

ANNOTATION

of the materials under art. 76 of the Regulations for the development of academic staff of PU
"Paisii Hilendarski"

Assoc. Prof. Maria Marudova-Zsivanovits, PhD

for participation in a competition for the academic position "Professor", announced in State Gazette, issue 92/18.11.2022. Field of higher education 4. Natural Sciences, Mathematics and Informatics, professional field 4.1 Physical sciences (Condensed Matter Physics)

The materials submitted for participation in the competition for the academic position "Professor" are developed after acquiring the academic position "Associate professor" and include 40 articles, 1 book chapter, 1 patent, 1 textbook, 1 study guide and 7 electronic courses.

- All publications for the competition are in journals indexed in databases with scientific information (Web of Science and/or Scopus).
- 20 of the publications participating in the competition are in journals with an impact factor and the total number of IF is 50.9 (out of 96.6).
- h-index 10 (according to Scopus)

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Articles

B4.1. Bodurov, I., Vlaeva, I., Exner, G., Uzunova, Y., Russev, S., Pilicheva, B., Viraneva, A., Yovcheva, T., Grancharova, T., Sotirov, S. & **Marudova, M.** (2016). Investigation of multilayered polyelectrolyte thin films by means of refractive index measurements, FT-IR spectroscopy and SEM. *Journal of Physics: Conference Series* 682, 012026, doi:10.1088/1742-6596/682/1/012026, [SJR = 0.24](#)

Abstract

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 nanolayers 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 were treated in negative corona. The multilayered structures consisted of 8, 9, 14, 15 or 20 nanolayers. Number of techniques, such as refractive index measurements, FT-IR spectroscopy and SEM morphology were employed in order to monitor the properties of the so prepared multilayered polyelectrolyte films. Depending on the deposition method, different thicknesses and roughness of the layers were found: the dip-deposited layers were rougher and with a thickness of (10 ± 1) nm, while the layers obtained by spincoating, were smooth, with a thickness of $(5 \pm 0, 5)$ nm. *The applicant's personal contribution consists in obtaining the structures and analyzing their roughness.*

B4.2. **Marudova, M**, Bodurov, I., Sotirov, S., Uzunova, Y., Pilicheva, B., Avramova, I., Viraneva, A., Vlaeva, I., Exner, G., & Yovcheva, T. (2016). Nanostructured polyelectrolyte multilayer drug delivery systems for buccal administration. *Bulgarian Chemical Communications*, 48, 468–474, **IF = 0.242 (Q4)**, **SJR = 0.148 (Q4)**

Abstract

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 interdiffusion 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. *The applicant's personal contribution consists in obtaining the structures, analyzing their roughness and preparing the manuscript.*

B4.3. Viraneva, A, **Marudova, M.**, Sotirov, S., Bodurov, I., Pilicheva, B., Uzunova, Y., Exner, G., Grancharova, T., Vlaeva, I., & Yovcheva, T. (2016). Deposition of polyelectrolyte multilayer films made from chitosan and xanthan on biodegradable substrate: Effect of pH

and ionic strength. *AIP Conference Proceedings*, 1722, 220025, <https://doi.org/10.1063/1.4944257>, SJR = 0,165

Abstract:

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 polyelectrolyte solutions. For this purpose, 0.1% chitosan solution and 0.05% xanthan solution in acetate buffers with pH 4; 4.5 and 5 and ionic strengths 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 polyelectrolytes 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 behavior was attributed to the changes in charge density of the polyelectrolytes and screening effect of the counterions. *The applicant's personal contribution consists in obtaining the structures and analyzing their chemical structure and roughness.*

B4.4. Yovcheva, TA, **Marudova, M.**, Viraneva, A., Sotirov, S., Rusev, S., Bodurov, I., Pilicheva, B., Uzunova, Y., Exner, G., & Grancharova, Ts Ts. (2016). Various corona treated biopolymer substrates for the deposition of polyelectrolyte multilayers. *AIP Conference Proceedings*, 1722, 220026, <https://doi.org/10.1063/1.4944258>, SJR = 0.165

Abstract:

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 substrate type for the irreversible binding of the chitosan/ xanthan polyelectrolytes was determined. *The applicant's personal contribution consists of sample preparation and analysis of SEM results.*

B4.5. Yovcheva, T, Viraneva, A., Marinova, A., Sotirov, S., Exner, G., Bodurov, I., **Marudova, M.**, Pilicheva, B., Uzunova, Y., & Vlaeva, I. (2018). Insulating chitosan/casein multilayers on corona charged polylactic acid substrates. *IEEE Transactions on Dielectrics and Electrical Insulation*, 25, 766–771, DOI: 10.1109/TDEI.2017.006948, IF = 0.25 (Q3), SJR = 0,682 (Q1)

Abstract

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. It was established that the final values of the normalized surface potential are highest for the lyophilized PLA electrets irrespective of the corona polarity because of their porous structure. *The applicant's personal contribution consists of sample preparation and surface topography analysis.*

- B4.6. Exner, G., **Marudova, M.**, Sotirov, S., Marinova, A., Viraneva, A., Pilicheva, B., Bodurov, I., Vlaeva, I., Uzunova, Y., & Yovcheva, T. (2019). Multilayered polyelectrolyte structures with potential for intracavity drug delivery systems. *Applied Surface Science*, 493, 620–627, <https://doi.org/10.1016/j.apsusc.2019.07.039>, **IF = 7.392 (Q1)**, **SJR = 1.23 (Q1)**.

Abstract:

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 polyelectrolytes 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. *The candidate's personal contribution consists of obtaining the samples preparation, studying the surface morphology by atomic force microscopy and conducting the drug release from the multilayer structure.*

- B4.7. **Marudova, Maria**, Exner, G., Pilicheva, B., Marinova, A., Viraneva, A., Bodurov, I., Sotirov, S., Vlaeva, I., Uzunova, Y., & Yovcheva, T. (2019). Effect of assembly pH and

ionic strength of chitosan/casein multilayers on benzydamine hydrochloride release. *International Journal of Polymeric Materials and Polymeric Biomaterials*, 68, 90–98, <https://doi.org/10.1080/00914037.2018.1525727>, IF = 3.221(Q2), SJR = 0.447(Q2)

Abstract:

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. *The candidate's personal contribution consists in formulating the structures and studying the kinetics of drug release.*

B4.8. Vlaeva, I., Pilicheva, B., Marinova, A., Bodurov, I., Yovcheva, T., Viraneva, A., Exner, G., Uzunova, Y., Sotirov, S., & **Marudova, M.** (2019). Investigation of flexible polyelectrolyte multilayered structure by using different techniques. AIP Conference Proceedings, 2075, 160007, <https://doi.org/10.1063/1.5091334>, SJR = 0.19.

