolyte multilayers on the colloidal particles". In 2010-2011 and 2024-2015 he realized two long-term specializations in the Laboratory of Physical Chemistry and Colloid Science, Wageningen University and Research Center, Wageningen, The Netherlands, and in the Institut für Biology und Biotechnologie der Pflanzen, Westfälische Wilhems-Universität Münster, Germany, respectively. She is actively involved in national and international projects and makes shorter visits to other universities outside Bulgaria.

2. Description of the presented materials.

For her participation in the competition Assoc. Prof. Milkova has presented five publications as the equivalent of a habilitation thesis, all of which have been published in reputable scientific journals - four in the first quartile (Q1): *Carbohydrate polymers*, *Polymers*, Gels, *Polysaccharides*, and one in *Sci* - having SJR without IF. A list of 11 other publications after acquiring the academic position of Associate Professor, which are also in reputable scientific journals, is also presented – 3 papers in Q1 6 in Q2, 1 in Q3 journals, and 1 book chapter.

A list of 61 citations is presented, i.e. 122 points by in group D (minimum required 120). The participation in international and national scientific projects and networks, as well as the management of three national projects with BGN 495,000 attracted correspond to 369 points (minimum required 150) in group F.

The materials presented in the application cover the minimum national requirements and those of BAS and IPC as well: group A - 50 points (min req. 50 points), group B - 110 points (min req. 100 points), group G - 225 points (min req. 220 points), group D - 122 points declared (min req. 120 points), group E - 369 points (min req. 150 points).

3. General characteristics of the research activities of the candidate.

Assoc. Prof. Milkova is the author and co-author of a total of 41 scientific publications, of which 37 are visible in the database Scopus. 20 publications are in renowned physicochemical and polymer journals from Q1 (JCIS, Langmuir, J. Phys.: Condense Matter, Biomacromolecules, Carbohydrate polymers, Polymers, CSB, Molecules, etc.), 13 are from Q2 (CSA, Colloid and Polymer Science, Coatings, Neurology International, Scientia Pharmaceutica), 1 is in a journal from Q3, and 7 are in books, conference proceedings and journals without SJR.

The main topics in the candidate's publications are the properties of adsorption layers of various synthetic and natural polymers studied using a variety of electro-optical methods, and applied for stabilization of disperse systems with various applications such as anti-corrosion coatings, or encapsulation of active substances for pharmaceuticals. A significant part of the work is devoted to fundamental physicochemical properties of polymer layers adsorbed on surfaces. Number of works present important applications of colloidal systems (mostly suspensions and nanoemulsions) stabilized with polymers, and especially polysaccharides.

4. Main scientific contributions.

Author's reference for the period after occupying the academic position of Associate Professor in the 2015 presents several groups of contributions in three main areas, in which are all 16 publications presented for the competition (5, which are equivalent to habilitation thesis in group of indicators B, and 11 in the group of indicators G).

The first area includes contributions to the study and description of the relationship between the physicochemical characteristics of polysaccharides (chitosan and alginate) and their ability to stabilize model colloid-polymer suspensions. These contributions are formulated on the basis of the results presented in five scientific publications on the adsorption of chitosan and alginate on different model particles.

The study of chitosan adsorption on model non-spherical particles (published in Colloids Surfaces A, 2015) demonstrates the applicability of the electro-optical methods for studying and describing the mechanical properties of multilayer films.

In the following works (Colloids Surfaces A 2017, Carbohydrate polymers 2021, Handbook of Research on Nanoemulsion Applications in Agriculture, Food, Health, and Biomedical Sciences, 2022) electrokinetic and electro-optical investigation of various chitosan systems has been systematically applied to outline many important properties of the chitosan films:

- The dependence of the ζ-potential on the concentration and of the electro-optical effect dependence on the applied electric field, have been analyzed in depth and the contributions of electrostatic and hydrophobic interactions responsible for achieving electrosteric stabilization of the studied systems have been distinguished.
- It has been experimentally confirmed that at a high degree of acetylation, hydrophobic interactions dominate the adsorption, while at a low degree of acetylation, adsorption

is determined by the electrostatic interactions between chitosan monomers and a charged surface.

