ABSTRACTS OF PUBLICATIONS AND STATEMENT ABOUT RESEARCH CONTRIBUTION

by **Senior Assist. Prof. Ivan Panayotov Bodurov, Ph.D.**

for participating in the competition for occupying the academic position
'Associate Professor',
proclaimed in State Gazette No. 57, 26 June 2020

higher education area: 4. Natural Sciences, Mathematics and Informatics
professional field: 4. 1. Physical sciences
(Electrical, magnetic and optical properties of the condensed matter)

The materials presented for participation in the competition for the academic position of 'Associate Professor' include 43 scientific publications in referenced scientific journals, which are not included the scientific publications for obtaining the educational and scientific degree 'Doctor'. The materials for participation in the competition for the academic position of 'Associate Professor' also include 1 textbook, 1 guide for laboratory exercises and 3 utility model registration certificates, which are the result of the scientific activity of the candidate after the academic position 'Senior Assistant Professor'.

I. MONOGRAPH (chapter of book)

1. M. Marudova, A. Viraneva, S. Sotirov, **I. Bodurov**, G. Exner, I. Vlaeva, T. Yovcheva, *Innovative Biopolymer Nano-Multylayered Films for Biomedical Applications: Fabrication and Physical Properties*, In **"Advances in Polymers for Biomedical Applications"**, D. Pathania, B. Gupta (Eds.), Nova Science Publishers, New York (2018). ISBN: 978-1-53613-612-8

The build-up of new functional materials with controlled structures and properties in micro - and nano-dimensional scale is of essential interest because of their use in biomedicine, pharmaceuticals, tissue engineering, and regenerative medicine. From that point of view, the layer-by-layer deposition of polyelectrolytes on a substrate is imposed and comparatively easy to realize. It is a technique, which includes a wide range of materials and surfaces, thanks to which it is possible to make nanostructured multilayer coatings.

The polyelectrolyte structures formulated by layer-by-layer deposition represent an outstanding and successful solution to the high demands of pharmaceutical science, where innovative therapeutic systems that provide sustained release in a specific target area with improved efficacy of well-known medical substances are targeted.

The present chapter summarizes the investigations on the formulation and physicochemical properties of polyelectrolyte multilayer (PEM) deposited onto planar polymer substrates, with a potential application as drug delivery carriers on buccal mucosa. The progress and success in the designed PEM was monitored by the newest, modern methods for characterization of the PEMs such as FT-IR, UV-VIS spectroscopy, XPS, SEM, AFM, laser refractometry. Biocompatible polymers, like polypropylene, poly-ε-caprolactone, and polylactic acid were used as substrates of PEM.

Multilayers were formulated from different natural polyelectrolytes – chitosan, xanthan, pectin, poly-L-lysine, carboxymethylcellulose. The layer-by-layer deposition process was accomplished by two methods, spin-coating and dipping.

The novelty in the PEMs presented here is the corona pretreatment of the substrate, which guaranteed an excess of charge on the substrate surface and improved the conditions for polyelectrolyte anchoring.

The experimental results suggested a successful, irreversible deposition of these well formulated PEMs. Changes in the deposition conditions led to corresponding changes in the PEMs structure, which gave one the route to precise modification of their properties in a desired direction, in accordance with the potential application.

The effect of the surrounding environment – pH and ionic strength on the formulation and stability of the PEMs was also investigated.

II. PAPERS IN JOURNALS AND CONFERENCE PROCEEDIGS

2. E. A. Gencheva, T. A. Yovcheva, M. G. Marudova, A. P. Viraneva, **I. P. Bodurov**, G. A. Mekishev and S. H. Sainov – *Formation and Investigation of Corona Charged Films from Polylactic Acid,* **AIP Conference Proceedings**, 1203, pp. 495-500 (2010). *http://dx.doi.org/10.1063/1.3322494*
SJR = 0.142;

The aim of the present work is the development of technology for formation of corona charged electret films from polylactic acid and investigation of their structural, optical and electret properties. Polylactide films with different degree of crystalinity were prepared by casting of poly-L-lactide and poly-DL-lactide blended solutions. Then glass transition, crystallization and melting temperatures, as well as the crystalinity degree were determined by a differential scanning calorimetry. The charging of the samples in a corona discharge was carried out by means of a conventional corona triode system. Sample surface potential was measured by the method of the vibrating electrode with compensation. The time dependences of the sample surface potential under room conditions were studied for 50 days. The effect of lower pressure on the surface potential of charged samples was investigated. It was established that the reduced pressure leaded to the surface potential decay of the PLA electrets. The same effect was earlier observed for other polymer films. The optical characteristics – surface refractive index and optical dispersion, were determined by the method of the disappearing diffraction pattern using a laser refractometer.

3. T. Yovcheva, E. Vozary, **I. Bodurov**, A. Viraneva, M. Marudova, G. Exner – *Investigation of apples' aging by electric impedance spectroscopy,* **Bulgarian Chemical Communications 45** (B), pp. 68-72 (2013).
SJR = 0.14; IF = 0.32; Q4 (2013);

Electric impedance spectroscopy, as a fast and non-invasive method, was used to monitor apples' properties during aging. This method provides information about the physical properties of apples which are closely related to the chemical ones. Two different analytical techniques for assessment of the changes of apples' properties during aging time were proposed. The first one is based on a single measurement in the low frequency range (around 100 Hz) and the other one - on Argand plot. According to our results, the observed changes in the electric impedance spectroscopy spectra can be attributed to the

changes in the relative moisture content of the apples. The apoplastic and simplistic resistances and relaxation times were derived by modeling the apples' behaviour with equivalent circuit scheme.

4. A. Viraneva, T. Yovcheva, **I. Bodurov** and M. Galikhanov – *Effect of TiO_2 particle incorporation on the electret properties of corona charged polypropylene composite films,* **Bulgarian Chemical Communications 45** (B), pp. 73-76 (2013).
SJR = 0.14; IF = 0.32; Q4 (2013);

In the present paper the influence of the concentration of TiO_2 particles of average size 500 nm on the electret properties of the polypropylene (PP) composite films were studied. We investigated the PP composite films with different weight concentrations of the TiO_2 particles (0 wt.%, 2 wt.% and 4 wt.%) and thickness of 200 μm. The samples were charged 1 minute under room temperature by the method of the corona discharge using a point-to-plate three electrode system in a positive or in a negative corona.

The voltage of the corona electrode was ± 5 kV and the one of the grid was ± 1 kV with the same polarity. The surface potential of the electrets was measured by the method of the vibrating electrode with compensation. We studied the surface potential decay with reference to both time and storage temperature aiming at determination of the particle influence on the stability of the electret composite films.

The results obtained showed a significant change in the electret behaviour of the composite films after the introduction of particles with different concentration into the PP matrix. It was established that the surface potential decay depended on the corona polarity and the concentration of the particles.