Abstract:

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. *The candidate's personal contribution consists in formulating the structures and studying the kinetics of drug release.*

B4.9. Yovcheva, T., Pilicheva, B., Marinova, A., Viraneva, A., Bodurov, I., Exner, G., Sotirov, S., Vlaeva, I., Uzunova, Y., & **Marudova, M.** (2019). Crosslinked Chitosan/Casein polyelectrolyte multilayers for drug delivery. *Journal of Physics: Conference Series*, 1186, 012030, DOI 10.1088/1742-6596/1186/1/012030, SJR = 0.227.

Abstract:

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, CaCl₂ 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. *The candidate's personal contribution is the selection of cross-linking agents and the study of the release kinetics of benzydamine hydrochloride.*

B4.10. Pilicheva, B., Uzunova, Y., Bodurov, I., Viraneva, A., Exner, G., Sotirov, S., Yovcheva, T., & **Marudova, M.** (2020). Layer-by-layer self-assembly films for buccal drug delivery: The effect of polymer cross-linking. *Journal of Drug Delivery Science and Technology*, 59, 101897, <https://doi.org/10.1016/j.jddst.2020.101897>, IF = 5.062(Q2), SJR = 0,663(Q2)

Abstract:

The goal of this study was the preparation of multilayer polyelectrolyte films intended for buccal delivery of benzydamine (BZ). Another important issue was to evaluate the effect of polymer cross-linking as a means to enhance drug loading and ensure sustained drug release. LbL deposition technique was applied for the multilayer build-up. The deposition was performed by alternative dip-coating of corona pretreated polylactic acid substrates into chitosan and casein solutions. Chitosan and casein deposition was followed by cross-linking with glutaraldehyde/sodium tripolyphosphate, and calcium chloride, respectively. For drug loading, the multilayers were soaked into benzydamine solution after chitosan cross-linking. The procedure was carried out until eight layers were laid. The formation of polyelectrolyte complex and the cross-linking occurrence were proven by ATR-FTIR. Further investigations on the morphology and topography of the samples were carried out by AFM. Moreover, swelling behavior, content uniformity, drug release and mucoadhesion were investigated. The experimental data displayed differences in the structure and surface properties of the films as per the cross-linking agent used. All the investigated parameters were influenced by the cross-linking mode. Double cross-linking of chitosan with glutaraldehyde and sodium tripolyphosphate proved to be the most appropriate method for the achievement of the desired goals. *The candidate's personal contribution is obtaining the structures and analyzing the experimental results.*

B4.11. Bodurov, I., **Marudova, M.**, Viraneva, A., Yovcheva, T., & Grigorov, A. (2021). Investigation of polyelectrolyte multilayers deposited on corona charged composite polylactic acid/poly (ϵ -caprolactone) substrates. *Journal of Physics: Conference Series* (Vol. 1762, No. 1, p. 012006), DOI 10.1088/1742-6596/1762/1/012006, SJR = 0.21 (Q4)

Abstract:

In the present study chitosan and casein polyelectrolyte multilayers (PEMs) deposited on composite polylactic acid (PDLA)/poly(ϵ -caprolactone) (PEC) substrates were investigated. The substrate's

morphology was investigated using polarized light microscopy and their degree of crystallization was studied by the application of differential scanning calorimetry. The substrates obtained were charged in a corona discharge system, consisting of a corona electrode (needle), a grounded plate electrode, and a metal grid placed between them. 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 dependences of the normalized surface potentials on the storage times of positively and negatively charged substrates were studied. Layer-by-layer (LbL) technique was used for multilayer deposition on the substrates. PEMs with different number of layers (4 or 8) were obtained. A model drug Benzydamine hydrochloride was loaded in the casein layers in order to evaluate the effect of the kind of substrate on the drug immobilization and release. A study of the drug release kinetics in saline buffer was carried out and the amount of the released drug was calculated spectrophotometrically. It was shown that the experimental results fit to the Peppas model with a very good level of correlation and the model parameters differ depending on the used substrate. *The candidate's personal contribution is in formulation of the polyelectrolyte structures and conducting the DSC analyses.*

B4.12. Pilicheva, B., Uzunova, Y., & **Marudova, M.** (2022). Polyelectrolyte Multilayer Films as a Potential Buccal Platform for Drug Delivery. *Polymers*, 14(4), 734, doi: 10.3390/polym14040734. **IF = 4,967(Q1)**, **SJR = 0.73(Q1)**

Abstract:

The goal of this research was to study the potential of polyelectrolyte multilayers as buccal dosage forms for drug delivery and to investigate how the properties of the drugs impact the overall performance of the delivery system. Multilayer films based on the polyelectrolyte interaction between casein and chitosan were developed using benzydamine, tolfenamic acid and betahistine as model drugs. The samples were characterized for surface pH, moisture content and moisture absorption, swelling behavior and mucoadhesion. Additionally, surface morphology was investigated, as well as the drugs' physical state after incorporation in the multilayer films. The samples proved to be nonirritant (pH was within the physiological range), physically stable (moisture content and moisture absorption below 5%) and mucoadhesive, adsorbing from 60 to 70% mucin. The release behavior correlated to the swelling index profiles of the samples and was strongly dependent on the drug solubility. The developed multilayer films appeared to be an optimum delivery system for sparingly soluble drugs due to the high drug loading achieved. *The candidate's personal contribution is the physical characterization of the multilayer films and investigation of the physical content of the drug substances by differential scanning calorimetry.*

B4.13. Viraneva, A., **Marudova, M.**, Grigorov, A., & Yovcheva, T. (2022). An Application of Corona-Treated and Chemically Modified Poly (D-Lactic Acid) Films as Benzydamine Hydrochloride Carriers. *IEEE Transactions on Dielectrics and Electrical Insulation*, 29(3), 794-799, DOI: 10.1109/TDEI.2022.3163797. **IF = 2.509(Q3)**, **SJR = 0.89(Q1)**

Abstract:

In the present article, chitosan and casein polyelectrolyte multilayers (PEMs) deposited on poly(D-lactic acid) (PDLA) substrates are investigated. PDLA substrates are modified both physically under negative corona discharge and chemically with N-ethyl-N'-(3-dimethylaminopropyl) carbodiimide hydrochloride (EDAC). The substrates modified by a combination of corona discharge and chemical modification are also studied. The topology of the multi layers is studied with AFM. The electret properties of the substrates obtained are investigated. The dependencies of the normalized surface potential on the storage time are studied. A layer-by-layer (LbL) deposition technique is used for multilayer deposition on the substrates. PEMs with eight layers are obtained. Benzydamine hydrochloride (Benz) is immobilized in the resulting PEMs. Drug loading efficiency and drug release from PDLA multilayers are studied. The results of PDLA multilayers demonstrate that the chemical modification of the PDLA substrates increases the amount of Benz loaded in the multi layers. The combination of corona treatment and chemical modification results in lower amounts of loaded drugs in both combination cases, when compared with only chemically modified samples. *The applicant's personal contribution consists of conducting the drug loading and release tests and analyzing the results obtained.*

- Г7.1. Gencheva, E., Yovcheva, T., **Marudova, M.**, Viraneva, A., Bodurov, I., Mekishev, G., & Sainov, S. (2010). Formation and investigation of corona charged films from polylactic acid. *AIP Conference Proceedings*, 1203, 495–500, <https://doi.org/10.1063/1.3322494>, SJR = 0,166

Abstract

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 crystallinity 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 crystallinity 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 led 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. *The candidate's personal contribution consists in conducting the differential scanning calorimetry experiments and analyzing the results.*

- Г7.2. Yovcheva, TA, **Marudova, M.**, Viraneva, A., Gencheva, E., Mekishev, G., & Sainov, S. (2010). Investigation of Pectin/Chitosan multilayers build-up on corona charged

polylactide substrates. *AIP Conference Proceedings*, 1203, 979–984, <https://doi.org/10.1063/1.3322594>, SJR = 0,166

Abstract:

The aim of the present research is to investigate the formation and stability of pectin/chitosan multilayer films on preliminary corona charged polylactide substrate with different polarity. For this purpose two different multilayer structures with alternative ordering of polycation and polyanion layers were prepared. Layer-by-layer (LbL) deposition technique was used for multilayer build-up. The FT-IR transmittance spectra of the substrates with multilayers indicated of the presence of pectin and chitosan. The intensity of the typical bands was found to increase with increasing of the number of the deposited layers. The stability and physico-chemical properties of the multilayer structures were investigated by determination of surface refractive index and swelling behaviour. Multilayers are stable enough in distilled water and their equilibrium degree of swelling increases with the increase of build-up layers. This relation is correlated with the increased amount of hydrophilic biopolymers. It was found out that chitosan/pectin multilayers build-up on negatively charged substrate consist of higher amount of polyelectrolytes and are more stable in distilled water. *The personal contribution of the candidate consists in the selection of the methods of analysis and the conduct of the experiments for the swelling of the structures.*

Г7.3. Bodurov, I., Vlaeva, I., **Marudova, M.**, Yovcheva, T., Nikolova, K., Eftimov, T., & Plachkova, V. (2013). Detection of adulteration in olive oils using optical and thermal methods. *Bulg. Chem. Commun.*, 45, 81–85, **IF = 0,242(Q4)**, **SJR = 0,175(Q4)**

Abstract:

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. The results suggest that all the presented physical methods are correlated and could be useful for a fast detection of adulteration and discriminating among olive oils of different commercial categories. *The candidate's personal contribution consists of conducting the tests with differential scanning calorimetry and analyzing the results.*

Г7.4. Yovcheva, T, Vozáry, E., Bodurov, I., Viraneva, A., **Marudova, M.**, & Exner, G. (2013). Investigation of apples aging by electric impedance spectroscopy. *Bulg. Chem. Commun.*, 45, 68–72, **IF = 0,242(Q4)**, **SJR = 0,175(Q4)**

Abstract:

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. *The candidate's personal contribution consists in modeling the spectra from dielectric impedance spectroscopy.*

Г7.5. Yovcheva, Temenuzhka, **Marudova, M.**, Viraneva, A., Gencheva, E., Balabanov, N., & Mekishev, G. (2013). Effect of gamma-irradiation on the electret properties of poly (L-lactide). *Journal of Applied Polymer Science*, 128, 139–144, <https://doi.org/10.1002/app.38140>, IF = 3,057(Q2), SJR = 0,629(Q1)

Abstract:

Electret stability of poly(L-lactide) (PLA) films, gamma-irradiated up to 100 kGy has been investigated by measuring the surface potential during the storage period. PLA samples – 40- μm thick films – were prepared by the casting method and then irradiated in a ^{60}Co radiation facility at a dose rate of 0.25 kGy/h. The structural changes during the irradiation were estimated by viscometric, differential scanning calorimetry and scanning electron microscope measurements. Random chain scission and appearance of end radicals are the most probable results of the irradiation process. After irradiation, the samples were charged in a corona discharge system and surface potential was measured by the method of the vibrating electrode with compensation. The values of the surface potential of the irradiated samples were higher in comparison with the non-irradiated samples. This effect could be related to the degradation of the macromolecules and changes in the crystal state of PLA during the irradiation. Both of the mentioned factors lead to structural defects that increase the number of discrete trapping levels. The effect of low pressure on the surface potential drop was also investigated. *The candidate's personal contribution is performing analysis by differential scanning calorimetry and viscometry.*

Г7.6. Hadjikinova, R, & **Marudova, M.** (2016). Thermal behaviour of confectionary sweeteners' blends. *Bulg. Chem. Commun*, 48, 446–450, IF = 0,242(Q4), SJR = 0,148(Q4)

Abstract:

The present research investigates the glass transition and melting of sucrose and some of the most commonly used in the confectionary industry sweeteners – erythritol, sorbitol, maltitol and isomalt. A comparison between the thermal properties of the studied sweeteners and the sucrose is done. It is found that the glass transition temperature and the melting temperature of the sucrose are the highest. The parameters of the maltitol were the closest to these of the sucrose probably due to their common disaccharide chemical structure. The erythritol is characterized as the sweetener with the lowest glass transition temperature and the highest enthalpy of melting. Based on the glass transition behaviour of the sugar mixtures, a miscibility between sucrose/erythritol,

sucrose/sorbitol, maltitol/erythritol, maltitol/sorbitol, maltitol/isomalt, erythritol/sorbitol, erythritol/isomalt and sorbitol/isomalt was established. Intermolecular hydrogen bonding between sucrose/maltitol, sucrose/isomalt and maltitol/isomalt were demonstrated. *The candidate's personal contribution consisted in developing the study concept and conducting the differential scanning calorimetry tests.*

Г7.7. Iliev, I., **Marudova, M.**, Cholev, D., Vasileva, T., Bivolarski, V., Viraneva, A., Bodurov, I., & Yovcheva, T. (2016). Kinetic studies of β -galactosidase immobilized in chitosan/xanthan multilayers. *Bulg. Chem. Commun.*, 48, 354–358, **IF = 0,242(Q4)**, **SJR = 0,148(Q4)**

Abstract:

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 constants 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. The applicant's personal contribution is to obtain the multi-layer coatings.

