International Scientific Conference:
Pharmaceutical Science, Physical Chemistry and Biophysics for Pharmacy 2026
“Pharmaceutical solutions and aqueous systems in medicine and technology”
7th of May, 2026

and

BIP Erasmus+ Program:
Blended Intensive Program course 2026
“Solutions as pharmaceutical products: the physicochemical properties of solutions and methods of solubilizing medicinal substances”
20-24 of April and 4-8 of May, 2026 Wrocław, Poland

BOOK OF ABSTRACTS

Auditory Hall of the Faculty of Pharmacy
Wroclaw Medical University
ul. Borowska 211, 50-556 Wroclaw

Department of Physical Chemistry and Biophysics
Wroclaw Medical University
ul. Borowska 211A, 50-556 Wrocław

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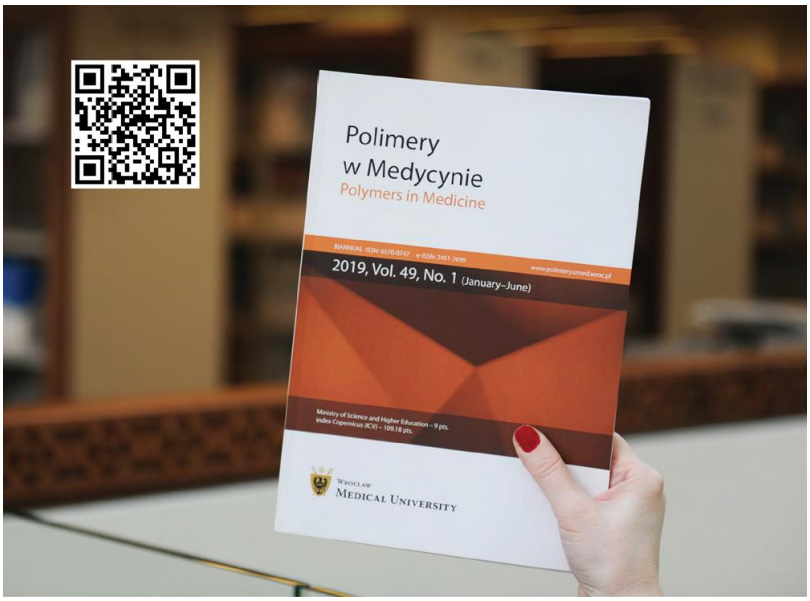

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Department of Physical Chemistry and Biophysics, Wrocław 2026

International Scientific Conference
Pharmaceutical Science.
Physical Chemistry and Biophysics for Pharmacy 2026.
“Pharmaceutical solutions and aqueous systems in medicine and technology”
May 7, 2026
Wrocław-Poland
Auditory Hall of the Faculty of Pharmacy, Wroclaw Medical University, ul. Borowska 211, 50-556 Wroclaw

Blended Intensive Program
Methods in physical pharmacy.
Solutions as pharmaceutical products: the physicochemical properties of solutions and methods of solubilizing medicinal substances.

On-line sessions and lectures:
April 20-24, 2026
Cagliari-Italy, Padova–Italy, Dublin-Ireland, Kaunas-Lithuania, Bragança-Portugal, Bucharest-Romania, Plovdiv-Bulgaria, Bratislava-Slovakia, Wrocław-Poland

On-site sessions and laboratory workshops:
May 4-8, 2026
Wrocław-Poland
Department of Physical Chemistry and Biophysics, ul. Borowska 211A, 50-556 Wrocław

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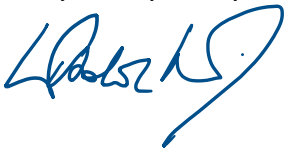
Dear Colleagues and Friends,

On behalf of the Organizing Committee, I would like to express gratitude for the excellent meetings, talks, lectures and workshop, which we could experience with You as a Team of the Department of Physical Chemistry and Biophysics. I thank all the participants of the workshops within Blended Intensive Program course 2026 entitled “Solutions as pharmaceutical products: the physicochemical properties of solutions and methods of solubilizing medicinal substances” as well as participants of international conference Physical Chemistry and Biophysics for Pharmacy 2026, which focused on the “Pharmaceutical solutions and aqueous systems in medicine and technology”. The aim of the conference gave us researchers, as well as PhD students and undergraduates, the opportunity to discuss the latest important research developments in physical chemistry applied in the field of pharmaceutical solutions. Thank you for lectures, posters and discussions of high merit value. We hope that also the picturesque heart of Wrocław's Old Town gave you the possibility to relax and fill the millennial history of our city in the breaks between scientific duties.

Witold Musiał, PhD, DSc, Professor



Topics

1. Electric conductivity of pharmaceutical solutions
2. Surface tension of pharmaceutical solutions
3. pH of pharmaceutical solutions
4. Potentiometric determination of ions concentration
5. Pharmaceutical biphasic formulations
6. Theory of electrokinetic conductivity
7. Pharmaceutical solutions as drug delivery systems
8. Enhancement of API solubility

Conference timetable: 7.05.2026

Lp.	Event	Time [min]	Hour [h]	Other
1.	Registration and reception	20/10	8.00-8.30	
Session No 1 Pharmaceutical solutions as drug delivery systems				
2.	**Lipo-Hydrophilic Modifications of Compounds and Effect on Solubility and Activity.** Josef Jampilek. Department of Analytical Chemistry, Faculty of Natural Sciences, Comenius University, Bratislava, Slovakia.	40	8.30-9.10	
3.	**Electrochemical evaluation of pharmaceutical systems – an approach to the assay of release kinetics measurements.** Witold Musial. Wroclaw Medical University, Wroclaw, Poland.	20	9.10-9.30	
4.	Discussion	5	9.30.-9.35	
5.	Coffee break	15	9.35-9.50	
Session No 2 Evaluation of aqueous pharmaceutical systems				
6.	**Engineering materials for nonenzymatic glucose sensors.** Mahabubur Rahman Chowdhury. Department of Chemical Engineering, Cape Peninsula University of Technology, Symphony Way, Bellville 7535, South Africa	40	9.50-10.30	
7.	**Assembly and Characterization of Polyelectrolyte Protein Reservoirs on Electrospun Mats**, Tomasz Urbaniak, Wroclaw Medical University, Wroclaw, Poland.	20	10.30-10.50	
8.	Discussion	5	10.50-10.55	
9.	Coffee break	15	10.55-11.10	
Session No 3 Enhancement of API solubility in aqueous environment				
10.	**Increasing the solubility of nanoparticles in medicinal formulations.** Sourav Bhattacharjee. University College Dublin, School of Veterinary Medicine, Belfield, Dublin, Ireland.	40	11.10-11.50	
11.	Discussion	10	11.50-12.00	
12.	Lunch break	75	12.00-13.15	
Session No 4 Complex aqueous systems – between emulsions and suspensions				
13.	**Liposomes: a pivotal drug delivery strategy. Analytical, technical and regulatory challenges.** Carla Caddeo. Università degli Studi di Cagliari, Italy.	40	13.15-13.55	
14.	Discussion	10	13.55-14.05	
15.	Coffee break	30	14.05-14.35	
Session No 5 Students and Young Researchers Forum				
16.	Presentations of the student and young researchers.	10	14.35-14.45	
17.		10	14.45-14.55	
18.		10	14.55-15.05	
19.		10	15.05-15.15	
20.		10	15.15-15.25	
21.	Summary	5	15.25-15.30	
Poster Session – general access				
22.	On billboards		8.00-15.30	

On-line BIP sessions: 20-24.04.2026

Day	Time	Location	Type	Theme
20.04.2026	9.00-11.00 Tomasz Urbaniak	Virtual auditorium[1)]	Seminar	Physicochemical Properties of Pharmaceutical Solutions and Advanced Methods for Solubilizing Medicinal Substances – a review.
21.04.2026	9.00-11.00 Josef Jampilek Agnieszka Gola	Virtual auditorium[1)]	Seminar	Electric conductivity of pharmaceutical solutions – pharmacopeial standard.
22.04.2026	9.00-11.00 Monika Gasztych Agnieszka Kostrzębska Iwona Golonka	Virtual auditorium[1)]	Seminar	Surface tension of pharmaceutical solutions – scientific standards.
23.04.2026	9.00-11.00 Justyna Kobryń Witold Musiał	Virtual auditorium[1)]	Seminar	Solubility and pH measurements in pharmaceutical solutions.
24.04.2026	9.00-11.00 Gianfranco Pasut Dorota Wójcik-Pastuszka	Virtual auditorium[1)]	Seminar	Pharmaceutical biphasic formulations stabilized with surfactant.