5. **I. Bodurov**, I. Vlaeva, T. Yovcheva, V. Dragostinova and S. Sainov – *Surface properties of PMMA films with different molecular weights*, **Bulgarian Chemical Communications 45** (B), pp. 77-80 (2013).
SJR = 0.14; IF = 0.32; Q4 (2013);

The paper presents the results of the investigation of the surface refractive index and the contact angle analysis of poly(methyl methacrylate) (PMMA) films. The following two PMMA trademarks, Vedril (Italy) and Plexigum (Germany) with different molecular weights were used. Films of PMMA were prepared by the drop casting technique using 10 wt. % solution of PMMA in 1,2-dichlorethane. The surface refractive index was measured by the method of the disappearing diffraction pattern using a laser microrefractometer at wavelengths of 405 nm, 532 nm and 656 nm. The experimental uncertainty was 1.5×10^{-4}. The obtained experimental data were used for dispersion analysis following the Sellmeier and the Wemple DiDomenico one term models. The differences between the surface refractive index values of the upper and lower side of the samples (the sample-air interface and the sample-substrate one) were observed. The influence of the polymer molecular weight on the surface properties of the lower and upper film's side was estimated based on the free surface energy values, calculated with the help of the contact angle technique and the Bickermann's method. The refractive index differences observed are analyzed on the basis of the molecular refraction and the free surface energy components changes.

6. **I. Bodurov**, I. Vlaeva, M. Marudova, T. Yovcheva, K. Nikolova, T. Eftimov and V. Plachkova – *Detection of adulteration in olive oils using optical and thermal methods,* **Bulgarian Chemical Communications 45** (B), pp. 81-85 (2013).

SJR = 0.14; IF = 0.32; Q4 (2013);

Quantification of olive oils is an important issue because of frequent adulteration with cheaper oils such as soybean, sunflower or canola. The standard chemical methods used to determine the chemical content of the oils are usually time-consuming, laboratory intensive and expensive. Therefore, we have tested three physical methods measuring refractive indices and their dispersion curves, fluorescence spectra and DSC spectra that are related to the chemical structure and content of the olive oils. These methods are fast, easy to perform and do not require any additional chemical agents. Two groups of olive oils – pure and adulterated, were investigated.

7. **I. Bodurov**, R. Todorov, T. Yovcheva, G. Spassov and S. Sainov – *On silver electro-migration in nano-sized As_2S_3,* **Bulgarian Chemical Communications 45** (B), pp. 86-89 (2013).
SJR = 0.14; IF = 0.32; Q4 (2013);

In this paper the silver mobility in thin chalcogenide films is investigated. The diffraction gratings in 96 nm thick As_2S_3 films are holographically recorded using evanescent wave, created by total internal reflection and normally incident plane one. The grating step Λ is 447 nm and corresponding spatial frequency is 2237 mm^{-1}. 5 kV corona discharge is applied during the holographic recording. The maximum measured value of the diffraction efficiency is greater than 8 %. The mobility of silver, μ, at temperature 17 °C is calculated by the Nernst-Einstein equation. The diffusion coefficient D is obtained using the method of holographic grating spectroscopy (Forced Rayleigh Scattering). The dependence of the diffusion coefficient and the mobility of silver on corona charge polarity are investigated.

8. M. Marudova, T. Eftimov, K. Nikolova, **I. Bodurov**, I. Vlaeva, C. Grancharova and T. Yovcheva – *Advanced physics methods for honey's quality estimation,* **Proc. of International Scientific-Practical Conference "Food, Technologies & Health 2013",** pp. 231-236 (2013).
ISBN: 978-954-24-0229-9

Several physical parameters (refractive index, fluorescence, thermal and rheological properties) were investigated for 9 varieties of honey, which differ from botanical and geographical origin. The values of the refractive index were measured by a laser refractometer and were used to determine water content by reference to standard tables. The glass transition temperature (Tg) was measured by differential scanning calorimetry and was found that it decreased when the water content increased. The results obtained show that the water content for the natural honey is lower than 18 %, while it increases till 21.9 % for mixtures of honey and fructose/glucose solution. In that way the refractive index and Tg are parameters that could be used to distinguish natural honey from fake one. An increase in the intensity of fluorescence peak for natural honey was observed at wavelength 495-510 nm but no universal tendency in fluorescence behaviour could be established for honey/sweeteners mixtures.

9. **I. Bodurov**, R. Todorov, T. Yovcheva and S. Sainov – *Holographic investigation of the corona discharge effect on the photo-doping of Ag, Au and Cr into nano-sized As_2S_3,* **Bulgarian Chemical Communications 46 (A)**, pp. 256-260 (2014).

SJR = 0.14; IF = 0.32; Q4 (2014);

The paper presents the results of holographically investigated photo-diffusion of Ag, Au and Cr ions into nano-sized As_2S_3 films. Evanescent wave's holographic recordings with spatial resolution 2 500 mm^{-1} in chalcogenide/metal sandwich like structures with 50 nm thick As_2S_3 layer, were performed. When the exposure was switched off at the maximum point of the diffraction efficiency during the holographic recording, 5 kV corona discharge was applied. During the holographic recording 5 kV corona discharge was applied. The maximum measured value of the diffraction efficiency was greater than 8 %. The metal ions (Ag, Au and Cr) mobility in thin chalcogenide films was investigated. The mobility of the metal ions, μ, at temperature 17 °C was calculated by the Nernst-Einstein equation. The diffusion coefficient D is obtained using the method of holographic grating spectroscopy (Forced Rayleigh Scattering). The values of the mobility and the diffusion coefficients for Ag, Au and Cr ions were discussed.

10. **Ivan Bodurov**, Temenuzhka Yovcheva and Simeon Sainov – *PMMA films refractive index modulation via TiO_2 nanoparticle inclusions and corona poling*, **Colloid and Polymer Science 292**, pp. 3045-3048 (2014).
http://dx.doi.org/10.1007/s00396-014-3373-y
SJR = 0.8; IF = 2.410; Q2 (2014);

The present study is focused on the characterization of optical properties of poly (methyl methacrylate) (PMMA) films and the possibilities of modulation and fine tuning of their refractive index by the inclusion of different concentrations of nano-sized titanium dioxide (TiO_2) particles (less than 33 nm) and corona poling. The samples are prepared by the "spin coating" method and they are charged in a conventional point-to-plain corona system. The transparent PMMA/TiO_2 films exhibit good optical properties in the visible range. An investigation of the film's surface refractive index by two wavelengths laser refractometry utilizing the disappearing diffraction pattern method is carried out. The refractive index increases with increasing the TiO_2 content in the nanocomposite films. The corona poling increases the refractive index values for all samples regardless of the polarity and concentration of TiO_2 nanoparticles. The results show that the prepared nanocomposite films have a potential application for optical devices.

11. **I. Bodurov**, T. Yovcheva and S. Sainov – *Refractive index investigations of nanoparticles dispersed in water*, **Journal of Physics: Conference Series 558**, Art. No. 012062 (5 pp.) (2014).
http://dx.doi.org/10.1088/1742-6596/558/1/012062
SJR = 0.229; Q3 (2014);

The refractive index of nanoparticles dispersed in water is measured, using the total internal reflection method. The critical angle is determined by the disappearance of diffraction orders from a metal grating. The investigated nanoparticles are titanium dioxide (anatase phase), (35 nm diameter), zinc oxide, (<50 nm diameter), zirconium dioxide, (<100 nm diameter). The refractive index is measured with the experimental uncertainty of 1 %. The Lorentz-Lorenz, Maxwell Garnett and Bruggeman relations are applied in the nanoparticle's refractive indices calculations.