Г7.8. Nikolova, K., Yovcheva, T., **Marudova, M.**, Eftimov, T., Bodurov, I., Viraneva, A., & Vlaeva, I. (2016). 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, 220019, <https://doi.org/10.1063/1.4944251>, **SJR = 0,165**

Abstract

Eleven samples from olive oil have been investigated using four physical methods – refractive index measurement, fluorescence spectra, color parameters and differential scanning calorimetry. 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 $\lambda = (500-540)$ nm, chlorophyll content at about $\lambda = (675-680)$ nm and non determined pigments at $\lambda = (700-750)$ 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. *The candidate's personal contribution consists in the study of oils by differential scanning calorimetry.*

- Г7.9. Uzunova, G., Nikolova, K., Perifanova, M., Gentscheva, G., **Marudova, M.**, & Antova, G. (2016). Physicochemical characterization of chia (*Salvia hispanica*) seed oil from Argentina. *Bulg. Chem. Commun.*, 48, 131–135, **IF = 0,242(Q4)**, **SJR = 0,148(Q4)**.

Abstract:

The physicochemical characteristics of chia oil from Argentina, which is one of the most efficient omega-3 (n-3) sources for enriching foods, have been studied. The results from analysis show that the chia oil has a relative density of 0.9288, refractive index 1.4810 and yellow color component that dominates over the red one. Its acidity index is 1.68 mg KOH/g, its saponification index is 197.9 mg KOH/g, iodine index is 208.3 g I₂/ 100g and the peroxide index is 1.95 meq O₂/kg. The fluorescence spectra for excitation wavelength 350 nm contain 3 peaks at about 472 nm, 503 nm and 670 nm, which are attributed to pigments, vitamins and oxidation products. Besides, the spectra in visible and UV range are used for determination of chlorophyll content, content of β -carotene, oxidation products and oxidant stability. Phase transition is observed at -36.9 °C. The content of some essential, non essential and toxic elements in the solution obtained after microwave-assisted (MW) digestion of the examined oil were determined by Inductively Coupled Plasma Mass Spectrometry (ICP-MS). This method could be useful for quality control of the oil when used in food industry, medicine and cosmetics. *The candidate's personal contribution consists of carrying out research with differential scanning calorimetry.*

- Г7.10. Viraneva, AP, Yovcheva, T., Bodurov, I., & Marudova, M. (2016). Polypropylene electrets films stored between two plate electrodes at low pressures. *Bulg. Chem. Commun.*, 48, 327–332, **IF = 0,242(Q4)**, **SJR = 0,148(Q4)**.

Abstract:

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. *The applicant's personal contribution consists of preparing the samples.*

Г7.11. **Marudova, Maria**, Momchilova, M., Antova, G., Petkova, Z., Yordanov, D., & Zsivanovits, G. (2017). Investigation of fatty acid thermal transitions and stability in poultry pates enriched with vegetable components. *Journal of Thermal Analysis and Calorimetry*, 133, 539–547, <https://doi.org/10.1007/s10973-017-6841-z>, IF = 4,755 (Q1), SJR = 0,587 (Q2).

Abstract:

The aim of the study was to describe the thermal characteristics of poultry pates enriched with vegetable components in relation to their chemical composition and technological process. Two poultry pates from chicken liver, chicken or turkey meat with vegetables were developed. The thermal characteristics of the raw materials and the ready pates were examined by differential scanning calorimetry; fatty acid profiles were detected by gas chromatography analysis. The study investigated the effect of such factors as heating/cooling rate and matrix effect of other components (e.g., proteins) in the raw materials and in the pates. It was observed that the cooling rate has a considerable effect on melting/crystallization temperature, enthalpy, and height of peaks in the process of pates fat crystallization, as well as peak height and enthalpy in the melting process. The first peaks formed during the crystallization were characterized by high instability, demonstrated by various peak shapes. The rapid cooling led to lowering of the melting point, assigned to the presence of unstable a crystals. The slow cooling led to mainly stable b0 crystals. The fraction of unsaturated fatty acids present in the fat was important for both crystallization rate and melting points in the raw materials and in the products as well. This effect was stronger in the pate products because of the presence of diverse components such as proteins. The results obtained could be used for the evaluation of thermal stability of pate fatty acids. *The candidate's personal contribution consisted in developing the study concept and conducting the differential scanning calorimetry tests.*

Г7.12. Sotirov, S., Bodurov, I., & **Marudova, M.** (2017). Novel ammonia sensor based on polyaniline/poly(lactic acid) composite films. *Journal of Physics: Conference Series*, 794, 012023, DOI 10.1088/1742-6596/794/1/012023, SJR = 0,241.

Abstract:

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 Al₂O₃ 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. *The applicant's personal contribution consists of developing the study concept and producing the sensor.*

Г7.13. Vlaeva, I., Nikolova, K., Bodurov, I., **Marudova, M.**, Tsankova, D., Lekova, S., Viraneva, A., & Yovcheva, T. (2017). Using differential scanning calorimetry, laser refractometry, electrical conductivity and spectrophotometry for discrimination of different types of Bulgarian honey. *Journal of Physics: Conference Series*, 794, 012034, DOI 10.1088/1742-6596/794/1/012034, [SJR = 0,241](#)

Abstract:

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. *The candidate's personal contribution consists of carrying out research with differential scanning calorimetry and analyzing the results.*

Г7.14. Yovcheva, T., Vasileva, T., Viraneva, A., Cholev, D., Bodurov, I., **Marudova, M.**, Bivolarski, V., & Iliev, I. (2017). Effect of immobilization conditions on the properties of β -galactosidase immobilized in xanthan/chitosan multilayers, *Journal of Physics: Conference Series*, 794, 0120324, DOI 10.1088/1742-6596/794/1/012032, [SJR = 0,241](#).