1) MS Teams environment (link to MSTeams meeting will be send to the participants at least two days before the event on the registration e-mails)

On-site BIP sessions: 04-08.05.2026

Day	Time	Location	Type	Theme
04.05.2026 (Monday)	9.00-9.45	Meeting room[2)]	Seminar	Theory of electrokinetic conductivity in pharmaceutical solutions Agnieszka Gola/Justyna Kobryń
	9.45-10.00	Meeting room[2)]	Coffee	Discussion and coffee
	10.00-13.00	Laboratory[3)]	Practice	Electrokinetic conductivity measurements Agnieszka Gola/Justyna Kobryń
	13.00-15.00	Meeting room[2)]	Seminar	Discussion and lunch
05.05.2026 (Tuesday)	9.00-9.45	Meeting room[2)]	Seminar	Theory of pH and potentiometric determination of ions concentration (Ion-Selective Electrode Method) measurements, solubility of pharmaceutical solutions Tomasz Urbaniak/Zuzanna Podgórniak
	9.45-10.00	Meeting room[2)]	Coffee	Discussion and coffee
	10.00-13.00	Laboratory[3)]	Practice	pH measurements and solubility Tomasz Urbaniak/Zuzanna Podgórniak
	13.00-15.00	Meeting room[2)]	Seminar	Discussion and lunch
06.05.2026 (Wednesday)	9.00-9.45	Meeting room[2)]	Seminar	Theory of surface tension measurements of pharmaceutical solutions Iwona Golonka/Agnieszka Kostrzębska/Monika Gasztych
	9.45-10.00	Meeting room[2)]	Coffee	Discussion and coffee
	10.00-13.00	Laboratory[3)]	Practice	Surface tension measurements Iwona Golonka/Agnieszka Kostrzębska/Monika Gasztych
	13.00-15.00	Meeting room[2)]	Seminar	Discussion and lunch
07.05.2026 (Thursday)	8.00-16.00	Auditory hall[4)]	Presentations, discussion, coffee and lunch	Lectures focused on physicochemical methodologies for the development and quality assessment of emerging pharmaceutical technologies.
08.05.2026 (Friday)	9.00-9.45	Meeting room[2)]	Seminar	Theory of emulsions for pharmaceutical applications Dorota Wójcik – Pastuszka/Maria Jolanta Szczygieł
	9.45-10.00	Meeting room[2)]	Coffee	Discussion and coffee
	10.00-13.00	Laboratory[3)]	Practice	Preparation and evaluation of emulsion properties Dorota Wójcik – Pastuszka/Maria Jolanta Szczygieł
	13.00-15.00	Meeting room[2)]	Seminar	Discussion and lunch

2) Department of Physical Chemistry and Biophysics, ul. Borowska 211A, 50-556 Wrocław (A.3/7.3/011), 3) Department of Physical Chemistry and Biophysics (A.3/7.3/003A), 4) Auditory Hall No W1, ul. Borowska 211, 50-556 Wrocław

PLENARY LECTURES

PL1. **Lipo-Hydrophilic Modifications of Compounds and Effect on Solubility and Activity.** Josef Jampilek. Department of Analytical Chemistry, Faculty of Natural Sciences, Comenius University, Bratislava, Slovakia.

PL2. **Electrochemical evaluation of pharmaceutical systems – an approach to the assay of release kinetics measurements.** Witold Musial. Wroclaw Medical University, Wroclaw, Poland.

PL3. **Engineering materials for nonenzymatic glucose sensors.** Mahabubur Rahman Chowdhury. Department of Chemical Engineering, Cape Peninsula University of Technology, Symphony Way, Bellville 7535, South Africa.

PL4. **Assembly and Characterization of Polyelectrolyte Protein Reservoirs on Electrospun Mats.** Tomasz Urbaniak, Wroclaw Medical University, Wroclaw, Poland.

PL5. **Increasing the solubility of nanoparticles in medicinal formulations.** Sourav Bhattacharjee. University College Dublin, School of Veterinary Medicine, Belfield, Dublin, Ireland.

PL6. **Liposomes: a pivotal drug delivery strategy. Analytical, technical and regulatory challenges.** Carla Caddeo. Università degli Studi di Cagliari, Italy.

PL1: Lipo-Hydrophilic Modifications of Compounds and Effect on Solubility and Activity

Josef Jampilek[1,2]

[1]Department of Chemical Biology, Faculty of Science, Palacky University Olomouc, Slechtitelu 27, 779 00 Olomouc, Czech Republic; [2]Department of Analytical Chemistry, Faculty of Natural Sciences, Comenius University, Ilkovicova 6, 842 15 Bratislava, Slovakia; e-mail: josef.jampilek@gmail.com

Optimization of the structure of bioactive agents with respect to ADMET & DMPK properties of molecules is one of the priorities of modern drug design [1,2]. Lipophilicity and, on the other hand, water solubility (hydrophilicity) are key properties of bioactive agents, but they act against each other. As a result, lipophilicity is responsible for solubility, transport across membranes, binding to plasma proteins, and also for the interaction of molecules with receptors, which most often manifests a biological effect [3-5]. Therefore, it is necessary to optimize lipo-hydrophobic properties with respect to the sites of action and the route of administration.

A common quantitative descriptor of lipophilicity is the logarithm of the partition coefficient log *P*. Studies show that the optimal range of lipophilicity, expressed as the logarithm of the n-octanol/water partition coefficient (log *P*), for optimal absorption in the gastrointestinal tract by passive diffusion after oral administration is from 0 to 3 [3,4,6]. However, log *P* values include only the neutral form of the compound and are independent of ionization under physiological conditions. If a molecule contains basic or acidic groups, it can be ionized and its distribution in the n-octanol/water system depends on pH. It is estimated that 95% of drugs are ionizable. Therefore, another descriptor of lipophilicity for ionizable molecules is expressed as the distribution coefficient *D* or its logarithm. Log *D* is dependent on the pH of the environment and its value includes the contribution of all ionized forms of the substance present at a given pH [3,6]. Lipophilicity can be determined experimentally using the so-called direct and indirect methods [3,6].

This brief presentation discusses various approaches to modifying the lipo-hydrophilic properties of bioactive compounds, which also has a direct connection with the level and duration of biological activity, toxicity of compounds, or persistence in the organism or environment.

Acknowledgement: This work was supported by projects APVV-24-0341 and VEGA 1/0727/25.

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[1] K. Wu, E. Karapetyan, J. Schloss, J. Vadgama, Y. Wu. Advancements in Small Molecule Drug Design: A Structural Perspective. Drug Discovery Today, 2023, Volume 28, 103730.

[2] L.D. Pennington, M.J. Hesse, D.C. Koester, R.C. McAtee, A.M. Qunies, D.X. Hu. Property-Based Drug Design Merits a Nobel Prize. Journal of Medicinal Chemistry, 2024, Volume 67, Pages 11452-11458.

[3] E.H. Kerns, L. Di. Drug-Like Properties: Concepts. Structure Design and Methods: From ADME to Toxicity Optimization. Academic Press, San Diego, CA, USA, 2008.

[4] V. Pliska, B. Testa, H. van der Waterbeemd. Lipophilicity in Drug Action and Toxicology. Wiley-VCH, Weinheim, Germany, 1996.

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[6] E. Rutkowska, K. Pajak, K. Jozwiak. Lipophilicity – Methods of Determination and Its Role in Medicinal Chemistry. Acta Poloniae Pharmaceutica, 2013, Volume 70, Pages 3-18.

PL2: Electrochemical evaluation of pharmaceutical systems – an approach to the assay of release kinetics measurements

Witold Musiał

Department of Physical Chemistry and Biophysics, Pharmaceutical Faculty, Wroclaw Medical University, Borowska 211, 50-556 Wrocław, Poland.

This lecture presents an electrochemical approach to assessing the properties of pharmaceutical systems, with particular emphasis on the release kinetics of active ingredients. The results of studies utilizing electrical conductivity measurements as a sensitive, label-free analytical tool for monitoring release processes will be presented. Using formulations containing iron ions as an example, it was demonstrated that the conductometric method allows for reliable, continuous monitoring of the diffusion kinetics of active ingredients and an assessment of the effect of formulation composition on the release mechanism.

Furthermore, the use of electrical conductivity as a parameter describing the properties of liposomal transdermal systems containing naproxen sodium is discussed. It was demonstrated that changes in conductivity reflect both the stability of lipid structures and interactions between formulation components, making this method useful in the design of carrier systems.

Furthermore, an alternative electrochemical approach to determining Fe(II) ions in pharmaceutical preparations is presented, confirming the high sensitivity and selectivity of methods based on measurements of conductivity and electrochemical properties. In summary, electrochemical methods are a valuable tool supporting classical analytical techniques in drug research, enabling rapid, non-invasive and cost-effective determination of release kinetics and characterization of complex pharmaceutical systems.

Bibliography: available from the author/authors.

PL3: Engineering materials for nonenzymatic glucose sensors

Mahabubur Rahman Chowdhury

Department of Chemical Engineering, Cape Peninsula University of Technology, Symphony Way, Bellville 7535, South Africa.

Presented as an oral lecture.

Bibliography: available from the author/authors.