- It has been shown that nanoemulsions stabilized with lecithin in the presence of different concentrations of chitosan oligosaccharides with fully uncharged 4 or 5 monomers gradually decrease the ζ-potential (by absolute value) with concentration, but no surface recharge is achieved. It has been proven that the adsorption of short uncharged chains results from the hydrophobic interactions with the hydrophobic domains of the lecithin layer stabilizing the emulsion droplets, and the decrease in electrokinetic charge is due to a shift in the plane of transition of the double electric layer.
- Critical degree of acetylation (DA) is defined of chitosan polysaccharides, below which an increase in the concentration of chitosan in the emulsion does not change the isoelectric point, and surface recharge does not depend on the molecular weight of the polymer: DA<28 %. At DA>28 %, the isoelectric point of the droplets and the recharge of the surface are shifted to a higher polymer concentration.
- It has been suggested that the electrical properties of the adsorbed polysaccharides on the model surface depend on the molecular weight and the degree of acetylation. The analysis of electrical polarizability makes it possible to distinguish the properties of chitosan with DA<28 % when the electrokinetic behavior of particles/emulsion droplets is almost the same. An estimate has been made of the fraction of the released Cl^- counterions as a result of the adsorption of chitosan on the surface. Based on the assumption that the polarization of the "condensed" counterion fraction near the polyion chain defines the electrical properties of the systems studied, the electrical polarizability of a polyelectrolyte molecule was calculated.

The properties of alginate adsorption films on model non-spherical particles have also been investigated by analyzing their electro-optical and electro-kinetic behavior (Gels, 2023), and the role of the structure of alginate and electrolyte for the stability of the studied suspensions is analyzed. I will highlight some of the more important contributions to this topic:

- It was found that the decrease in electrophoretic mobility upon Ca^{2+} addition is greater the lower the ratio of blocks mannuronate (M) to blocks guluronate (G) or the higher the molecular weight of the alginate. It has been found that the electro-optical effect (at 1 kHz) of stable suspensions of particles coated with alginate increases until the critical concentration of Ca^{2+} is reached, and then decreases upon further increase of Ca^{2+} concentration. This critical concentration of Ca^{2+} (3×10^{-5} M) does not depend on the characteristics of alginate.
- It has been suggested that the polarization of condensed Na^+ counterions along the length of the polyion is responsible for the recorded electro-optical effect. An estimate of the fraction of condensed counterions released as a result of alginate adsorption (without Ca^{2+}) has been carried out. This analysis is based on theoretical models according to which highly charged polyelectrolytes retain some of their condensed counterions when adsorbed on a weakly charged surface.
- A correlation has been established between the increase in the electro-optical effect (at high orientation energies, in absence of Ca^{2+}) and an increase in the fraction of guluronate blocks, as well as an increase in the molecular weight of polymers. In the presence of a very low concentration of Ca^{2+} a correlation has been established between

the increase in the electro-optical effect (at 1 kHz) and the increase in the fraction of guluronate blocks, which is explained by a stronger interaction between divalent ions and alginate molecules.

The second area includes contributions to the formation and characterization of multilayer films of polysaccharides and carbon nanomaterials (carbon dots) on non-spherical particles, which have been published in Milkova's work in Polymers 2023. Among the contributions here, I would like to highlight:

- The successful inclusion of Cdots in the film as a result of the electrostatic interaction between the negatively charged Cdots and the positively charged monomers of chitosan absorbed on the surface of the film.
- Proposed mechanism of film formation, which explains the anomalous behavior in the oscillation of the thickness and polarizability of the film with the formation of non-stoichiometric complexes in the suspension, which are adsorbed on the surface at the next absorption step.

The third area includes contributions to the development and characterization of model polysaccharide-containing systems for the transport and controlled release of active components. These contributions have been published in a total of 10 scientific publications in reputable journals (Polysaccharides, Molecules, Plants, Life, и др.) in the period 2020 – 2025. Here I would like to highlight:

- Stable liposomes are obtained suitable for encapsulation of various bioactive components (the drug Veklury®, homotaurine or extracts of medicinal Bulgarian plants) stabilized with a monolayer of poly- and oligosaccharides of chitosan, as well as with a multilayer film formed by chitosan and hyaluronic acid or κ-carrageenan. Detailed analysis of the influence of the physicochemical characteristics of polysaccharides and the experimental conditions (concentrations, pH, ionic strength, temperature, combination of polysaccharides) on the size, stability, amount of encapsulated agent is performed. Microbiological tests and assessment of oxidative stress in the presence of the resulting structures are carried out.
- The drug Veklury® is encapsulated in polymer capsules. The main ingredient of the drug is remdesivir, a substance that was among the contenders for a drug against COVID-19.
- Stable liposomes loaded with multicomponent aqueous extract of Bulgarian medicinal plants have been obtained and successfully characterized (Glycyrriza glabra L.; Sambucus nigra; Aesculas hippocastanum; Potentilla reptans; Allium sativum) and their effect on human coronavirus HCoV-OC43 was analyzed.
- Stable oil-core nanocapsules suitable for encapsulation of active molecules and drugs (indomethacin, Veklury®, curcumin and caffeine) have been obtained. For this purpose, O/W nanoemulsions stabilized with lecithin were obtained, which were further stabilized by adsorption of a thick layer of chitosan or a multilayer film of chitosan/hyaluronic acid. Slightly soluble in water substances are encapsulated in the oil phase and highly water-soluble substances are encapsulated in a polymer shell. Through a systematic study of the influence of the physicochemical characteristics of polysaccharides, stable nanocapsules suitable for encapsulating a high concentration of the active component have been obtained. The stability of the obtained structures and

the kinetics of the release of the active component in simulated biological media are characterized.

- By ion-induced gelation, chitosan particles (nanogels) are obtained and characterized, respectively empty and loaded with a corrosion inhibitor (benzotriazole). The resulting particles are embedded in a zinc coating.

Overall, the scientific activity of Assoc. Prof. Victoria Milkova is characterized by a systematic and in-depth scientific approach.

Assoc. Prof. Milkova is the first author of 13 of the 16 scientific publications submitted for the competition. She is the single author of 4 of the five papers presented as the equivalent of habilitation thesis. These facts clearly demonstrate the principal role of the candidate to the research and the scientific contributions.

Most of the scientific contributions from the research activity of the candidate can be defined as proving significant new aspects of existing and new scientific and applied scientific problems. The developed approaches and the obtained results enrich significantly the scientific knowledge, and are undoubtedly essential for obtaining new materials with pharmaceutical, biomedical and technical applications.

5. Impact of the scientific publications of the candidate in the Bulgarian and international scientific literature.

The total number of publications of Assoc. Prof. Milkova, referenced in Scopus database is 37 (up to 24.09.2025), the citations (with excluded self-citations by all authors) are 211 (h-index 10). The Author's reference (prepared in July 2025) includes 244 citations and proves an h-index of 12. There are over 50 citations on the works submitted for the competition, and given that 14 out of 16 works were published after 2020, I consider this number to be significant. The results of these papers have been presented at 25 scientific conferences. All these facts show the quality and relevance of the candidate's scientific work, and the good assessment of the international scientific community for the works.

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

I have no critical comments on the submitted works and materials of the competition. There are some technical errors in the presented documents, but the important scientific results and contributions are well presented and highlighted.

I have a question about the specified critical concentration of Ca^{2+}, at which the electro-optical effect (at 1 kHz) is maximum. It has been shown that this critical Ca^{2+}concentration (3×10^{-5} M) does not depend on the characteristics of alginate. My question is whether the dependence on the concentration of alginate has been studied and how the results are explained?

7. Personal impressions of the reviewer about the candidate.

I have good impressions of Victoria Milkova from her work in our department in the period 1998 – 2000 as a modest and hardworking student. Her scientific and academic development over the past 25 years testifies to hard and fruitful work, as well as good organizational and communication skills.

CONCLUSION

Based of the materials submitted in the competition, the quality of the scientific publications, the systematic and in-depth approach, and the clear substantial contribution of Assoc. Prof. Victoria Milkova Nakova for the contemporary development of important areas in the physical chemistry of colloids and surfaces, polymers and biopolymers, I find the application to fully correspond to the requirements of the Act of Development of Academic Staff of the Republic of Bulgaria and the Regulations for its implementation for occupying the academic position Professor. I am confidently giving a POSITIVE assessment and I recommend Assoc. Prof. Viktoria Milkova Nakova to be elected to the academic position of "Professor" at IPC-BAS, in the professional field 4.2 Chemical Sciences, Speciality "Physical chemistry".

24.09.2025 Reviewer:

Sofia /Prof. Krastanka Marinova/