Abstract:

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 galactooligosaccharides 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 transgalactosylase 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. *The candidate's personal contribution consists in synthesizing the multilayer films and analyzing the results of the atomic force microscopy.*

- Г7.15. Zsivanovits, G., Grancharova, T., Dimitrova-Dyulgerova, I., Ivanova, D., Kostadinova, S., & **Marudova, M.** (2018). Postharvest quality and safety of fresh-cut melon fruits coated with water soluble chitosan films. *Progress in Agricultural Engineering Sciences*, 14, 133–145, , <https://doi.org/10.1556/446.14.2018.s1.13>, SJR = 0,202 (Q3)

Abstract:

The research presents the effect of novel edible coatings based on low molecular weight chitosan on some properties of fresh-cut melon fruits – weight loss, total soluble solids, total acidity, mechanical strength and bacteria growth. Three different compositions were used as coatings – pure chitosan, chitosan and Ca lactate and alginate/chitosan multilayers. It was shown that the additional alginate layer substantially improves the protective properties of pure chitosan coating, resulting in preservation of cell structure. Negligible negative effect on the antibacterial activity of pure chitosan is demonstrated. *The applicant's personal contribution is development of the research concept, development of the coating methodology and investigation of the mechanical strength of the packaged melon slices.*

- Г7.16. Gechev, B., Zsivanovits, G., & **Marudova, M.** (2019). Rheological models of gluten free bread dough. *AIP Conference Proceedings*, 2075, 160012, <https://doi.org/10.1063/1.5091339>, SJR = 0.19

Abstract:

Wheat-based bread products are major nutrition components in most countries around the world. The production of gluten-free bakery products with similar characteristics as wheat products is a challenge, and therefore a thorough study has been done over the past decades to produce gluten-free bread with the right structure and crumb texture. In addition, improving the quality of the bakery products and the development of the relevant apparatuses is entirely dependent on the overall knowledge of the dough rheology. The present research is focused on investigation of gluten free dough flow behavior and determining the best rheological model describing it. Rice, chestnut, sweet potato and maize flours were used in the experiments. A wheat flour was introduced as a reference. The main rheological curve (shear stress-shear rate dependence) was measured by HAAKE™ Viscotester™ 550 Rotational Viscometer, equipped with SV DIN measuring bob and cup configuration. The measurements were done at room temperature and shear rate range (0.01 – 1000) s⁻¹. Three categories of rheological models - empirical, theoretical, and structural, were applied to fit the experimental data. The most proper models, which describes the flow properties, were chosen based on statistical analysis. *The candidate's personal contribution consists of developing the research concept and modeling the experimental results.*

- Г7.17. Goranova, Z., **Marudova, M.**, & Baeva, M. (2019). Influence of functional ingredients on starch gelatinization in sponge cake batter. *Food Chemistry*, 297, 124997, <https://doi.org/10.1016/j.foodchem.2019.124997>, IF = 9.231 (Q1), SJR = 1.775(Q1).

Abstract:

The present study evaluated the thermal properties of sponge cake batters with different functional ingredients, and the effects of their adding on starch gelatinization. Samples of sponge cake batter: with wheat flour (control batter), with a reduced quantity of wheat flour and addition of functional ingredients (sponge cake batter with 50% einkorn wholemeal flour, sponge cake batter with 20% Jerusalem artichoke powder, sponge cake batter with 35% cocoa husk powder) were investigated. Using the method of differential scanning calorimetry (DSC) the starch gelatinization temperature intervals (°C) and energies of the different batters during baking were evaluated. Based on the experimental results, it could be concluded that the addition of functional ingredients in the cake batter retard the starch gelatinization. The gelatinization occurs at higher temperature and with higher energy consumption. The retarding effect of the functional ingredients is related to the water binding capacity and the presence of dietary fiber. *The candidate's personal contribution consists in carrying out the research using the method of differential scanning calorimetry and analyzing the results.*

Г7.18. Iserliyska, D., Zsivanovits, G., Gechev, B., **Marudova, M.**, Petrova, T., Ruskova, M., Bakalov, I., Iliev, A., & Ivanova, K. (2019). Influence of different polysaccharides on rheological behavior and thermal properties of gluten free dough. *AIP Conference Proceedings*, 2075, 160018, <https://doi.org/10.1063/1.5091345>, SJR = 0.19.

Abstract:

Polysaccharides traditionally have been used as replacer of gluten in bakery and bread production for increasing the quality of products for coeliac patients. The objective of the present study is to investigate the effect of some polysaccharides and emulsifiers on the rheological and thermal properties of gluten-free dough based on chestnut and rice flour. Herschel–Bulkley model was used to describe the non-Newtonian flow behavior of the dough. The viscoelastic properties of the dough were characterized by relaxation, retardation test. Water state (non-freezable and freezable water) in the dough and starch gelatinization were investigated by the method of differential scanning calorimetry (DSC). It was shown that because of specific interactions between the polysaccharides and the other ingredients, the rheological properties of the doughs with added polysaccharides are improved and the water absorption capacity increased. *The candidate's personal contribution consists in carrying out the research using the method of differential scanning calorimetry and analyzing the results.*

Г7.19. **Marudova, Maria**, & Yorov, T. (2019). Chitosan/poly (lactic acid) blends as drug delivery systems. *International Journal of Polymeric Materials and Polymeric Biomaterials*, 68, 99–106, IF = 3,221 (Q2), SJR = 0,447 (Q2), <https://doi.org/10.1080/00914037.2018.1525728>,

Abstract:

The immobilization and controlled release of salicylic acid (SA) in chitosan/poly(lactic acid) (Ch/LA) blends were studied in the present work. The Ch/PLA blend's morphology was studied by SEM. FT-IR and DSC were used to investigate the interactions between the polymer matrix and

the SA. The SA release kinetics was interpreted by the Weibull and Higuchi models. The SA release was the fastest in Ch/PLA systems with inhomogeneous and porous structure. It was slower in neat PLA matrix due to its dense structure and hydrophobic behavior, and in neat chitosan matrix, because of specific electrostatic chitosan/SA interactions and complex formation. *The candidate's personal contribution consists in developing the research concept, performing and analyzing the measurements using the differential scanning calorimetry method and interpreting the results.*

Г7.20. Radusheva, P., Pashev, A., Uzunova, G., Nikolova, K., Gentscheva, G., Perifanova, M., & **Marudova, M.** (2019). Physicochemical characteristics of seed oil of *Sambucus ebulus*, *Coriandrum sativum* L. and *Silybum marianum* L. *Bulgarian Chemical Communications*, 51, 144–149, SJR = 0,142 (Q4).