12. **Ivan Bodurov**, Temenuzhka Yovcheva and Simeon Sainov – *Five-wavelength laser micro-refractometer*, **Optica Applicata 45**, pp. 199-204 (2015).
http://dx.doi.org/10.5277/oa150206/
SJR = 0.14; IF = 0.643; Q4 (2015);

In this paper, the design and testing of a five-wavelength laser microrefractometer are presented. Five semiconductor lasers are used for the spectral region of 405–1320 nm. The presented device is based on the critical angle method. In this case, the critical angle of total internal reflection is determined with the help of a CCD camera detecting the disappearance of the diffraction pattern, created by a metal diffraction grating. The samples of a thin liquid layer (< 10 μm) are placed between a flint-glass prism and a chromium diffraction grating. The refractive indices of two matching liquid products of Cargille Laboratories are investigated for the approbation of the presented device. The measured values of the refractive indices are used for the dispersion curves construction. The obtained values of the refractive indices are compared with the catalog data given by the manufacturer.

13. T. Yovcheva, K. Nikolova, A. Viraneva, **I. Bodurov** and T. Eftimov – *Characterization of extra virgin olive oils adulterated with sunflower oil using different physical methods*, **Bulgarian Chemical Communications 46B**, pp. 16-19 (2014).
SJR = 0.14; IF = 0.349; Q4 (2014);

This paper describes a study of the usefulness of some physical methods in the detection of adulteration of extra virgin olive oil with controlled concentration of relatively cheap sunflower oil. We have tested three physical methods measuring refractive indices (RI) and their dispersion curves, fluorescence spectra and color parameters that are related to the chemical structure and content of the olive oils. The RI values of the samples were measured with a total experimental uncertainty of less than 3×10^{-4} by the method of the disappearing diffraction pattern for two wavelengths – 405 nm and 532 nm at a temperature 23 °C. Fluorescence spectra were measured using a fiber optic spectrometer (AvaSpec-2048, Avantes) and the samples were excited by light emitting diodes at 370 nm, 395 nm, 425 nm and 450 nm using the set up. The spectrometer's sensitivity is in the (200 – 1100) nm range with a resolution of about 8 nm. The color parameters (index of lightness L*, a*, b*, chroma C* and hue angle hab) corresponding to the uniform color space CIELab, were determined on a Lovibond PFX 880. The color parameters were used for determining the β – carotene and chlorophyll content in the investigated samples. All of the obtained experimental results suggest that the three optical methods presented are correlated and could be useful for a fast detection of sunflower adulteration of extra virgin olive oils. These techniques are sensitive and rapid and also do not require any additional chemical agents.

14. Valentin G. Kabadzhov, Todorka L. Dimitrova and **Ivan Bodurov** – *A turbidimetric measurement of casein micelles*, **Proc. of International Scientific-Practical Conference "Food, Technologies & Health 2015",** pp. 60-65 (2015).

This study is an attempt to define the size of casein micelles in cow milk by turbidimetric methods. Casein micelles are the largest structures of skimmed milk and their sizes characterize milk dispersity. Milk is turbid liquid absorbing feebly visible light. Casein mi-

celles are almost spherical and their dimensions do not exceed 1/10 of the wavelength of visible light, so that Rayleigh's scattering theory can be applied.

Here, skimmed cow milk diluted with distilled water in a weight ratio of 1:9 was investigated. Samples with different fat concentration were prepared by adding whole natural milk and using the Pearson concentration method. The optical density of the samples was evaluated by an optical fiber setup and an AvaSpec 2048 spectrometer. The turbidity was determined for selected wavelengths in the region from 600 nm to 770 nm where the optical absorbance is lowest. An investigation of the refractive index by a three-wavelength laser refractometer using the disappearing diffraction pattern method was carried out. The dispersion curves of the refractive index were obtained using the Sellmeier dispersion equation. Rayleigh's equation for the intensity of scattered light was used to infer scattering particles' radii. The casein micelle sizes have be found to be around several ten micrometers. The results will later be validated by high-resolution (AFM or SEM) microscopy.

The work aims at testing the ability of the used method for an evaluation of casein micelles growing during the early stage of milk coagulation.

15. **I. Bodurov**, I. Vlaeva, G. Exner, Y. Uzunova, S. Russev, B. Pilicheva, A. Viraneva, T. Yovcheva, Ts. Grancharova, S. Sotirov and M. Marudova - *Investigation of multilayered polyelectrolyte thin films by means of refractive index measurements, FT-IR spectroscopy and SEM*, **Journal of Physics: Conference Series 682**, Art. No. 012026 (7 pp.) (2016).
http://dx.doi.org/10.1088/1742-6596/682/1/012026
SJR = 0.217; Q3 (2016);

Multilayered polyelectrolyte films are promising structures in the biomedical field. In order to meet the demands for biomedical applications, the structures have to be built from biocompatible and/or biodegradable, nontoxic starting materials, possessing some specific functional properties, depending on the particular application. In the present study, the multilayered polyelectrolyte films with potential use as buccal bioadhesive drug delivery systems were investigated. They were prepared via layer-by-layer deposition of successive nanolayers onto substrate. Three different biopolymers were used. The substrate, from poly(lactic acid), was solvent casted. After that, it was subjected to corona treatment, which ensures surface charge excess for the multilayer deposition. The nano-layers were prepared either from 0.01 g/L solutions of chitosan or 0.05 g/L xanthan. Acetate buffer (pH 4.5 and ionic strength 0.1 M) was used as a solvent. The substrate was dipped successively into one of the solutions, allowing formation of polyelectrolyte complexes of chitosan (polycation) and xanthan (polyanion). The substrates was treated in negative corona. The multilayered structures consisted of 8, 9, 14, 15 or 20 nanolayers. Number of techniques, such refractive index measurements, FT-IR spectroscopy and SEM morphology were employed in order to monitor the properties of the so prepared multi-layered polyelectrolyte films.

16. Kr. Nikolova, T. Yovcheva, M. Marudova, T. Eftimov, **I. Bodurov**, A. Viraneva and I. Vlaeva – *Optical methods and differential scanning calorimetry as a potential tool for discrimination of olive oils (extra virgin and mix with vegetable oils)*, **AIP Conference Proceedings 1722**, Art. No. 220019 (2016).
http://dx.doi.org/10.1063/1.4944251
SJR = 0.152

Eleven samples from olive oil have been investigated using four physical methods – refractive index measurement, fluorescence spectra, color parameters and differential scanning colorimetry. In pomace olive oil (POO) and extra virgin olive oil (EVOO) the oleic acid (65.24 % - 78.40 %) predominates over palmitic (10.47 % - 15.07 %) and linoleic (5.26 % - 13.92 %) acids. The fluorescence spectra contain three peaks related to oxidation products at about λ = (500-540) nm, chlorophyll content at about λ = (675-680) nm and non determined pigments at λ = (700-750) nm. The melting point for EVOO and POO is between -1 °C and -6 °C. In contrast, the salad olive oils melt between -24 °C and -30 °C. The refractive index for EVOO is lower than that for mixed olive oils. The proposed physical methods could be used for fast and simple detection of vegetable oils in EVOO without use of chemical substances. The experimental results are in accordance with those obtained by chemical analysis.