PL4: Assembly and Characterization of Polyelectrolyte Protein Reservoirs on Electrospun Mats

Tomasz Urbaniak, Zuzanna Podgórniak, Witold Musiał

Department of Physical Chemistry and Biophysics, Pharmaceutical Faculty, Wroclaw Medical University, Borowska 211, 50-556 Wrocław, Poland.

Electrospun fibrous mats offer a highly versatile platform for biomedical applications due to their high surface area, tunable porosity, and structural similarity to the extracellular matrix. However, achieving controlled and sustained protein delivery from such systems remains a significant challenge, primarily due to rapid burst release and limited stability of surface-bound biomolecules. This work presents a strategy for modifying electrospun mats via polyelectrolyte multilayer coatings to enable tunable protein adsorption, retention, and release.

Polyelectrolyte coatings were assembled on electrospun substrates to create functional interfaces capable of binding model proteins via electrostatic interactions. The interfacial properties and adsorption behavior were systematically investigated using surface plasmon resonance (SPR) and spectroscopic ellipsometry, providing quantitative insight into layer growth, protein binding kinetics, and film stability. These complementary techniques allowed precise monitoring of coating buildup and protein incorporation under varying assembly conditions. To further enhance control over protein release and improve coating robustness, an in situ crosslinking approach was introduced, targeting polyanionic components within the multilayer architecture. Crosslinking was performed under mild conditions compatible with protein stability, leading to the formation of stabilized networks with reduced solubility and increased resistance to environmental perturbations. The effect of crosslinking on protein retention and release profiles was evaluated, demonstrating a significant reduction in burst release and prolonged delivery. Scanning electron microscopy (SEM) was employed to assess the morphology of electrospun mats before and after coating and crosslinking, confirming preservation of fibrous structure and uniform coating coverage. The combined results indicate that polyelectrolyte functionalization, coupled with controlled crosslinking, provides an effective means to tailor protein delivery from electrospun systems.

This approach offers a modular and adaptable platform for designing advanced biomaterials with tunable release characteristics, with potential applications in wound healing, tissue engineering, and localized therapeutic delivery.

This work was supported by the National Science Centre (NCN), Poland, under the SONATA programme (grant no 2023/51/D/NZ7/00797).

Bibliography: available from the author/authors.

PL5: Increasing the solubility of nanoparticles in medicinal formulations

Sourav Bhattacharjee

University College Dublin, School of Veterinary Medicine, Belfield, Dublin, Ireland

Presented as an oral lecture.

Bibliography: available from the author/authors.

PL6: Liposomes: a pivotal drug delivery strategy. Analytical, technical and regulatory challenges

Carla Caddeo

Dept. of Life and Environmental Sciences, University of Cagliari, S.P. 8 Monserrato-Sestu km 0.700, 09042 Monserrato (Cagliari), Italy

Introduction: Liposomes are the first nanoparticle-based drug delivery system to receive regulatory approval from FDA/EMA in the 90s and remain the most commercially successful and widely utilized nanoparticle platforms in the pharmaceutical industry. Small-molecule chemotherapy drugs, virosomal vaccines, depot systems for pain management, and recombinant protein vaccines have reached the market as parenteral liposomal formulations, enhancing pharmacokinetic properties and mitigating off-target adverse effects. No marketed liposomal medicinal products are currently available for skin application, while many liposomal cosmetic products are already in the market. Liposomes Liposome technology is also widely used in commercial food supplements.

Materials and methods: Liposomes are composed of amphiphilic phospholipids that assemble into bilayers, which then close into nanosized vesicles. Conformation and size are typically determined by composition and preparation conditions. It is crucial to fine-tune the liposome's characteristics because liposome composition, structure, size, and surface charge play crucial roles in how they behave. A comprehensive characterization of liposomes based on multiple complementary techniques is required to ensure quality, safety, and efficacy - essential for regulatory approval and clinical use.

Results: Biocompatibility, versatility, the ability to carry different types of compounds, increased solubility, protection from degradation, enhanced bioavailability, controlled and targeted delivery, and reduced toxicity are behind liposomes' success.

Discussion: Despite the enormous advantages of liposomes, they display limitations in entrapping certain macromolecules or high doses of hydrophobic compounds, their susceptibility to oxidation and hydrolysis, the risk of drug outflow and vesicle fusion during storage and within the body, scalability issues, high production costs, and the lack of comprehensive regulatory and standardization guidelines. Addressing these challenges is crucial to ensuring the safety, efficacy, and regulatory compliance of liposomal formulations.

Conclusions: Liposomes are a well-established drug delivery system with decades of clinical and market success. Producing liposomes consistently and at scale is difficult, and strict quality standards for medical use are hard to meet. Nonetheless, liposome technology continues to grow as a vital component of the healthcare system, increasing the number of available therapeutic options.

Bibliography: available from the author/authors.

ACADEMIC LECTURES
in the frames of BIP Erasmus+

L1: Electric conductivity of pharmaceutical solutions – pharmacopoeial standards

Agnieszka Gola

Wroclaw Medical University, Department of Physical Chemistry and Biophysics, Pharmaceutical Faculty Borowska 211, 50-556 Wroclaw, Poland

Electrical conductivity is a pivotal physicochemical parameter that is utilised in pharmaceutical analysis, serving as an indicator of the total ionic content of aqueous systems. The instrument's sensitivity to dissolved ionic species renders it a rapid and non-specific tool for the assessment of purity and quality in pharmaceutical matrices.

In the domain of pharmaceutical practice, the primary application of conductivity measurements is in the control of pharmaceutical water systems, encompassing Purified Water and Water for Injection, as well as specific drug formulations where the ionic composition is pivotal to performance and safety.

The determination and evaluation of conductivity are governed by pharmacopeial standards, such as the European Pharmacopoeia and the United States Pharmacopeia. These documents specify measurement conditions, acceptance criteria, and structured, multi-stage evaluation procedures. These frameworks ensure harmonised interpretation of results and mitigate the limitations associated with the non-specific nature of conductivity measurements.

Conductivity analysis has been shown to constitute a robust, efficient, and standardized approach for monitoring ionic purity and supporting quality assurance in pharmaceutical systems.Electrical conductivity is a fundamental physicochemical parameter employed in pharmaceutical analysis as an indicator of the total ionic content of aqueous systems. Owing to its sensitivity to dissolved ionic species, it serves as a rapid and non-specific tool for the assessment of purity and quality in pharmaceutical matrices.

In pharmaceutical practice, conductivity measurements are primarily applied to the control of pharmaceutical water systems, including Purified Water and Water for Injection, as well as to selected drug formulations in which ionic composition is critical for performance and safety.

The determination and evaluation of conductivity are governed by pharmacopeial standards, such as the European Pharmacopoeia and the United States Pharmacopeia, which specify measurement conditions, acceptance criteria, and structured, multi-stage evaluation procedures. These frameworks ensure harmonized interpretation of results and mitigate the limitations associated with the non-specific nature of conductivity measurements.

Overall, conductivity analysis constitutes a robust, efficient, and standardized approach for monitoring ionic purity and supporting quality assurance in pharmaceutical systems.

Bibliography: available from the author/authors.

L2: Determination of Surface Tension Using the Langmuir Method

Iwona Golonka

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Introduction: Surface tension is a key physicochemical parameter originating from intermolecular interactions at phase boundaries, particularly at the liquid–air interface. It plays an important role in processes such as adsorption, wetting, and colloidal stability. The Langmuir method is a well-established technique for studying insoluble monolayers of amphiphilic molecules at the air–water interface. It enables both determination of surface tension and characterization of molecular organization based on surface pressure–area relationships [1-3].

Materials and methods: The Langmuir method relies on the formation of a monolayer at the air–water interface and its controlled compression using movable barriers in a Langmuir trough. Amphiphilic molecules spontaneously orient at the interface, minimizing energy. Surface pressure (π) is defined as $\pi = \gamma_0 - \gamma$, where γ_0 is the surface tension of the pure subphase (≈72.8 mN/m at 20 °C) and γ is the surface tension in the presence of the monolayer. Measurements are performed using a Wilhelmy plate with high sensitivity (≈0.1 mN/m). The mean molecular area (A) is calculated from the amount of deposited substance and the instantaneous surface area of the monolayer.

Results: The obtained π–A isotherms, recorded under controlled temperature conditions (20–25 °C), exhibit distinct regions corresponding to gaseous, liquid-expanded, and condensed phases. Analysis of these isotherms enables identification of phase transitions and evaluation of intermolecular interactions. The compressibility modulus ($C_s^{-1} = -A\cdot(d\pi/dA)$) provides quantitative information on monolayer elasticity and molecular packing. A systematic increase in surface pressure with decreasing molecular area confirms progressive monolayer condensation.

Discussion: The Langmuir technique provides detailed insight into interfacial structure and thermodynamic behavior of monolayers. The accuracy of measurements strongly depends on experimental conditions, including compression rate, temperature stability, subphase purity, and equilibration time. Deviations from ideal behavior may result from molecular heterogeneity or experimental limitations.