Abstract:

The physicochemical properties of oil extracted from the seeds of *Sambucus ebulus*, *Coriandrum sativum* L. and *Silybum marianum* L. (0.5:1:1) were examined. The fatty acid composition of the oil mixture was found to contain oleic (51.35%) and linoleic acids (35.01%) predominantly. The characteristic peak in infrared spectrum at about 1740 cm^{-1} was attributed to the C=O stretching in the carboxyl group of the fatty acids, oxidation products exhibit bands in $1730\text{-}1670\text{ cm}^{-1}$ region. The O-H stretching of the monomer fatty acid appears at about 3550 cm^{-1} , the signal around 3470 cm^{-1} was attributed to the overtone of the CO stretching and the other peaks at 3535 , 3621 and 3700 cm^{-1} are related to the stretching vibration of the OH group. The oxidative stability index was determined to be 12.7 h, the total content of tocopherols is 1340 mg/kg and total content of sterols was found at about 0.46%. The plant sterols with highest content that were found in the oil were β -Sitosterol (58.4%) and Δ^5 -Avenasterol (19.3%). Two fluorescent signals were observed at 570 nm and 680 nm which were assigned to correspond to oxidation products and chlorophyll respectively. Concentration of the toxic elements Cd and Pb were below $5\text{ ng}\cdot\text{g}^{-1}$ and $50\text{ ng}\cdot\text{g}^{-1}$ respectively. *The candidate's personal contribution consists in carrying out the research using the method of differential scanning calorimetry and analyzing the results.*

Г7.21. **Marudova, M.**, Stankov, S., & Baeva, M. (2020). Staling of sponge cakes with added emulsifiers. *Progress in Agricultural Engineering Sciences*, 101-108, SJR = 0,14 (Q4), <https://doi.org/10.1556/446.2020.20012>

Abstract:

The effect of three types of emulsifiers (polyglycerol monostearate ester – E475, sucrose stearate ester – E473 and modified inulin palmitate ester – HP-25) on the starch retrogradation in sponge cake (SC) during storage was investigated. The method of differential scanning calorimetry (DSC) was applied to determine the changes in the starch retrogradation during the staling process. The retrogradation temperature and the enthalpy of the endothermic transition decreased when emulsifiers were added. The lowest values of the enthalpy for the whole storage period were found for SC with 1% HP-25. The methods of differential thermal analysis (DTA) and thermogravimetry

analysis (TGA) showed significantly bigger (1.43 times) amount of strongly bound water in the crumb of the SC with E475 and HP-25 in comparison to the control sample on the sixth day of storage. Based on our results, emulsifiers possessed retarding effect on the starch retrogradation and extend the shelf-life of the SC. *The candidate's personal contribution consists in carrying out the research using the method of differential scanning calorimetry and analyzing the results.*

Г7.22. Radusheva, P., Pashev, A., Uzunova, G., Nikolova, K., Gentsheva, G., Perifanova, M., & **Marudova, M.** (2021). Comparative physicochemical analysis of oils derived from *Nigella sativa* and *Coriandrum sativum* L. *Journal of Chemical Technology and Metallurgy*, 56(6), 1175-1180, [SJR = 0,25 \(Q3\)](#).

Abstract:

The black cumin (*Nigella sativa*) and coriander (*Coriandrum sativum* L) are well-known representatives from Ranunculaceae and Apiaceae families, respectively. The aim of the present study is to evaluate the physicochemical properties of oils derived from black cumin and coriander. Their visible and fluorescent spectra have been recorded. The fatty acid profile for both oils has been obtained, indicating the predominant constituent of the oil to be linoleic acid (C 18:2) in 58.2 % and 42.29 %, respectively. The oils have a high content of polyunsaturated fatty acids, γ - and α -tocopherols. Oxidative stability of coriander oil is lower (8.2 h) compared to that of the black cumin oil (12 h). Differential Scanning Calorimetry (DSC) was used to measure the enthalpy changes and phase transitions in both oils samples. The concentrations of some elements (essential and toxic) in the oils were determined after acidic decomposition by using Inductively Coupled Plasma Mass Spectrometry (ICP-MS). The low content of Pb, As and Cd makes the oils safe to be used. *The candidate's personal contribution consists in carrying out the research using the method of differential scanning calorimetry and analyzing the results.*

Г7.23. Iserliyska, D., Zsivanovits, G., & **Marudova, M.** (2021). Study on the potential of chia gel usage as a natural fat substitute in cake formulation. *Progress in Agricultural Engineering Sciences*, 17(S1), 127-135., [SJR = 0,14 \(Q4\)](#), DOI: <https://doi.org/10.1556/446.2021.30015>

Abstract:

In the current study, cakes were prepared with the addition of different levels of chia gel obtained by soaking 1 part of chia seeds in 9 parts of water by weight. Mix was allowed to stand for 30 min for gel formation and seeds were left in the gel and later incorporated into the batter. The addition of chia gel to cake batter to partially substitute the fat from the basic recipe (control) resulted both in improved quality characteristics at all levels of substitution and reduction of caloric value, at the expense of energy from fat, especially at higher reduction levels (40 and 60%). The fat replacement at 40 and 60% had a caloric value decrease by 48 kcal per 100 g compared to the control and respectively the energy at the expense of the fat was 37.9 and 25.7% (reduction by 71.3 and 48.3%). Sensory evaluation demonstrated good acceptability for all the products with slight prevail for the samples with 40% followed closer by those with 20% fat replacement. Hence, chia gel proved to be a good alternative for fat substitution in baking goods recipes while preserving the quality and

sensory parameters aiming to produce healthier foods. *The candidate's personal contribution consists in carrying out the research using the method of differential scanning calorimetry and analyzing the results.*

Г7.24. **Marudova, M.**, Sotirov, S., Zhelyazkov, S., & Zsivanovits, G. (2021). Formulation and Characterization of Hydroxypropyl Methylcellulose Edible Films Containing Grape Seed Oil. *Macromolecular Symposia* (Vol. 395, No. 1, p. 2000278), **IF = 0,913/Q3**, **SJR = 0,25 (Q3)**, <https://doi.org/10.1002/masy.202000278>

Abstract:

Novel biobased multicomponent edible films from hydroxypropyl methylcellulose (HPMC) and grapeseed oil (GsO) are developed. This study investigates the effect of GsO concentration on some physical and physico-chemical properties of the films. The hydrophobicity of the films increases, which is expressed in improved water vapor permeability and reduced moisture absorption. Color and penetration properties of the films are also investigated. The pure cellulose film is almost colorless, but it becomes darker with pale greenish yellow color from the grape seed oil. The break force of the films is independent from the grape seed oil concentration, but the break deformation and the deformation work of the films with GsO is much higher and these are more elastic. Finally, multicomponent films demonstrated strong antioxidant activity. The obtained results suggest that the new multicomponent films may be used as food active packaging. *The candidate's personal contribution consists of developing the research concept, obtaining the edible films and investigating their barrier properties.*