17. A. Viraneva, M. Marudova, S. Sotirov, **I. Bodurov**, B. Pilicheva, Y. Uzunova, G. Exner, Ts. Grancharova, I. Vlaeva and T. Yovcheva – *Deposition of polyelectrolyte multilayer films made from chitosan and xanthan on biodegradable substrate: Effect of pH and ionic strength*, **AIP Conference Proceedings 1722**, Art. No. 220025 (2016).
http://dx.doi.org/10.1063/1.4944257
SJR = 0.152

The aim of the present work is to investigate the effect of pH and ionic strength on the deposition of chitosan/xanthan multilayers on preliminary corona charged substrates from polylactic acid. The multilayer films were formed by alternative dipping the substrate into chitosan and xanthan solution in acetate buffers with pH 4; 4.5 and 5 and ionic strenghts 0; 0.01; 0.1 and 1 mol/L were used. The film properties were investigated by FTIR, laser refractometry, XPS and AFM methods. It was found that the binding of the polyelectrolites to the substrate was irreversible over the time of deposition. The investigated parameters were found to depend on both pH and ionic strength of the polyelectrolyte solutions. This behaviour was attributed to the changes in the charge density of the polyelectrolytes and screening effect of the counterions.

18. T. A. Yovcheva, M. G. Marudova, A. P. Viraneva, S. I. Sotirov, S. H. Rusev, **I. P. Bodurov**, B. A. Pilicheva, Y. I. Uzunova, G. K. Exner, Ts. Ts. Grancharova and I. Y. Vlaeva – *Various corona treated biopolymer substrates for the deposition of polyelectrolyte multilayers*, **AIP Conference Proceedings 1722**, Art. No. 220026 (2016).
http://dx.doi.org/10.1063/1.4944258
SJR = 0.152

In the present paper the effect of the substrate type and the corona polarity were investigated. Various biopolymer substrates (poly lactic acid (PLA), PLA with chitosan and lyophilized PLA) were prepared. These substrates were charged in a positive and in a negative corona and time dependences of the normalized surface potential were studied. After that multilayer films were formed by alternative dipping the substrates into chitosan and xanthan polyelectrolyte solutions. For this purpose 0.1 % chitosan solution and 0.05 % xanthan solution in acetate buffers with pH 4.5 and ionic strength 0.1 mol/L were used. The films' morphology was investigated by FTIR and SEM methods. A comparative analysis of the experimental results was presented and the most appropriate subst-

rate type for the irreversible binding of the chitosan/xanthan polyelectrolytes was determined.

19. **Ivan Bodurov** and Dimitar Petrov – *Dielectric spectroscopy of gadolinium monoaluminate nanoparticles*, **Materials Discovery 3,** pp. 13-16 (2016).
http://dx.doi.org/10.1016/j.md.2015.12.002

Nanocrystalline $GdAlO_3$ with particle size of 40 nm has been studied in form of tablets by means of dielectric spectroscopy. Impedance, phase angle, capacitance, relative dielectric permittivity, and loss tangent have been measured in the frequency range 20 Hz – 1 MHz at temperatures between 298 K and 473 K. The polarizability volume of $GdAlO_3$ has been determined and the dielectric properties of the material have been discussed.

20. A. Viraneva, **I. Bodurov**, M. Marudova and T. Yovcheva – *Project activity – useful practice in non-formal education at the university*, **XLIV Conference on Physics Education**, pp. 130-133 (2016).
ISBN: 978-954-580-361-1
(full text in bulgarian)

The present paper systematizes the role of project training in the universities, the main types of project training and the requirements for its proper implementation. As examples are considered two projects organized and successfully implemented by the Faculty of Physics of PU - Student Practices and projects "Young Scientists".

Some of the more important advantages of project training over traditional classroom teaching are:

- increasing the opportunities for active participation of students in the learning process;
- creating motivation for cognitive activity;
- formation of habits for independent acquisition of knowledge through selection and analysis of the necessary information;
- opportunity to obtain applied knowledge and skills;
- creating skills for hypotheses, drawing conclusions and conclusions;
- creating conditions for team work.

21. I. Vlaeva, Kr. Nikolova, **I. Bodurov** and T. Yovcheva – *The Physical Review – a bridge between the science and the education*, **XLIV Conference on Physics Education**, pp. 146-149 (2016).
ISBN: 978-954-580-361-1
(full text in bulgarian)

The article presents one of the extracurricular forms of education and an effective method of teaching students - mutual learning. This teaching method prepares students for the pursuit of new knowledge, developing a combination of bearing, innovation, teamwork and responsibility. The article presents a fast and accurate method for food analysis - refractometric and its application for characterization of various food products. The extracurricular form of training, students must use scientific apparatus and learn how solve a specific case from practice.

22. **Ivan Bodurov**, Ivanka Vlaeva, Asya Viraneva, Temenuzhka Yovcheva and Simeon Sainov – *Modified design of a laser refractometer*, **Nanoscience & Nanotechnology 16**, pp. 31-33 (2016).

For all kinds of optical applications it is important to know the refractive indices of materials for the corresponding wavelength. An accurately measured refractive index value can be used for structural analysis in many branches of the science and the industry. That is why investigators sometimes have to design new or to modify standard refractometers to perform adequate and precise measurements. This paper describes how a conventional laser refractometer can be modified with a CCD camera and a motorized rotary stage for precise determination of the refractive index. This system can determine the refractive indices of nanoscale solid films and liquids in micro quantities in wide spectral range with accuracy better than 1×10^{-4}. The presented refractometer is based on the method of the disappearing diffraction pattern at the critical angle. Three laser pointers generating at 405 nm, 532 nm, 635 nm with up to 20 mW power are used as light sources. Measurements carried out on water, organic liquids, polymer films and nanoparticles dispersed in water are reported. Dispersion dependences for all investigated samples are built.

23. M. Marudova, **I. Bodurov**, S. Sotirov, Y. Uzunova, B. Pilicheva, I. Avramova, A. Viraneva, I. Vlaeva, G. Exner and T. Yovcheva – *Nanostructured polyelectrolyte multilayer drug delivery systems for buccal administration*, **Bulgarian Chemical Communications 48** (E), pp. 468-474 (2016).
SJR = 0.144; IF = 0.229; Q4 (2016);

Polyelectrolyte multilayers (PEMs) are well-defined nanoarchitectures with many potential applications, usually as biomaterial coatings. They possess excellent characteristics, such as fine tuning of thickness, stiffness, stability, morphology and topography. Hence they may exhibit special biological properties, such as mucoadhesion and local drug delivery. We present our recent investigations on layer-by-layer assembled polyelectrolyte multilayers from chitosan and xanthan on preliminary corona charged substrates from poly-ε-caprolacton. Polyelectrolyte multilayers were deposited by two different techniques – dip-coating and spincoating. The presence of PEMs on the substrates was proved by ATR FT-IR spectroscopy. The surface chemical composition was established by X-ray photoelectron spectroscopy (XPS). Further investigations on the morphology and topography of the samples were done by scanning electron microscopy (SEM) and atomic force microscopy (AFM). All the experimental data confirmed differences in the structure and surface properties of the PEMs assembled by dip-coating and spin-coating. An interfusion of the polyelectrolyte layers was observed in dip-coated PEMs, while flat and clearly separated layers were deposited by spin-coating. The ability to control the inner structure of the PEMs enables to manipulate the physical properties or chemical activity of the functionalized thin films. In this way tunable mucoadhesion and drug release properties could be achieved.