Conclusions: The Langmuir method is a reliable and precise technique for determining surface tension and analyzing monolayer properties. It enables quantitative assessment of molecular organization, phase behavior, and mechanical characteristics of interfacial systems, provided that experimental conditions are carefully controlled.

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L3: The Importance of Surface Tension in Pharmaceutical Formulation: A Review.

Monika Gasztych

Wroclaw Medical University, Department of Physical Chemistry and Biophysics, Pharmaceutical Faculty Borowska 211, 50-556 Wroclaw, Poland

Surface tension is a fundamental physicochemical property that plays a crucial role in the design, performance, and quality of pharmaceutical and cosmetic formulations. It significantly influences the behavior of multiphase systems, affecting formulation development, drug delivery, product stability, and quality control. The aim of this review is to summarize the importance of surface tension in pharmaceutical and cosmetic sciences and to discuss the most commonly used techniques for its determination.

Surface tension originates from the imbalance of intermolecular forces acting on molecules located at the interface between two phases. This phenomenon causes liquids to minimize their surface area and directly affects wetting, spreading, emulsification, foaming, and the stability of dispersed systems. In pharmaceutical formulations, surface tension influences the solubility of poorly water-soluble drugs, aerosol droplet formation in pulmonary drug delivery, and the stability of protein-based therapeutics by reducing interfacial aggregation. In cosmetics, lowering the surface tension of aqueous formulations improves skin wetting, cleansing efficiency, and facilitates the penetration of active ingredients through the epidermal barrier. Consequently, surfactants represent essential excipients in both pharmaceutical and cosmetic products.

This review also presents the principles, advantages, and limitations of the major techniques used for surface tension measurements. Classical methods, including the capillary rise and stalagmometric methods, are based on capillary action and droplet formation, respectively. Modern tensiometric techniques such as the Du Noüy ring and Wilhelmy plate methods provide highly accurate and reproducible measurements of surface and interfacial tension and are widely applied in pharmaceutical research and industrial quality control. Particular attention is given to the Pendant Drop method, a non-contact optical technique that determines surface tension through image analysis of a suspended droplet. This method requires only a small sample volume, offers excellent accuracy, and enables dynamic studies of interfacial phenomena, including surfactant adsorption.

In conclusion, surface tension represents a key parameter in the development and optimization of pharmaceutical and cosmetic products. Appropriate selection of measurement techniques provides valuable information about the physicochemical properties of formulations, supporting the development of stable, effective, and safe products. Furthermore, advances in tensiometric methods continue to improve the characterization of complex formulations and contribute to innovations in pharmaceutical technology and cosmetic science.

Bibliography: available from the author/authors.

L4: Pharmaceutical biphasic formulations stabilized with surfactant

Dorota Wójcik-Pastuszka

Wroclaw Medical University, ul. Borowska 211A, 55-556; Wrocław, Poland, Faculty of Pharmacy, Department of Physical Chemistry and Biophysics

Introduction: Biphasic pharmaceutical formulations are heterogeneous systems composed of two immiscible phases, typically with a dispersed phase in a continuous medium. They are used to improve the delivery and bioavailability of poorly soluble drugs and enable controlled release. Due to thermodynamic instability, they require stabilization, most often with surfactants. This work outlines their structure, types, instability mechanisms, and stabilization methods [1].

Materials and methods: The study is based on a literature review and analysis of emulsions and suspensions, supported by microscopic observations of model systems with essential oils and lipids. Key parameters included droplet size, surfactant concentration, and critical micelle concentration (CMC). Mechanisms of destabilization (sedimentation, creaming, flocculation, coalescence, phase separation) and stabilization (interfacial tension reduction, steric/electrostatic repulsion) were examined [2-4].

Results: Emulsions and suspensions are the most common biphasic pharmaceutical formulations. Their stability depends on droplet or particle size, interfacial properties, and the presence of appropriate stabilizing agents. Surfactants effectively reduce interfacial tension and enable the formation of stable dispersions. Above the CMC, surfactants form micelles, which enhance the solubilization of lipophilic drugs. Additionally, smaller droplet sizes lead to improved stability and slower destabilization processes. The Hydrophilic–Lipophilic Balance (HLB) concept was shown to be essential for selecting suitable surfactants and determining the type of emulsion formed [2-6].

Discussion: Biphasic systems inherently tend toward instability, making the understanding of destabilization mechanisms crucial for formulation design. Processes such as flocculation and creaming are often reversible, while coalescence and phase separation are typically irreversible and lead to formulation failure. The choice of surfactant type (nonionic, anionic, cationic, or amphoteric) significantly influences system stability, toxicity, and compatibility. Advanced stabilization strategies, including nanoemulsions and Pickering emulsions, offer improved performance by reducing droplet size or creating physical barriers at interfaces [1].

Conclusions: Biphasic formulations are important in drug delivery, especially for poorly soluble compounds. Their effectiveness depends on proper stabilization and optimization of parameters such as droplet size and CMC. Understanding stability mechanisms is essential for designing reliable systems.

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L5: Contact angle. Significance and applications in pharmacy

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Introduction: The contact angle and surface tension are important physicochemical parameters that influence the properties of pharmaceutical materials and the efficacy of medicinal products. Their interrelationship, described by Young's equation, determines the degree of surface wettability and, consequently, the interactions between the liquid, solid, and gas phases. These parameters are important for both manufacturing processes and the quality and bioavailability of medicinal products.

Methods: Various methods are used to determine the contact angle of different types of pharmaceutical materials. The most common of these are the sessile drop method and the Wilhelmy method, which allow for the evaluation of the wettability of smooth surfaces and dynamic analysis. For powdered materials, the Washburn method and wetting time measurement are used, which are particularly useful in evaluating active and excipient substances. These methods allow for the analysis of surface properties relevant to the design of pharmaceutical formulations.

Applications in pharmacy: Contact angle and surface tension are widely used in pharmacy, influencing the solubility of active ingredients, the stability of suspensions and emulsions, the effectiveness of surfactants, and the bioavailability of drugs. The contact angle plays a significant role in the design of tablets, self-emulsifying systems, dermatological preparations, coating processes, and in the evaluation of biomaterials and inhalation preparations. Controlling wettability allows for the optimization of the technological and therapeutic properties of medicinal products.

Conclusions: The contact angle and surface tension are key parameters in evaluating the properties of pharmaceutical materials. Understanding and controlling these parameters allows for the optimization of formulation processes, improves the stability of dispersions, and enhances the therapeutic efficacy of drugs. The analysis of these properties is of great importance in both research and development and in the quality control of pharmaceutical products.

Bibliography: available from the author/authors.

L6: Solubility and pH Measurements in Pharmaceutical Solutions

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Solubility and pH are fundamental physicochemical parameters that critically influence the stability, efficacy, and bioavailability of pharmaceutical formulations. This study provides an overview of the principles and methodologies used to assess solubility and pH in pharmaceutical solutions, with an emphasis on their interdependence and practical implications in drug development.

Solubility, defined as the maximum amount of a substance that can dissolve in a solvent under specific conditions, is a key determinant of drug absorption and therapeutic performance. It is influenced by factors such as temperature, solvent composition, ionic strength, and the chemical nature of the solute. In pharmaceutical systems, poor aqueous solubility remains a major challenge, particularly for lipophilic drug candidates. Various experimental techniques, including shake-flask [1] methods and instrumental analysis, are employed to quantify solubility accurately.

The pH of a solution significantly affects both solubility and chemical stability. Many pharmaceutical compounds are weak acids or bases, and their ionization state - governed by the pH - directly impacts their solubility profile. The Henderson–Hasselbalch [2] relationship is commonly used to describe this dependency and predict solubility changes across different pH conditions. Precise pH measurement, typically performed using calibrated pH meters, is therefore essential in formulation design and quality control.

Furthermore, the interplay between solubility and pH is particularly important in buffered systems, where maintaining an optimal pH range ensures drug stability while maximizing solubility. This balance is crucial for oral, parenteral, and topical formulations, as it can affect dissolution rate, precipitation risk, and overall drug performance.

In conclusion, accurate determination and control of solubility and pH are vital components of pharmaceutical research and development. A thorough understanding of these parameters enables the design of effective and stable drug products, ultimately contributing to improved therapeutic outcomes.

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L7: Quality Assurance of Pharmaceutical Solutions

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Pharmaceutical solutions are liquid dosage forms formed by dissolving one or more drugs in a suitable solvent, most often water. From a physical point of view, they are homogeneous systems with solute particles smaller than 1 nm. These dosage forms, which allow precise and flexible dosing, are characterized by a rapid onset of action and ease of application. The disadvantages include the incompressible volume and weight, the need to mask the often unpleasant taste, the risk of microbial contamination, as water is an ideal environment for the growth of microorganisms, and lower chemical stability than solid dosage forms. According to the route of application, liquid dosage forms can be divided into topical, oral and parenteral [1,2].