Г7.25. Grigorov, A., Viraneva, A., **Marudova, M.**, & Yovcheva, T. (2021). Effect of pH and ionic strength of chitosan/casein and casein/chitosan multilayers on curcumin release. *Journal of Physics: Conference Series* (Vol. 1762, No. 1, p. 012005), **SJR = 0,21 (Q4)**, doi:10.1088/1742-6596/1762/1/012005

Abstract:

In the present paper the effect of pH and ionic strength on the immobilization and release of curcumin from chitosan and casein polyelectrolyte multilayers (PEMs) was investigated. The investigated PEMs were deposited on polylactic acid (PDLA) substrates. The PLA substrates were charged in a corona discharge system, consisting of a corona electrode, a grounded plate electrode and a grid placed between them. The substrate was charged for 1 minute at room temperature. Positive or negative 5kV voltage was applied to the corona electrode and 1 kV voltage with the same polarity was applied to the grid. Chitosan solutions with different pH and ionic strength were prepared. Layer-by-Layer (LbL) deposition technique was used for the multilayer build-up. For the deposition process was ensured that the first deposited layer always possessed an opposite electric charge to that of the substrate. An investigation of the water uptake properties of the deposited PEM multilayers was carried out. Curcumin was immobilized in the resulting casein layers. The release of the immobilized curcumin from the multilayers in saline buffer was investigated and the effects of the different pH and ionic strengths of the chitosan solutions were determined. *The*

candidate's personal contribution consists of developing the study concept and establishing the release kinetics of curcumin.

- Г7.26. Zhelyazkov, S., Zsivanovits, G., Stamenova, E., & **Marudova, M.** (2022). Physical and Barrier Properties of Clove Essential Oil Loaded Potato Starch Edible Films. *Biointerface Research in Applied Chemistry* 12 (4), 4603 – 4612, **IF = 0,35 (Q3)**, **SJR = 0,25 (Q3)**, <https://doi.org/10.33263/BRIAC124.46034612>

Abstract:

This study explores the effect of Clove essential oil (CEO) nanoemulsion on the physical and physicochemical properties of potato starch edible films. Mechanical properties at puncture tests, film thermal stability, morphology, color CIELAB parameters, water vapor permeability, and gas barrier properties towards oxygen and carbon dioxide were determined. Films were characterized with white color and high opacity. The films' surface morphology was examined by polarized microscopy, and homogeneous distribution of the incorporated nanoemulsion into the edible film was observed. The loaded CEO improved the water and gas barrier properties of the films. In this way, the formulated new multicomponent films are suitable for use in the design of active food packaging. *The candidate's personal contribution consists of developing the research concept, obtaining the edible films and investigating their barrier properties.*

- Г7.27. Sotirov, S., Demirci, S., **Marudova, M.**, & Sahiner, N. (2022). Trimesic Acid-Based Co (II) MOFs as Colorimetric Sensor for Detection of Ammonia Gas. *IEEE Sensors Journal*, 22(5), 3903-3910, **IF = 4,325 (Q1)**, **SJR = 0,93 (Q1)**, DOI: 10.1109/JSEN.2022.3145046

Abstract:

The design of colorimetric sensing materials with low detection limits, and high stability are considered as important parameters in the development of ammonia (NH₃) sensors. In this research, we present a Metal-Organic Framework (MOF) based on Trimesic Acid and Co(II) (TMA-Co(II)) as the sensing material. The color detection of MOF upon exposure to NH₃ was detected by Visible (VIS) fiber spectrometer, developed on the integrated circuit C12880MA of HAMAMATSU PHOTONICS, which is an integrated mini spectrometer operating in the spectral range between 340-850 nm. The activated TMA-Co(II) MOF demonstrated a limit detection of 60 ppm and the time of response ranged from 2 min to 12 min depending on the NH₃ concentration. The sensor showed outstanding stability and reversibility in the cyclic test. It was easily recoverable by interaction with acid. *The candidate's personal contribution consists of developing the research concept and developing a composite film of (TMA-Co(II)) and polylactic acid.*

- Г8.1. **Marudova, M.**, Viraneva, A., Sotirov, S., Bodurov, I., Exner, G., Vlaeva, I., & Yovcheva, T. (2018). Innovative biopolymer nano-multilayered films for biomedical applications: Fabrication and physical properties. *Advances in Polymers for Biomedical Applications*, 2018, 1–27, Nova Science Pub Inc., ISBN-10: 1536136123, ISBN-13: 978-1536136128.

Abstract:

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. *The applicant's personal contribution consists in developing the concept for creating the overview publication.*

Г9.1. Patent for invention Reg. No. 67404 B1, Title: Preparation of water-insoluble glucan by means of a transferase enzyme reaction, Inventor/s: Ilia Nikolov Iliev, Tonka Atanasova Vasileva. Veselin Petrov Bivolarski, Temenuzka Atanasova Yovcheva, Maria Georgieva Marudova-Zhivanovich, Asya Petrova Viraneva, Ivan Panayotov Bodurov

Summary:

The present patent application relates to the enzymatic synthesis of water-insoluble glucan by means of a transferase reaction with glucansucrase URE 13-300. The latter was obtained by cultivating a recombinant strain E. coli BL21(DE3), containing the gene for glucansucrase URE 13-300, which was transferred from strain Leuconostoc mesenteroides URE 13 (registration number NBIMCC 8970, NBPMKK, Sofia). The water-insoluble glucan has a molecular mass of 2.49×10^6 Da and a radius of gyration (RG) of 60.0 to 2.78×10^6 and a radius of gyration of 67.0 and a branched structure, with a predominance of α -(1,6) linkages between main chain glucose

residues (67.2%); 16.18% α -(1,3) linkages at branch points and 8.32% α -(1,6) linkages at branches. The high-molecular-weight glucanase URE 13-300 was successfully immobilized in multilayer films involving 1% chitosan and 0.2% xanthan/water-soluble glucan in a 1:1 ratio with the highest enzyme activity in a positively charged 12-layer film and synthesized short-chain oligosaccharides with a degree of polymerization of 4 to 6 glucose units. The synthesized glucan forms a film with antistatic properties when combined with locust bean gum and xanthan in a ratio of 1:1:1. *The candidate's personal contribution consists in investigating the thermal properties of water-insoluble glucan.*

Textbooks, study guides and e-courses:

1. M. Marudova, "Mechanics", "Paisii Hilendarski" University Publishing House, Plovdiv, 2023, ISBN

This textbook is intended for all students studying "Mechanics" at the Faculty of Physics and Technology at the University of Plovdiv. The material presented is in accordance with the current bachelor's degree curricula and programs. In the fourteen sections of the textbook, the main concepts, laws and phenomena of mechanics are examined, with special attention being paid to the clarification of their physical meaning and their practical applications. Experimental studies are combined with theoretical explanations, in which a mathematical apparatus studied in the first year of the students' studies is used. The textbook can also be useful for students from other universities in which physics is the main discipline, as well as for students studying in other specialties of Plovdiv University who study physics.