24. A. P. Viraneva, T. A. Yovcheva, **I. P. Bodurov** and M. G. Marudova – *Polypropylene electrets films stored between two plate electrodes at lower pressures*, **Bulgarian Chemical Communications 48** (E), pp. 327-332 (2016).
SJR = 0.144; IF = 0.229; Q4 (2016);

The electrets are dielectric materials of specific type which are able to create an external quasi static electric field. In many modern devices, built on electret effects, electrets are placed as active elements between two electrodes with an air gap. In these cases, if the device is under low pressure, one can expect a decrease in the electric charge. In the present paper we investigated the low pressure (p from 1013 mbar to 0.1 mbar) influence on the surface potential decay of polypropylene electrets films, placed between two short circuited plate electrodes at various air gaps (d values could be from 0.1 mm to 3.00 mm) between the charged surface of electrets and the upper electrode. For all ranges of the pd values the main process responsible for the surface potential decay can be associated with the desorption of charged species from the electret surface. In addition it was established that only for some relevant ranges of pd values the breakdown voltage following the Paschen's law was reached in the initial moment of the period for which the sample had been situated in the vacuum chamber and a spark breakdown in the air gap could be observed. The results obtained have both phenomenological character and great practical use as the investigated electrets were in similar conditions to those under which the electret elements of various sensors and signal transducers, dosimeters, air filters, generators, focusing systems of the electret optics, etc. operate.

25. I. N. Iliev, M. G. Marudova, D. S. Cholev, T. A. Vasileva, V. P. Bivolarski, A. P. Viraneva, **I. P. Bodurov** and T. A. Yovcheva – *Kinetic studies of β-galactosidase immobilized in chitosan/xanthan multilayers*, **Bulgarian Chemical Communications 48** (E), pp. 354-358 (2016).
SJR = 0.144; IF = 0.229; Q4 (2016);

A study of the kinetic parameters of β-galactosidase produced from *Aspergillus niger* was carried out in the present work. This enzyme was immobilized in chitosan and xanthan polyelectrolyte multilayers (PEMs) deposited by dip coating method on corona charged polylactic acid pads. The enzyme activity showed a temperature optimum at 50 °C and a pH optimum at 5.0. The effects of lactose concentrations on the initial velocity of the enzyme reaction were also compared and Michaelis-Menten constans were calculated at 53.4 mmol of lactose. These results gave insights for further optimization of transgalactosydase reactions in order to obtain lactulose and other specific galactooligosaccharides having pronounced bioactive properties.

26. S. Sotirov, **I. Bodurov** and M. Marudova – *Novel ammonia sensor based on polyaniline / polylactic acid composite films*, **Journal of Physics: Conference Series 794**, Art. No. 012023 (2017).
https://doi.org/10.1088/1742-6596/794/1/012023
SJR = 0.211; Q3 (2017);

We propose a new type of ammonia sensor based on composite film between polyaniline (emeraldine base) dissolved in dimethylformamide, and poly(DL-lactic) acid dissolved in chloroform. The two solutions were mixed in weight ratio of the components 1:1 and cast on Al_2O_3 substrate, on which silver electrodes were deposited previously. The active layer structure and morphology were examined by atomic force microscopy. The sensor resistance at constant humidity and different ammonia concentrations was measured. It was found that an increase in the ammonia concentration leads to resistance increase. This result is explained in the terms of ionic interactions between the polyaniline and the ammonia, which change the permittivity of the sensor active media. A response

between 2 % and 590 % was shown depending on the ammonia concentration. The sensor is reversible and possesses response time of typically 100 s. Based on the changes of the sensor resistance, ammonia concentration from 10 ppm to 1000 ppm could be detected.

27. A. Viraneva, **I. Bodurov** and T. Yovcheva – *Low Pressure Influence on the electret stability of PP and PET films*, **Journal of Physics: Conference Series 794**, Art. No 012024 (2017).
https://doi.org/10.1088/1742-6596/794/1/012024
SJR = 0.211; Q3 (2017);

The influence of low pressure on the surface potential decay of gamma irradiated polymer films of polypropylene (PP) and poly(ethylene terephtalate) (PET) were studied. Polymer film samples were subjected to integral irradiation doses (Ey = 1.25 MeV, ^{60}Co source) of 5 kGy and 25 kGy accumulated in air at a dose rate of 0.26 Mrad/h. After irradiation, the samples were charged in a corona discharge by means of a corona triode system for 1 minute under room conditions. Positive or negative 5 kV voltages were applied to the corona electrode. Four different voltages of the same polarity as that of the corona electrode were applied to the grid. The electret surface potential V_0 was measured by the method of the vibrating electrode with compensation. After charging the electrets were placed into a vacuum chamber as the pressure was reduced step by step in the range of 1000 mbar to 0.1 mbar. At each step the samples were stored for 1 minute and the surface potential V was measured again. Then values of the normalized surface potential V/V_0 were calculated. Low pressure dependences of the normalized surface potential for positively and negatively charged PP and PET films were presented. It was established that the low pressure lead to the surface potential decay of the electrets. The influence of low pressure was analyzed by the equation that describes processes of desorption from the electret surface accompanied with surface diffusion. The experimental results obtained show a significant change in the electret behaviour of the polymer films after gamma irradiation and storage at different low pressure. It was established that the surface potential decay depends on the corona polarity, gamma irradiation and the values of low pressure.

28. **I. Bodurov**, I. Vlaeva, A. Viraneva and T. Yovcheva – *Discrimination of sweeteners based on the refractometric analysis*, **Journal of Physics: Conference Series 794**, Art. No. 012033 (2017).
https://doi.org/10.1088/1742-6596/794/1/012033
SJR = 0.211; Q3 (2017);

In the present work, the refractive characteristics of aqueous solutions of several sweeteners are investigated. These data in combination with ones from other sensors should find application for brief determination of sweeteners content in food and dynamic monitoring of food quality. The refractive indices of pure (distilled) water and aqueous solutions of several commonly used natural and artificial sweeteners (glucose, fructose, sucrose, lactose, sorbitol [E420], isomalt [E953], saccharin sodium [E950], cyclamate sodium and glycerol [E422]) with 10 wt.% concentration are accurately measured at 405 nm, 532 nm and 632.8 nm wavelengths. The measurements are carried out using three wavelength laser microrefractometer based on the total internal reflection method. The critical angle is determined by the disappearance of the diffraction orders from a metal grating. The experimental uncertainty is less than ±0.0001. The dispersion dependences of the refractive indices are obtained using the one-term Sellmeier model. Based on the

obtained experimental data additional refractive and dispersion characteristics are calculated.

29. T. Yovcheva, T. Vasileva, A. Viraneva, D. Cholev, **I. Bodurov**, M. Marudova, V. Bivolarski and I. Iliev – *Effect of immobilization conditions on the properties of β-galactosidase immobilized in xanthan/chitosan multilayers*, **Journal of Physics: Conference Series 794**, Art. No. 012032 (2017).
https://doi.org/10.1088/1742-6596/794/1/012032
SJR = 0.211; Q3 (2017);

The effect of lactose concentration on the activity of the immobilised enzyme β-galactosidase from *Aspergillus niger* has been evaluated, considering future applications for the production of galactooligosaccahrides with prebiotic potential. The following enzyme was immobilized in xanthan and chitosan polyelectrolyte multilayers (PEMs) deposited by dip coating method on polylactic acid positively corona charged pads. The pads were charged in a corona discharge system, consisting of a corona electrode (needle), a grounded plate, and a metal grid placed between them. Positive 5 kV voltage was applied to the corona electrode. 1 kV voltage of the same polarity as that of the corona electrode was applied to the grid. The chitosan layers were crosslinked with sodium tripolyphosphate (Na-TPP). The enzyme showed a temperature optimum at 50 °C and a pH optimum at 5.0. The immobilization was carried out over the different adsorption time and optimum conditions were determined. These results give insights for further optimization of transgalactosydase reactions in order to produce galactooligosaccharides with specific structure and having pronounced better prebiotic properties. For the determination of the surface morphology of the investigated samples an atomic force microscope was used and root mean square roughness was obtained.