It is precisely the lower stability and the need to maintain strictly sterile and apyrogenic properties that underline the irreplaceability of quality assurance, and therefore safety and quality control [1,3]. Pharmaceutical quality assurance is a comprehensive, proactive framework that ensures that products are safe, effective and in compliance with all regulatory standards throughout their life cycle [3-5].

This lecture deals with the classification and characterization of various types of liquid dosage forms, the requirements and regulations for their quality, including the analytical methods used to control and ensure this quality.

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L8: Electrical Conductivity of Pharmaceutical Solutions - in Formulation Studies

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Hereby we present the theoretical foundations and importance of conductometry in formulation studies of pharmaceutical systems. The mechanism of electrical conduction in electrolyte solutions is discussed, highlighting the role of ion movement in an electric field and the relationship between their velocity (v) and mobility (u). It is emphasized that these values are closely related to the ion charge, the properties of the medium, and the electric field strength, which directly influences charge transport in the electrolyte solution.

The relationship between ion velocity and charge in solution is presented, highlighting the importance of interionic interactions and the degree of electrolyte dissociation. In this context, the basics of Ohm's law are also presented as a tool for describing electrical conduction in solution systems, taking into account parameters such as current intensity, electric field, and specific electrical conductivity.

Electrical conductivity is an important physicochemical parameter enabling the characterization of pharmaceutical solutions. Particular attention was paid to the use of conductometric measurements in the analysis of formulation processes, including the conductometric evaluation of the release kinetics of active substances from pharmaceutical preparations. It was shown that changes in conductivity over time can reflect diffusion, dissolution, and interaction processes of formulation components.

Conductometric methods are a useful and sensitive analytical tool in pharmaceutical research, enabling the quantitative assessment of electrolyte properties and monitoring of processes occurring in complex systems.

Bibliography: available from the author/authors.

ACADEMIC POSTERS

P1: The Effect of a Natural Emulsifier on Selected Physical Properties of Emulsions

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Introduction: Starch is the primary storage material in plants, accumulated as water-insoluble granules in seeds, fruits, rhizomes, and tubers. It constitutes the main carbohydrate in the human diet and is one of the most widely utilized renewable raw materials across various industries. In the pharmaceutical industry, starch serves as a valuable excipient in drug formulation, functioning as a disintegrant, binder, lubricant, and coating material in tablets and capsules [1]. Additionally, it exhibits stabilizing properties in dispersed systems, primarily through modification of the viscosity of the continuous phase or by forming a protective layer around droplets, preventing their coalescence [2]. The aim of this study was to characterize selected chemically modified starches in terms of their emulsifying capacity.

Materials and methods: Chemically modified potato starch, functionalized with citric acid and amine groups, was used. The chemical modification differed in the degree of amine substitution, specifically 13%, 18%, and 20%. The pH and viscosity of starch suspensions and emulsions containing orange essential oil were compared at 25 °C. Microscopic images of the obtained formulations were also acquired.

Results and discussion: The results demonstrated a decrease in pH and an increase in the viscosity of the emulsions. The highest pH and viscosity values were observed for the emulsion stabilized with starch substituted with 20% amine groups. Microscopic analysis confirmed an increase in the volumetric swelling of starch granules with increasing levels of amine substitution.

Conclusions: The studied chemically modified starches exhibited differentiated emulsifying properties. While the pH values of starch suspensions did not change significantly after emulsification of the essential oil, the process markedly increased the viscosity of the resulting formulations.

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P2: The balance between stability and activity: the role of ethanol in hydrogels containing AMPD and erythromycin

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Introduction: Acne vulgaris is a chronic inflammatory disease of the pilosebaceous unit, characterized by excessive sebum secretion, free fatty acids and an overgrowth of C. acnes bacteria. Erythromycin is one of the most commonly prescribed antibiotics for topical acne treatment. It exhibits antibacterial and anti-inflammatory properties [1]. To improve the effectiveness of the topical treatment, erythromycin was combined with AMPD to create a multi-action formulation that modulates sebum secretion and effectively penetrates the hair follicle, thereby enhancing the antibacterial effect. Ethanol was used as a penetration enhancer and stabilizer [2].

Materials and methods: The study was conducted in two stages. The first stage focused on selecting ingredients for the gel formulation and evaluating its activity against model sebum components. The second stage involved assessing erythromycin stability in water-ethanol solutions. In the first stage, hydrogels containing the selected alcoholamines were prepared and their interaction with the model sebum and penetration capacity were compared [3]. Taking into account its high activity against sebum, the possibility of adjusting the pH to ensure erythromycin stability, and the greater stability of the system, 2% AMPD was selected for further studies. The activity of hydrogels with varying ethanol concentrations was tested for 48 hours using a hair follicle model filled with solidified artificial sebum. Based on the results obtained, the formulation with the most favorable property profile was selected. Erythromycin stability was evaluated in aqueous-alcoholic solutions containing 40–100% ethanol. The solutions were stored at 5, 23 and 37 °C for 25 days and changes were monitored using UV-Vis spectrophotometry.

Results: Of the alcoholamines tested, AMPD had the most favorable properties, including good interaction with model sebum and formulation stability [3]. Despite comparable activity in ethanol-free systems, TRIS precipitated in an aqueous-alcoholic environment, eliminating its potential for further use. In penetration studies of hydrogels containing 2% AMPD, a correlation was observed between ethanol content and reaction with sebum components. Higher ethanol concentrations increased penetration; however, at very high concentrations, deterioration of the gel's structural properties was observed. The most favorable balance of system stability, penetration, and formulation properties was achieved with a formulation containing 60% ethanol and 2% AMPD.

Erythromycin stability studies demonstrated a strong influence of ethanol concentration and temperature on the degradation rate. The greatest instability occurred in systems containing 40% ethanol, especially at 37°C. Increasing the ethanol concentration to 80–100%, however, improved the stability of the active ingredient considerably.

Discussion and conclusions: The efficacy of the tested systems depends on balancing erythromycin stability, formulation penetration, and the structural properties of the gel. AMPD is superior to other alcoholamines because it is effective against sebum and stable in water-alcohol systems.

Ethanol served a dual purpose: it increased the stability of erythromycin and the penetration of the hydrogels. However, at higher concentrations, ethanol impaired the rheological properties of the system.

The most favorable profile was obtained with a formulation containing 2% AMPD and 60% ethanol. This formulation balances antibiotic stability, penetration into the sebum layer, and gel structure preservation. These results suggest that a multi-component approach may be a promising strategy for developing topical anti-acne systems.

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P3: Evaluation of the molecular-level stability of clotrimazole-loaded nanoemulsions using NMR Spectroscopy

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Introduction: Nanoemulsions (NEs) are promising carriers for poorly water-soluble drugs such as clotrimazole (CLT), enhancing solubility and bioavailability. Nevertheless, their long-term stability remains a critical challenge [1]. Nuclear magnetic resonance (NMR) spectroscopy provides a powerful tool for probing molecular-level interactions and structural changes within formulations. This study evaluates the stability of CLT-loaded nanoemulsions over time using NMR spectroscopy [2]. Materials and methods: CLT-loaded nanoemulsions were prepared using oleic acid (OA) as the oil phase, with surfactants (Kolliphor EL (KOL) or Tween 80 (T80)) and cosurfactants (propylene glycol (PG), triacetin (TR), or polyethylene glycol 200 (PEG)) by high-pressure homogenization (three cycles, 1000 bar). 1H NMR spectra were acquired using a Bruker NMR Avance III spectrometer (600.13 MHz) for CLT-loaded nanoemulsions (series 1 – freshly prepared, series 2 – after 30 days at 25 °C, series 3 – after 9 months at 25 °C), control samples without the drug (blank series), and oil solution of CLT in oleic acid (CLT_OA) [3]. Results and Discussion: The stability of the formulations was evaluated based on changes in lineshape, integral values, and the full width at half maximum (FWHM) of NMR resonance peaks corresponding to individual components. Particular attention was devoted to the ^{1}H NMR spectral region associated with signals of the active pharmaceutical ingredient (Fig. 1), which was subjected to detailed analysis. After 30 days, smaller changes in the intensity values of CLT peaks were observed in formulations containing KOL as the surfactant compared to those with T80. After 9 months of stability testing, the peaks recorded for CLT were significantly altered, with characteristic flattening observed in preparations containing T80, regardless of the cosurfactant used, as well as in formulations containing KOL and 6 % TR, indicating their lower stabilizing capacity. Therefore, the physical and chemical stability of nanoemulsions depends primarily on the type of surfactant and cosurfactant used. The obtained results clearly indicate that the use of KOL as a surfactant exerts a stabilizing effect on nanoemulsion systems. The addition of TR as a cosurfactant resulted in the least stabilizing effect of the prepared nanoformulations.