2. A. Viraneva, G. Exner, E. Marekova, I. Bodurov, M. Marudova, T. Yovcheva, "Manual for laboratory exercises in physics", "Paisii Hilendarski" University Publishing House, Plovdiv, 2018, **ISBN 978-619 -202-358-4**.

The Physics Laboratory Manual is intended to help students gain a deeper understanding of the physics course, to become aware of basic physical laws, and to acquire practical habits for accurate measurements. Acquaintance with the equipment and measurement methods is an introduction to the students' further independent work. For each exercise, the manual provides: exercise objective, accessories, question theory and working formulas, performance tasks, description of the experimental setup and method of operation, experimental data and results, evaluation of experimental uncertainty, and control questions. Tables are given for a more visual representation of the obtained measurement results. For ease of work, tables with values of various physical quantities are given as appendices at the end.

3. M. Marudova, "Mechanics and molecular physics", <https://v4.dipseil.net>

The lecture course is intended for students from all specialties of the Faculty of Physics and Technology who study the discipline "Mechanics and Molecular Physics". It is a consistent modern presentation of the basic concepts, quantities, laws and experimental facts of molecular physics

and classical thermodynamics, which uses the mathematical apparatus studied in the first year. With the help of the two mutually complementary approaches (thermodynamic and molecular-kinetic), the simplest thermodynamic system – an ideal gas – is studied. Real gases (van der Waals equation, internal energy, Joule-Thomson effect) as well as basic questions of statistical physics (Boltzmann and Maxwell distributions) are also considered.

The learned thermodynamic principles and the fundamentals of the molecular-kinetic theory are applied when considering the structure and properties of liquids, at phase transitions of the first order and at transfer phenomena in gases - diffusion, internal friction and heat conduction. The following questions are also included in the study materials: air humidity; dependence of saturated vapor pressure on the curvature of the free surface of the liquid with application to phenomena in the atmosphere; anomalous properties of ice and water – hydrogen bonding; role of convection in some atmospheric phenomena.

4. M. Marudova, "High molecular compounds", <https://v4.dipseil.net>

The course on "High molecular compounds" for the specialty "Engineering Physics" aims to acquaint students with the basic concepts and regularities in studying the physics of polymeric materials. The need for such a course is conditioned by their increasing use in all areas of the material sphere. A particularly relevant direction is to acquaint students with the classes of polymers obtained from renewable sources. Knowledge of their physical and physico-chemical properties enables the development of new materials that are environmentally friendly, biodegradable and, in most cases, non-toxic. Competencies acquired within the course are necessary and sufficient in the application of physical approaches to the study of polymers and enable the realization of students in new and perspectival areas.

5. M. Marudova, "Fundamentals of Electronics", <https://v4.dipseil.net>

The lecture course is intended for students from all specialties of the Faculty of Physics and Technology who are studying the discipline "Fundamentals of Electronics". The lecture material presents the basic physical principles of operation of the most commonly used semiconductor elements - diodes, various types of transistors and optoelectronic elements. Basic parameters, characteristics, principle of operation and applications of various types of amplifiers and generators are analyzed. Included are possibilities to implement any logic function using basic logic elements. Variants for their schematic implementation are analyzed as action and basic parameters. Types of combinational and sequential circuits, digital pulse generators, digital-to-analog converters (DACs) and analog-to-digital converters (ADCs) are studied.

6. M. Marudova, "Application of polymers in medicine and biotechnology", <https://v4.dipseil.net>

The course is offered for BSc students from specialties "Medical Physics" and "Engineering Physics". Its main goal is to acquaint students with the latest trends in the use of polymeric materials

in medicine, pharmacy and biotechnology. The relevance of the course is confirmed by the extremely voluminous and in-depth research in recent years related to the study of the synthesis and properties of functional polymers and composite materials that exhibit non-toxicity and biocompatibility - properties that put them in the position of leaders in their use in medicine, pharmacy and biotechnology. Students who have attended the course "Application of polymers in medicine and biotechnology" receive systematic knowledge about the interaction of polymer materials with living organisms, become familiar with certain classes of synthetic and natural polymers and their areas of application - implants in the cardiovascular system, implants in bone and cartilage tissues, soft tissue substitutes, skin wound dressings, drug delivery systems, etc.

7. M. Marudova, "Physics - mechanics and molecular physics", <https://v4.dipseil.net>

The course in "Physics - mechanics and molecular physics" is part of the basic education of students from the specialty "Telecommunications with Management" at the Faculty of Physics and Technology and "Bioengineering" at the Faculty of Biology. Its task is to acquaint students with the basic concepts, quantities, laws and experimental facts of mechanics, molecular physics and classical thermodynamics. The course is built inductively, with an emphasis on experimentation. Special attention is paid to the examination of phenomena from production practice and everyday life.

8. M. Marudova, "Physics 1 - mechanics" (in English), <https://v4.dipseil.net>

The course is designed for the specialty "Telecommunications and Information Systems" (in English), Distance training, Education and Qualification level Bachelor's degree. It is divided thematically into two parts. The first part presents basic concepts, physical quantities, laws and experimental facts from classical mechanics of idealized models and real objects. Major topics cover kinematics, dynamics, conservation laws, solid mechanics, fluid mechanics, vibrations and waves.

9. 9. M. Marudova, "Polymers in Electronics and Telecommunications" (in English), <https://v4.dipseil.net>

The course is designed for the specialty "Telecommunications and Information Systems" (in English), Distance training, Education and Qualification level Bachelor's degree. The need for such a course is due to the increasing use of polymers in all areas of the material sphere and especially in engineering. It aims to familiarize learners with the basic concepts and regularities in the study of polymer materials and to present some specific applications related to electronics and telecommunications. Particular attention is paid to the study of the interrelationships between structure, properties and applications. The electrical behavior of polymers is described in detail, not only in terms of their well-established insulating properties, but also as conductive materials playing an increasingly important role in modern electronics. Information is given on some classes

of special polymers, including ferroelectric polymers. Specific applications of polymers in electronics and telecommunications devices are reviewed.

The competencies acquired within the course are necessary and sufficient for the selection of polymer materials in the construction of various electronic and telecommunication devices and for predicting their changes (aging) during the operational period.

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