30. I. Vlaeva, Kr. Nikolova, **I. Bodurov**, M. Marudova, D. Tsankova, S. Lekova, A. Viraneva and T. Yovcheva – *Using differential scanning calorimetry, laser refractometry, electrical conductivity and spectrophotometry for discrimination of different types of Bulgarian honey*, **Journal of Physics: Conference Series 794**, Art. No. 012034 (2017).
https://doi.org/10.1088/1742-6596/794/1/012034
SJR = 0.211; Q3 (2017);

The potential of several physical methods for investigation of the botanical origin of honey has been discussed. Samples from the three most prevalent types of honey in Bulgaria (acacia, linden and honeydew) have been used. They have been examined by laser refractometry, UV, VIS and FTIR spectroscopy, electric conductivity measurement and differential scanning calorimetry. The purpose of this study was to reveal the physical characterizations of honeys from different flora produced in Bulgaria and to identify honeys with a high apitherapy potential for future studies.

31. T. Yovcheva, S. Sotirov, A. Viraneva, **I. Bodurov** and S. Kabasanov – *Measurement of piezoelectric d_{33} coefficients in Thin Films – Part 1: Experimental Setup Description*, **Физика Диэлектриков (Диелектрики-2017) 2**, pp. 213-215 (2017).

A device for precise measurement of the piezoelectric coefficient d_{33} in thin layers with a thickness of several μm is presented. To carry out the measurement, the piezoelectric sampleis placed between two electrodes which are then pressed together by electro-

magnet. The main structural elements and mechanical features of the measuring device are described. An electronic circuit for amplifying and measuring the resulting piezoelectric signal is provided. The developed setup is easy to use. It requires minimal operator training. An important advantage of the developed setup is the structure of the electrodes, where in the lower measuring electrode is not rigidly fixed to the base. It is placed on a guiding bearing ball, which allows it to change its angle relative to the upper electrode. The goal is the electrodes to stand parallel to each other when a force is applied. The bearing ball ensures the large contact area between the sample and the electrodes. This solution leads to improved system parameters, and reduces the impact of the gaps on the accuracy. The precise adjustment of the mechanical stress on the sample by the current supplied to the electromagnet makes it possible to achieve high repeatability measurements.

32. T. Yovcheva, S. Sotirov, A. Viraneva, **I. Bodurov** and S. Kabasanov – *Measurement of piezoelectric d_{33} coefficients in Thin Films – Part 1: Experimental Results*, **Физика Диэлектриков (Диэлектрики-2017) 2**, pp. 216-218 (2017).

The aim of this work is to demonstrate the possibilities of the proposed device. Two measurement series of the d_{33} piezoelectric module are carried out. The first series of experiments explores the circular samples of piezoceramicslead zirconate titanate (PZT) with thickness 600 μm.The second series of experiments investigate thin polymer films from polytetrafluoroethylene (PTFE) with a thickness 80 μm and the polyethyleneterephthalate (PET) with a thickness 100 μm, having the shape and the diameter of the two measuring electrodes. Before the measurement, the samples are charged in the corona discharge. The corona charging of the samples was carried out by the method of the corona discharge using a point-to-plane three-electrode corona discharge system. The experimental results on PZT films, charged PET and charged PTFE films with known piezoelectric coefficients indicate that the proposed device is accurate within the experimental uncertainty.

33. Iliana Milkova-Tomova, Ivaylo Minchev, Poly Radusheva, Krastena Nikolova, Petko Dinev, Dragomira Buhalova, **Ivan Bodurov**, Temenuzhka Yovcheva – *Physico-chemical properties of infusion of sea and sweet water seaweeds*, Proceeding of National Scientific Conference „15 years Pharmacy in Medical University – Plovdiv, 1-3 June 2018, pp. 221-226.

The aim of the present study is to determine some physico-chemical indicators of seaweed from the Bulgarian Black Sea area (*Rhodophyta*, *Ulva Intestinalis* and *Phaeophiceae*) and freshwater seaweed produced in a bioreactor in Bulgaria (*Spirulina* and *Chlorella*). The antioxidant activity of the seaweeds was established by two methods - ORAC and HORAC. The content of flavonoids and polyphenolic acids was determined. Prepared aqueous infusions of 3 g and 6 g of *Spirulina* and *Chlorella* (98-100 °C, 30 min) were examined. Fluorescence spectra of aqueous extracts were obtained at a length of excitation light λ = 290 nm. No significant difference was found in the relative radiation intensity of the extracts with different percentages of seaweed in the infusion (*Spirulina* and *Chlorella*). However, infusions with *Chlorella* show a more intense fluorescent peak of chlorophyll than those with *Spirulina*. The color parameters of the samples in the SIE Lab in a system are also determined.

34. T. Yovcheva, A. Viraneva, A. Marinova, S. Sotirov, G. Exner, **I. Bodurov**, M. Marudova, B. Pilicheva,Y. Uzunova and I. Vlaeva - *Insulating Chitosan/Casein Multilayers on Corona Charged Polylactic Acid Substrates*, **IEEE Transactions on Dielectrics and Electrical Insulation**, Vol. 25, No. 3 (June 2018) pp. 766-771.
https://doi.org/10.1109/TDEI.2017.006948
SJR = 0.68; IF = 1.774; Q1 (2018);

The influence of the structure and physico-chemical properties of chitosan/casein multilayer films on their potential use for drug delivery systems was investigated. The multilayer films were prepared using layer-by-layer self-assembly, whereby chitosan and casein were deposited onto poly(lactic acid) substrates pretreated with either a positive or a negative corona. The corona discharge system consisted of a corona electrode, a grounded plate and a grid. The deposition was studied by ATR FT-IR, AFM, and surface energy measurements. ATR FT-IR spectra proved the formation of polyelectrolyte chitosan – casein complexes. The increasing content of chitosan and casein with increasing number of bilayers was further confirmed by XPS analysis. The surface topography was examined by AFM and the average roughness was evaluated. A comparative analysis of the experimental results was performed and the most appropriate substrate corona treatment for the irreversible binding of the chitosan/casein polyelectrolytes was determined.

35. Asya Viraneva, **Ivan Bodurov**, Temenuzhka Yovcheva - *Electrical properties of polylactic acid composite films*, **Chemistry: Bulgarian Journal of Science Education**, Volume 27, Number 4, pp. 589-597 (2018).
Print ISSN: 0861-9255
Online-ISSN: 1313-8235

In the present study, some electrical properties of polylactic acid (PLA) composite films with different percentages of MgO – 0 wt.%, 2 wt.%, 4 wt.% and 8 wt.% were investigated. Composite films were prepared using a Brabender Plastograph EC Plus blender under controlled electric heating for 5 minutes at 190 °C. The films obtained were charged by the corona discharge method using a trielectrode system for 1 minute under room conditions. Positive or negative 5 kV voltage was applied to the corona electrode. 1 kV voltage of the same polarity as that of the corona electrode was applied to the grid. The surface potential of the charged samples was measured by the vibrating electrode method with compensation. The time dependencies of surface potential were investigated. The results obtained show a significant change in the electret behavior of PLA composite films after insertion of MgO particles with different concentration. Some dielectric and impedance characteristics of composite films were also studied. Dielectric permittivity was calculated. The results obtained show a change in dielectric permittivity by increasing the concentration of the inserted MgO particles in the PLA matrix.