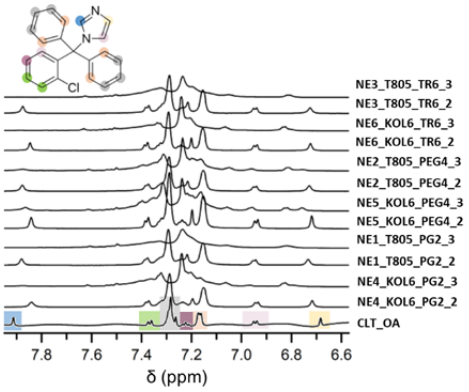

Fig. 1. 1H NMR spectra (CLT region) of nanoemulsions studied (series 2 and 3 differing with the cosurfactant: PG, TR, PEG) and CLT_OA for reference.

Conclusions: NMR spectroscopy enabled precise detection of molecular-level changes, confirming its usefulness in evaluating the long-term stability of nanoformulations. These findings highlight the importance of excipient selection for designing stable nanoemulsion drug delivery systems.

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P4: From physicochemical characterisation to application: Integrated Analysis of Smart Polymers for Drug Delivery Systems

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Introduction: The development of effective polymer-based drug delivery systems requires not only the design of functional materials but also a thorough understanding of how their physicochemical properties influence behaviour in biologically relevant environments. Parameters such as thermal stability, structural organization, and particle morphology directly influence interactions with active substances, as well as drug loading capacity and release profiles [1]. Therefore, comprehensive physicochemical characterization is a crucial step in assessing the suitability of polymer systems for pharmaceutical applications. This study focuses on a detailed analysis of thermosensitive cross-linked polymer systems derived from N-vinylcaprolactam, obtained in five independent syntheses differing in the chain length of the cross-linking component. This study pursues two main objectives. The aim of this study is to assess how variations in polymer structure translate into differences in critical material properties including particle size, zeta potential, and thermal properties, such as the glass transition temperature (Tg) degradation temperature (T_{onset}), maximum decomposition temperature (T_{max}), and to identify systems that exhibit the most favourable properties for use as drug carriers.

Materials and methods: Thermogravimetric analysis (TG) and differential scanning calorimetry (DSC) were used to assess the thermal properties of the polymer systems, including mass loss and thermal transitions. X-ray powder diffraction (PXRD) was applied to determine the crystalline or amorphous nature of the materials. Nuclear magnetic resonance (NMR) spectroscopy was used to confirm chemical structure and asses sample purity. Scanning electron microscopy (SEM) was employed to examine surface morphology, including particle shape and size distribution. Results: TG and DSC analysis provided a complete thermal characterization. All analysed materials exhibited thermal stability up to approximately 300°C. PXRD analysis confirmed their amorphous nature. NMR spectra verified the polymerization process and the effective incorporation of the crosslinker into the polymer network. SEM observations showed that the resulting structures exhibited a spherical morphology.

Discussion and Conclusions: A detailed analysis of the thermogravimetric data revealed a general decrease in the temperature of the first decomposition stage with increasing chain length of the crosslinking agent, with an exception observed for the material containing the longest crosslinker. This trend suggests that lower effective crosslinking density and increased flexibility of the polymer chains promote an earlier onset of thermal degradation. These findings help to elucidate the relationship between polymer structure and physicochemical behaviour, which is essential for predicting performance in drug delivery applications. In particular, they may support the evaluation of drug–polymer interactions, stability under biological conditions, and the potential for controlled drug release. Overall, this study highlights the importance of physicochemical characterisation as a key step in the development of safe and effective polymer-based carriers and contributes to advancing research in pharmaceutical materials science.

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P5: When skin loses its balance: the role of pH in skin changes

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Introduction: Physiological skin pH (4.5 – 5.5) plays a crucial role in maintaining barrier functions, microbiome balance, and health state. In various skin infections, significant changes in this parameter are observed, which contribute to the development of dermatological diseases and the progression of their symptoms. In acne, an increase in pH (6.0 – 6.5) is observed, which promotes excessive colonization of pathogenic bacteria Cutibacterium acnes and exacerbates clinical symptoms. Furthermore, this pH level creates a favourable environment, which may cause atopic dermatitis, fungal infections, and impair wound healing. Management should include the use of topical products that preserve the skin's acidic pH, and alkaline medicated soaps (9 – 10) should be avoided due to their irritative effects. Patient education is crucial, and skin pH measurement may serve as a simple, non-invasive tool to support clinical assessment [1].

The aim of the study is to present a critical review of the role of the skin pH as a fundamental factor involved in the pathogenesis of major dermatological diseases and to compare contemporary pH measurement techniques. Materials and methods: In this research, a comprehensive review and analysis of the literature available in major bibliographic databases, including PubMed, Embase, and Scopus. Key words: "pH level", "skin pH", "skin diseases", "dermatological conditions", "pH meter", "acne", "psoriasis, "atopic dermatitis", "melanoma", "microbial infections", "skin pH measurement".

Results and discussion: The analysis yielded a total of 28 references, including 3 related to acne, 2 to psoriasis,6 to atopic dermatitis, 1 to melanoma, 1 to bacterial infections, 1 concerning wound healing, as well as 11 addressing skin pH measurement methods and 3 focusing on skin pH changes. The findings indicate a significant relationship between alterations in skin pH and the pathogenesis of dermatological conditions. A variety of measurement techniques were identified, including glass electrodes, microneedle sensors, fluorescent films, the MPA multi-probe adapter, flexible hydrogel fibers, high-frequency ultrasonography, and devices such as the Sin-pH-Meter. These results highlight the growing importance of precise diagnostic approaches in dermatology [2,3].

Conclusions: Maintaining a slightly acidic skin pH (4.5 – 5.5) is essential for preserving its protective functions. Disruptions to this balance contribute to the development and exacerbation of skin diseases, therefore, monitoring and regulating skin pH represent important components of modern prevention, diagnosis and treatment in dermatology.

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P6: Emerging COX-independent mechanisms of NSAIDs and their relevance to naproxen

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Introduction: Naproxen is a nonsteroidal anti-inflammatory drug (NSAID) that exerts its primary effects through inhibition of cyclooxygenase enzymes (COX-1 and COX-2), thereby reducing prostaglandin synthesis and alleviating inflammation and pain [1]. However, increasing evidence suggests that NSAIDs may also act via COX-independent mechanisms, which could additionally contribute to their anti-inflammatory and analgesic effects [2], [3].

Materials and methods: This narrative review was based on selected recent scientific literature addressing NSAID pharmacology, COX-independent mechanisms, and the development of COX-2 inhibitors. Publications from PubMed-indexed journals, MDPI, and the Royal Society of Chemistry (RSC) from the years 2024–2025 were analyzed.

Results: NSAIDs may exert COX-independent effects through modulation of key inflammatory pathways, including NF-κB signaling and the NLRP3 inflammasome, leading to reduced expression of pro-inflammatory mediators [2]. Additionally, interactions with neural mechanisms of pain, including ion channels and receptor systems, have been reported. Some studies also suggest effects on apoptosis, oxidative stress, and mitochondrial function. These mechanisms appear to be shared across the NSAID class and may therefore contribute, at least in part, to the pharmacological profile of naproxen [2], [3].

Discussion: Current evidence indicates that the pharmacological activity of naproxen is not limited solely to COX inhibition but may also involve COX-independent pathways described for NSAIDs. Importantly, these mechanisms should not be interpreted as unique to naproxen, but rather as class-related effects. Recognizing these additional pathways may improve understanding of NSAID pharmacodynamics and support the development of novel derivatives with enhanced selectivity and safety profiles [2], [3].

Conclusions: NSAIDs exhibit additional COX-independent mechanisms of action that may contribute to their biological effects. In the case of naproxen, these mechanisms are best understood as shared features of the drug class rather than as distinct properties. This perspective broadens our understanding of its pharmacological profile and may inform future drug development.

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P7: Langmuir Monolayer Characterization of Phosphatidylinositol with Different Fatty Acid Compositions

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Introduction: Phosphatidylinositol (PI) is an anionic glycerophospholipid that plays a crucial role in cellular signaling and membrane organization. Due to its amphiphilic nature, PI can form stable monolayers at the air–water interface, making it a valuable model for studying lipid packing and interfacial behavior using Langmuir trough techniques. This study investigates the influence of fatty acid composition on the physicochemical properties of PI monolayers by comparing two soybean-derived samples (1PI and 2PI) differing in standardization and acyl chain composition. Surface pressure–area (π–A) isotherms, compressibility modulus, collapse pressure, lift-off area, and hysteresis behavior were analyzed at 25°C, 30°C, and 35°C [1–3].