36. Ilia Iliev, Tonka Vasileva, Veselin Bivolarski, Asya Viraneva, **Ivan Bodurov**, Maria Marudova, Temenuzhka Yovcheva - *Immobilization of fructosyltransferases on composite films of polylactic acid, xanthan and chitosan*, **Chemistry: Bulgarian Journal of Science Education**, Volume 27, Number 5, pp. 639-647 (2018).
Print ISSN: 0861-9255
Online-ISSN: 1313-8235

Fructosyltransferases catalyze the synthesis of Levan type polysaccharides in the presence of sucrose in the reaction medium. In the presence of acceptors (maltose, isomaltose, lactose, fructose) and fructose donor sucrose, they synthesize oligosaccharides with a degree of polymerization DP 3 - 5 monosaccharide residues that have prebiotic potential. In the present study, the fructosyltransferase from *Leuconostoc mesenteroides* Lm17 strain is immobilized on a multilayer polysaccharide structure composed of chitosan and xanthan. The layers were applied onto pre-loaded corn root cans of polylactic acid. The resulting composite films were investigated for the degree of immobilization of the enzyme and the ability to synthesize fructan on the surface of the film. The activity of immobilized enzyme film was found 0.73 U/mg in the resulting films. In carrying out an enzymatic reaction in the presence of over 10 % sucrose, a hydrolysis and transferase reaction was established by which a polysaccharide was synthesized in both the solution and the membrane. Surface morphology of multilayer films is investigated using the Nanosurf Flex AFM. The values of the average roughness were obtained. It is found that it increases with increasing number of layers, regardless of their sequence.

37. Antoaneta Marinova, Temenuzhka Yovcheva, Asya Viraneva, **Ivan Bodurov**, Maria Marudova - *Polyelectrolyte complex formation of chitosan and casein*, **Chemistry: Bulgarian Journal of Science Education**, Volume 27, Number 5, pp. 692-699 (2018).
Print ISSN: 0861-9255
Online-ISSN: 1313-8235

In the recent decades, intensive studies have been performed on the interactions between polyelectrolytes and the possibilities for polyelectrolyte complex (PEC) formation. The main purpose of these studies is to investigate the properties of PECs and to extend their application in solving different technological and environmental problems. The interest in natural polyelectrolytes - polysaccharides, proteins, amino acids, DNA, etc., has been increased due to their role in living organisms, their bioavailability, biodegradability and uses in pharmacy and medicine. In the present study attractive, electrostatic interactions between oppositely charged polyelectrolytes have been used to prepare a novel complex between a polyampholyte casein and a natural polycation - chitosan. The complex casein/chitosan is formed during the mixing of acid chitosan solutions and basic casein solutions. The complex yield was investigated by viscometric, spectroscopic and gravimetric methods. The optimum stoichiometry of the complexes at different pH has been determined.

38. Maria Marudova, Ginka Exner, Bissera Pilicheva, Antoaneta Marinova, Asya Viraneva, **Ivan Bodurov**, Sotir Sotirov, Ivanka Vlaeva, Yordanka Uzunova and Temenuzhka Yovcheva – *Effect of assembly pH and ionic strength of chitosan/casein multilayers on benzydamine hydrochloride release*, **International Journal of Polymeric Materials and Polymeric Biomaterials** 68 (1-3) 90-98 (2019).
https://doi.org/10.1080/00914037.2018.1525727
ISSN: 0091-4037 (Print) 1563-535X (Online)
SJR = 0.503; IF = 2.263; Q2 (2019);

Multilayer biopolyelectrolyte films are built from chitosan and casein by layer-by-layer deposition onto corona precharged poly(DL-lactic acid) substrate. Such structure allows optimization with respect to the morphology and ability of drug immobilization

and release by changing the assembly conditions. Variation of chitosan and casein solutions ionic strength and chitosan solution pH at constant casein solution pH, effects significantly the polyelectrolyte multilayer structure and drug release. pH and ionic strength increase change the morphology from dense to loose, and the ionic strength increase let to screening effect and complexation of the drug, resulting in slow drug release.

39. I. Vlaeva, B. Pilicheva, A. Marinova, **I. Bodurov**, T. Yovcheva, A. Viraneva, G. Exner, Y. Uzunova, S. Sotirov and M. Marudova – *Investigation of flexible polyelectrolyte multilayered structure by using different techniques*, **AIP Conference Proceedings 2075**, Art. No. 160007 (2019).
https://doi.org/10.1063/1.5091334
SJR = 0.182;

The presented paper deals with the formulation of medical pads with potential use as drug delivery systems via buccal mucosa adhesion. The pads consists of a substrate and deposited on it multilayered structure of alternating casein and chitosan. The method of preparation of this multilayer structure is layer-by-layer deposition. The electrolyte nature of the used polymers (chitosan – polyanion and casein – polycation) was employed in the formulation process. The substrate initial excess charge was provided by corona discharge pretreatment. The formulation process was monitored by index of refraction measurements by using a laser refractometer. The ability of the formulated pads as drug delivery system was proven by drug release tests, where the kinetics of benzydamine hydrochloride (BH) was used. The method of mucin reaction was employed to establish the potential of pads' adhesion.

40. S. Milenkova, **I. Bodurov** and M. Marudova – *Effect of assembly conditions on chitosan/alginate polyelectrolyte complexes particle size*, **AIP Conference Proceedings 2075**, Art. No. 160011 (2019).
https://doi.org/10.1063/1.5091338
SJR = 0.165

Polyelectrolytes have remained one of the most attractive subjects of scientific research in recent decades owing to their great importance in advanced technologies and molecular biology. In this study, particle polyelectrolyte complexes (PPECs) were formed by mixing cationic chitosan (Ch) and anionic alginate using the jet mixing technique. Within certain limits, the size of the formed PPECs could be controlled and they are in the nano-sized range. The aim was to investigate the effect of the assembly pH and ionic strength on the PPECs size. The influence of Ch molecular weight on the PPECs size was also studied. Dynamic light scattering was used for PPECs size estimation. It was found that the pH and ionic strength affect the chitosan/alginate interaction force. Hence, PPECs with desired size could be formed by varying the assembly conditions.

41. **Ivan Bodurov**, Asya Viraneva and Temenuzhka Yovcheva – *Electret and Dielectric Properties of Lyophilized Polymer Films*, **Journal of Physics: Conference Series 1186**, Art. No. 012013 (2019).
https://doi.org/10.1088/1742-6596/1186/1/012013
ISSN: 1742-6588, 1742-6596
SJR = 0.221; Q3 (2019);

Polymer electrets are one of the most important types of electrets, which are widely used both in academic research and industrial applications. The effect of trapped charges on dielectric properties of the polymer electrets is crucial for more intelligent utilization of these materials. The aim of the present paper is to investigate the lyophilization effect on electret and dielectric properties of polymer films. The properties of one synthetic polymer (polystyrene – PS) and two biopolymers (polylactic acid – PDLA and poly-ε-caprolactone – PεC) were investigated and compared. The samples were analyzed by means of dielectric relaxation spectroscopy in the range of 20 Hz – 1 MHz using QuadTech 1910 Inductance Analyzer. The frequency dependences of the impedance magnitude and the phase angle were measured. Regarding the electret properties, the samples were charged in a conventional three-electrode corona system. Positive and negative 5 kV voltage was applied to the corona electrode and 600 V voltage with the same polarity was applied to the grid as to the corona electrode. The results showed that the lyophilization increases time relaxation of the trapped charges. It was established that the samples charged in a positive corona are more stable than those charged in a negative corona.

42. T. Yovcheva, B. Pilicheva, A. Marinova, A. Viraneva, **I. Bodurov**, G. Exner, S. Sotirov, I. Vlaeva, Y. Uzunova and M. Marudova - *Crosslinked Chitosan/Casein Polyelectrolyte Multilayers for Drug Delivery*, **Journal of Physics: Conference Series 1186**, Art. No. 012030 (2019).
https://doi.org/10.1088/1742-6596/1186/1/012030
ISSN: 1742-6588, 1742-6596
SJR = 0.221; Q3 (2019);

Polyelectrolyte multilayers (PEMs) are widely used as drug delivery systems, but still remain challenging for their small drug immobilizing capacity. One way to increase the immobilized drug amount may be crosslinking of the PEMs, which stabilize them and increase their porosity. The aim of the present study is fabrication and characterization of chitosan/casein PEMs, which are crosslinked with different crosslinking agents – glutaraldehyde, sodium tripolyphosphate, $CaCl_2$ and combinations of two of them. XPS method was used to prove the PEMs crosslinking. SEM was used to observe film morphology and its variation due to crosslinking. Water capacity of PEMs in 100 % relative humidity was investigated. Release of model drug Benzydamine Hydrochloride was monitored spectrophotometrically at 306 nm. The crosslinking improves the PEMs stability and causes formation of porous surface. After crosslinking the amount of the immobilized drug increased several times.

43. G. Exner, M. Marudova, S. Sotirov, A. Marinova, A. Viraneva, B. Pilicheva, **I. Bodurov**, I. Vlaeva, Y. Uzunova and T. Yovcheva, *Multilayered polyelectrolyte structures with potential for intracavity drug delivery systems*, **Applied Surface Science 493**, 620-627 (2019).
https://doi.org/10.1016/j.apsusc.2019.07.039
ISSN: 0169-4332
SJR = 1.115; IF = 5.155; Q1 (2019);

A design of multilayered polyelectrolyte structures consisting of a substrate of poly-DL-lactide film covered with multilayers of chitosan and casein is reported. An innovative method of corona pretreatment of the substrate was used to ensure the required substrate surface excess charge for the electrostatic attachment of the polyelectroly-

tes on it. The number of layers was varied from 4 to 16 and the ability of the system to load drugs and to adhere to the buccal mucosa was investigated by means of UV-VIS-NIR spectroscopy, atomic force microscopy, and the small sessile drop technique. At the particular pH and ionic strength used, the optimal number of layers is 8, which results from the loose morphology and complex nature of multilayered structural formation. The drug release is accompanied by polyelectrolyte dissolution.

III. MANUALS

44. A. Viraneva, G. Exner, E. Marekova, **I. Bodurov**, M. Marudova, T. Yovcheva – *A guide for laboratory exercises in physics*, University Press Paisii Hilendarski (2018).
ISBN: 978-619-202-356-84

The guide for laboratory exercises in physics aims to help students to master the course in physics, to understand the basic physical laws and to acquire practical habits for accurate measurements. The acquaintance with the equipment and the methods for measurement appears as an introduction to the further independent work of the students.

For each exercise, the manual provides: the purpose of the exercise, accessories, theory and working formulas, tasks for implementation, description of the experimental setup and method of work, experimental data and results, assessment of experimental uncertainty and test questions. Tables are given for a clearer presentation of the obtained measurement results.

To facilitate the work, tables with values of different physical quantities are finally given as appendices.

45. Temenuzhka Yovcheva, Asya Viraneva and **Ivan Bodurov** – Short course on Electro-Magnetism and Optics, University Press Paisii Hilendarski (2019).
ISBN: 978-619-202-408-6

This textbook “Short course in electricity, magnetism and optics” is intended for students studying in the following engineering specialties of the Faculty of Physics and Technology of Paisii Hilendarski University of Plovdiv: “Hardware and software systems”, “Computer and communication systems”, “Electric Power Engineering”, “Automotive Engineering”, “Mechanical Engineering and Technology”, “Telecommunication and Information Systems”, “Telecommunications with Management”, “Information and Computer Engineering”.

The material is in line with the current curricula for the bachelor's degree.

In the developed 23 topics of the textbook the basic concepts, laws and phenomena of electricity, magnetism and optics are considered, with special attention paid to the clarification of their physical meaning and their practical applications. Experimental research is combined with theoretical explanations, using a sufficiently simple mathematical apparatus.

IV. PATENTS AND UTILITY MODELS

46. Simeon Hristov Sainov, Georgi Ganchev Minchev, Temenuzhka Atanasova Yovcheva, **Ivan Panayotov Bodurov**, *Four-wavelength laser microrefractometer*, **Patent Office of the Republic of Bulgaria**, Utility Model Registration Certificate BG 1985 U1, published in Bulletin No. 10 on 31.10.2014.

The four-wavelength laser microrefractometer is designed to measure the refractive index of microliter liquid samples and thin submicron layers in laboratory tests in physics, chemistry, biology and medicine. The advantage of the microrefractometer is the reduced uncertainty of the measurements and the possibility to study the refractive index of liquid and solid samples in a wide spectral range.

47. Temenuzhka Atanasova Yovcheva, Asya Petrova Viraneva, **Ivan Panayotov Bodurov**, Sotir Ivanov Sotirov, *A device for measuring piezoelectric coefficients of dielectric materials*, **Patent Office of the Republic of Bulgaria**, Utility Model Registration Certificate BG 2250 U1, published in Bulletin No. 7 on 29.07.2016.

The device is designed for direct measurement of piezoelectric coefficients of a wide range of dielectric materials in laboratory research in the field of physics. It provides high accuracy of measurements and the ability to precisely control the force of pressure on the sample. The device has a specific grip of the measuring electrodes, in which the lower measuring electrode is attached to a movable insulating pad positioned on a bearing ball, which allows it to change the angle of its position relative to the upper fixed electrode. The measuring electrodes are made of brass and have a cylindrical shape with a thickness of 4 mm and a diameter of 30 mm.

48. **Ivan Panayotov Bodurov**, Temenuzhka Atanasova Yovcheva, Simeon Hristov Sainov – *Universal laser microrefractometer*, **Patent Office of the Republic of Bulgaria**, Utility Model Registration Certificate BG 2842 U1, published in Bulletin No. 12.1 on 15.12.2017

The universal laser microrefractometer is designed to measure the complex refractive index, which includes the real refractive index and the imaginary refractive index, characterizing the absorption. The objects are microliter liquid samples and thin submicron layers in laboratory and technical research in physics, chemistry, biology, ecology and medicine. Advantages of the universal laser microrefractometer are the ability to measure absorbing and scattering samples, the improved uncertainty of the measurements and the study of the complex refractive index of liquid and solid samples in a wide spectral range.