Materials and methods: The Langmuir monolayer experiments were performed using a Langmuir trough equipped with movable barriers to control the surface area of the air–water interface. Phosphatidylinositol (PI) solutions were spread onto the aqueous subphase, and after solvent evaporation, the monolayer was compressed at a constant speed of 10 mm/min. Surface pressure (π) was continuously monitored using a highly sensitive Wilhelmy-type platinum probe and calculated as $\pi = \gamma_0 - \gamma$. The mean molecular area was determined from the amount of deposited lipid and the instantaneous surface area, allowing the formation of π–A isotherms and analysis of monolayer properties.

Results: 2PI exhibits higher collapse pressure and a higher compressibility modulus than 1PI across the entire temperature range, indicating a more tightly packed monolayer structure. The lift-off area is similar for both samples and shows no clear temperature dependence. In hysteresis experiments, 2PI demonstrates significantly higher and more stable Rf values across successive cycles compared to 1PI.

Discussion: The observed differences between 1PI and 2PI monolayers can be attributed primarily to variations in fatty acid composition and acyl chain uniformity. The more standardized 2PI likely has a narrower distribution of acyl chain lengths and unsaturation, which promotes tighter molecular packing and stronger van der Waals interactions, resulting in higher collapse pressures and compressibility moduli. In contrast, the more heterogeneous structure of 1PI disrupts regular packing at the interface, leading to lower mechanical stability and greater sensitivity to compression–expansion cycles, as reflected in lower and more variable hysteresis (Rf) values. Overall, molecular uniformity plays a key role in determining monolayer organization and stability.

Conclusions: 2PI shows enhanced monolayer ordering and mechanical stability compared to 1PI, presumably due to increased fatty acid uniformity leading to more efficient molecular packing and improved interfacial stability.

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P8: Particle Size and Zeta Potential Analysis of a Temperature- and pH-Responsive Polymer

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Introduction: Particle size analysis is crucial for characterizing physicochemical properties and determining parameters relevant to the safety and efficacy of potential drug delivery carriers. One group of compounds used as drug carriers are responsive polymers, which can be designed to react to local changes in external stimuli, enabling controlled release of the therapeutic agent at the site of administration. The mechanism of action of pH-sensitive polymers is associated with the presence of acidic or basic functional groups in their structure, whose degree of ionization depends on the pH of the surrounding environment. Key parameters used to evaluate the properties of responsive polymers and to confirm their sensitivity to temperature and pH include measurements of hydrodynamic diameter (HD) and zeta potential (ZP). HD measurements allow determination of the phase transition temperature based on changes in particle size, whereas ZP measurements enable assessment of system stability and the tendency for particle aggregation. The aim of this study was to characterize newly synthesized thermo- and pH-responsive polymers using particle size and zeta potential measurements.

Materials and Methods: Three copolymers, PS1, PS2, and PS3, synthesized based on 2-acrylamido-2-methyl-1-propanesulfonic acid (AMPS) and poly(ethylene glycol) methyl ether methacrylate (PEGMEM) with varying chain lengths, were used in this study. Hydrodynamic diameter measurements were performed using dynamic light scattering (DLS), based on the analysis of Brownian motion of particles in solution. Zeta potential was determined from electrophoretic mobility (EM) measurements, defined as the velocity of particles moving toward an oppositely charged electrode divided by the applied electric field strength. HD and ZP were measured as a function of temperature (range 18–44 °C) and at different pH values.

Results: The hydrodynamic diameter of particles below the estimated phase transition temperature was approximately 370 nm for PS1, 320 nm for PS2, and 540 nm for PS3. The phase transition temperature was estimated to be 31 °C for PS1 and 29 °C for both PS2 and PS3. Within the studied temperature range (18–44 °C), all analyzed polymers exhibited negative zeta potential values. Above 30 °C, the mean ZP values for PS1 and PS3 ranged from −6 to −4 mV, whereas for PS2 a gradual increase in ZP with temperature was observed, from −29.5 mV to −7 mV. In the analysis of particle size as a function of pH, a decrease in HD was observed above pH 7.6 for PS1, pH 6.6 for PS2, and pH 5.6 for PS3.

Conclusions: These results confirm the thermo- and pH-responsive behavior of the studied copolymers, while the observed phase transition temperatures close to physiological conditions suggest their potential applicability as controlled drug delivery systems.

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P9: Thermodynamic characterization of drug binding to human serum albumin and its significance for the optimization of pharmacotherapy

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Introduction: The optimization of pharmacotherapy is crucial in the management of patients with multiple comorbidities. It enables precise dose adjustment to meet individual patient needs, thereby minimizing toxicity risks and enhancing therapeutic efficacy. Isothermal titration calorimetry (ITC) is a prominent method for investigating interactions between drugs and human proteins. Considered the "gold standard" in pharmaceutical research, ITC allows for the direct measurement of the complete thermodynamic profile of drug-protein interactions without the need for labeling (determining: Ka, ΔH, ΔS, ΔG, n). This method serves as a foundation for screening drug affinity for receptors, transport proteins, or enzymes by analyzing interaction forces (enthalpy vs. entropy). It enables the prediction of bioavailability under physiological conditions, which is applicable in the optimization of drug therapies, including onco-rheumatological treatments. Utilizing the ITC technique to characterize drug binding to human serum albumin (HSA)—a key transport protein—allows for predicting the metabolic pathway of a drug and its binding in the presence of other compounds.

Materials and methods: Studies of the interactions between the analyzed substances and human serum albumin at physiological pH were carried out using isothermal titration calorimetry.

Results and discussion: Differences in the thermodynamic parameters of the interactions of sulfasalazine (Ka ≈ 10^6 M^{-1}, ΔH = -168 kJ/mol), (Ka ≈ 104 M^{-1}, ΔH = -198 kJ/mol), and idelalisib (Ka ≈ 105 M^{-1}, ΔH = -162 kJ/mol) with human serum albumin (HSA) suggest distinct profiles. The strong and stable binding of sulfasalazine to the protein may result in prolonged drug transport, whereas the weaker binding of methotrexate suggests rapid or shorter distribution. These findings, including those for idelalisib, may imply varied pharmacokinetic/ pharmacodynamic profile (PK/PD) profiles in the treatment of autoimmune diseases and malignancies.

Conclusions: ITC results may play a significant role in the rational design of treatment plans, dosing schedules, and the selection of concomitant medications based on interactions with human serum albumin—one of the most abundant and critical transport proteins in the human body.

Bibliography: available from the author/authors.

P10: Engineering Nanostructured Foam Matrices: The Impact of High-Pressure Homogenization on Bio-Based Topical Delivery Systems

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Introduction: The effective management of chronic dermatological conditions such as psoriasis requires innovative delivery systems capable of providing uniform coverage over large areas of skin. This study focuses on developing nanostructured, surfactant-based foam placebos utilising macerates of the botanicals Lavandula angustifolia and *Linum usitatissimum*. The study aimed to evaluate the influence of high-pressure homogenisation (HPH) on the kinetic and electrostatic stability of these green chemistry matrices, positioning them as advanced platforms for future active pharmaceutical ingredients.

Methods: To optimise the surfactant-based placebo, ten unique systems were initially screened for structural integrity and visual stability (Fig. 1). The most promising formulations containing coco-glucoside and coco-betaine (designated K and KL) were then subjected to high-pressure homogenisation (HPH) for one to three cycles at 800 bar to achieve uniform nanostructure. Technological stability was rigorously monitored over a 30-day period at three distinct storage temperatures: 9 °C, 24 °C and 37 °C. These matrices were evaluated using dynamic light scattering (DLS) to determine the mean particle size (Z-Ave) and polydispersity index (PDI), as well as zeta potential (ZP) measurements to quantify electrostatic stabilisation. Comprehensive physicochemical profiling was also performed, including a visual assessment of foam architecture against a dark background and precise pH monitoring using calibrated potentiometry, to ensure compatibility with physiological skin levels.

Figure 1. A scheme for obtaining emulsions and selecting formulation components.

Results: The application of high-pressure homogenization proved definitive in achieving long-term stability, whereas non-homogenized samples faced rapid phase separation. Regarding dispersive uniformity, the optimized K and KL systems successfully maintained a nanometric scale with a Z-Ave below 200 nm and high homogeneity characterized by a PDI under 0.4. The electrostatic robustness of the formulations was confirmed as zeta potential reached approximately -50 mV, specifically -51.58 mV for the KL variant, which indicates strong inter-particle repulsion that effectively prevents liquid drainage. Furthermore, pH optimization addressed the initial high alkalinity, which had reached levels exceeding 14 in some phases, by successfully neutralizing the matrix with citric acid to reach skin-compatible levels without compromising the dense micro-architecture of the foam.

Discussion**:** The K and KL foam formulations represent a modern, nanostructured alternative to traditional topical emulsions, leveraging biocompatible surfactants and botanical macerates for enhanced delivery. High-pressure homogenization (HPH) is essential for kinetic stability, reducing particle size to a nanometric scale (Z-Ave < 200 nm) to potentially improve the bioavailability of plant compounds. High zeta potential values (~ -50 mV) provide robust electrostatic stabilization, preventing drainage and structural aging across varying temperatures. Furthermore, successful pH neutralization with citric acid ensures a skin-compatible environment while fully preserving the dense foam architecture and systemic integrity.

Conclusion: The study confirms that these optimized foam platforms provide a technologically advanced, stable, and biocompatible foundation for dermocosmetic applications. The integration of HPH at 800 bar ensures the structural uniformity and physical endurance necessary for treating extensive chronic skin lesions like psoriasis. These formulations effectively combine high application efficiency with superior physicochemical stability, serving as a promising matrix for future active pharmaceutical ingredients.

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P11: The impact of thermolabile compounds and microbial incorporation on the physicochemical stability of flaxseed-based foam matrices: A modelling approach

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Introduction: This pilot study evaluated the potential of a novel, lightweight, flax-based foam as a carrier for dermatological active substances. The matrix, which is made up of *Linum usitatissimum* macerate and mild surfactants, was tested for its compatibility with resveratrol (RSV) and *Lactobacillus rhamnosus*. The aim was to verify the synergy between the film-forming properties of flax, the antioxidant effects of resveratrol and the influence of probiotics on the skin microbiome. This bioadhesive system offers a promising alternative to traditional semi-solid formulations for the treatment of conditions such as atopic dermatitis and rosacea.

Methods: Four experimental systems were developed to evaluate the technological suitability and stability of the foaming matrix. These were: a placebo formulation (FP); a formulation containing the bacterium *Lactobacillus rhamnosus* (FB); a formulation containing resveratrol (RSV); and a formulation containing both the bacterium and resveratrol (FRB) (see Fig. 1). The aqueous phase was based on a 72% macerate of *Linum usitatissimum* seeds. The preparation procedure involved a specialised multi-step process. First, the surfactant system (coco-glucoside and cocamidopropyl betaine) was sonicated for 20 minutes to ensure optimal micellar dispersion. After combining the macerate and glycerine, resveratrol (RSV) was introduced using a Transcutol-based concentrate, along with DL-α-tocopherol acetate (DHA) as a preservative. The systems were then adjusted to a pH of approximately 5.5 (physiological for skin) using citric acid. Finally, the probiotic strain was gently incorporated into the designated formulations to maintain cellular integrity. The resulting foams were rigorously monitored for stability over a period of four weeks under various storage conditions (4 °C, 21 °C, 37 °C, and UV exposure). Physicochemical characterisation included longitudinal pH measurements and dose-repeatability tests. The quality of the foams was evaluated using foamability and kinetic stability tests. Particle size (Z-Ave), polydispersity index (PDI) and zeta potential were determined to evaluate the internal structure and electrostatic stability. Additionally, the chemical integrity of resveratrol was verified by HPLC. This comprehensive protocol enabled the synergistic effects of the flax matrix, antioxidants and probiotics to be thoroughly evaluated in advanced dermocosmetic applications.

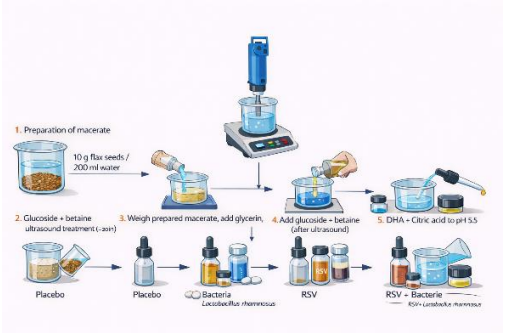

Figure 1: Scheme for obtaining the formulations: FP, FB, FR and FRB, and the selection of formulation components.

Results: A comprehensive characterisation of the foam formulations revealed good physicochemical compatibility and stability during storage. The systems maintained a skin-friendly pH ranging from 5.70 to 6.06, which is close to physiological skin conditions. Pump dose repeatability tests showed that a single application delivered 0.17–0.25 g of foam. While repeatability was high at 21 °C and 37 °C, greater variability was recorded at 4 °C due to increased formulation viscosity. Foam stability analysis demonstrated volume retention between 62% and 92% of the initial value, with RSV-containing formulations exhibiting the highest stability (up to 91.7% at 4 °C) and bacteria-containing samples showing the lowest (62.1% at 21 °C). Regarding internal structure, particle size analysis indicated that the placebo remained a stable nanodispersed system (35–60 nm), whereas the addition of bacteria and RSV induced the formation of larger aggregates, resulting in higher polydispersity and Z-average values reaching several micrometres. The zeta potential was most negative for bacteria-containing formulations, supporting electrostatic stabilisation. HPLC analysis confirmed the chemical integrity of resveratrol, showing higher stability at lower temperatures and no systematic depletion in the presence of *Lactobacillus rhamnosus*. Finally, microbiological assays proved that excipients such as glycerin and Transcutol did not inhibit bacterial growth, ensuring the safety and biocompatibility of the developed carrier.

Discussion: The results suggest that the stability and performance of these formulations are due to a synergistic interaction between the flaxseed macerate, resveratrol and the biological component. The flaxseed-derived polysaccharide matrix provides a hydrophilic, film-forming environment that supports colloidal stability and improves foam persistence. Within this matrix, resveratrol forms aggregates that increase local viscosity and reduce liquid drainage, thereby improving rheological behaviour. Inclusion of *Lactobacillus rhamnosus* results in a more negative zeta potential, confirming the role of microbial surface charge in electrostatic stabilisation. Furthermore, the absence of RSV depletion in the presence of bacteria confirms the system's chemical compatibility and safety.

Conclusion: The combination of flaxseed macerate, resveratrol and bacteria creates a stable colloidal system with favourable biophysical and application properties. These findings suggest that such a combined system could be a promising basis for developing functional dermal delivery systems.

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P12: Phase-Solubility Study (Higuchi-Connors) of the Loratadine/Cyclodextrin Complex

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Introduction: Poor aqueous solubility remains a major limitation in the development of effective drug delivery systems for many active pharmaceutical ingredients, including loratadine. Cyclodextrins are widely used as solubilizing agents due to their ability to form inclusion complexes with hydrophobic molecules. The Higuchi-Connors model provides a standard approach for characterizing drug-cyclodextrin interactions and evaluating complex stability. This study aims to investigate the phase-solubility behavior of loratadine with β-cyclodextrin (β-CD) and hydroxypropyl-β-cyclodextrin (HP-β-CD), with a focus on their applicability in hydrogel-based drug delivery systems.

Experimental: A calibration curve for loratadine was established using UV-Vis spectrophotometry at 248 nm, demonstrating excellent linearity (R^2 = 0,9997). Phase-solubility studies were performed by equilibrating an excess amount of loratadine with aqueous solutions containing increasing concentrations of β-CD or HP-β-CD. The mixtures were subjected to controlled shaking and sonication to ensure equilibrium, followed by filtration. The dissolved drug concentration was determined spectrophotometrically.

Results: Both cyclodextrins enhanced the apparent solubility of loratadine. For β-CD, an initial increase in solubility was followed by a plateau, suggesting deviation from linearity and indicating a non-ideal phase-solubility profile, likely of A_N-type. In contrast, HP-β-CD demonstrated a more gradual and sustained solubilization effect over a broader concentration range, although deviations from ideal linearity were also observed. Linear regression of the initial concentration range (0-1 µg/mL) yielded slope values exceeding unity for both systems. This violates the assumptions of the Higuchi-Connors model, preventing reliable calculation of the stability constant ($K_{1:1}$) and complexation efficiency (CE). The observed deviations are attributed to an unfavorable drug-to-cyclodextrin ratio and possible experimental limitations.

Conclusion: The study confirms that both β-CD and HP-β-CD improve loratadine solubility, with HP-β-CD showing superior performance. However, the inability to apply the Higuchi-Connors model quantitatively highlights the critical importance of proper experimental design, particularly regarding concentration ranges and system equilibrium. These findings support the potential use of cyclodextrin-based systems in hydrogel formulations while emphasizing the need for optimized phase-solubility methodologies.

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STUDENTS LECTURES – INTERNATIONAL

in the frames of BIP Erasmus+

No	Title	Authors	Affiliation
1	Applications of Conductivity in Pharmacy and Medicine.	Emir Korkmaz, Rugilė Mažuolytė, Ema Januškaitytė, Urte Radušytė	Lithuanian University of Health Sciences (LSMU)
2	Optical properties of pharmaceutical biphasic formulations.	Eduard Alexandru Druta	National University of Science and Technology POLITEHNICA of Bucharest
3	pH-responsive polymers application.	Rebecca Garau, Laura Carbone, Nicola Salis, Gloria Pia Satta,	University of Cagliari
4	The application of contact angle and surface tension in the field of pharmacy.	Diogo Morais, Sérgio Rodrigues, Iva Pousa, Milena Beatriz Krug	Instituto Politécnico de Bragança - IPB, Portugal
5	Fenofibrate: Comparison of Solubilization Strategies in Oral Drug Formulations.	Afnan Alagtal, Jude Ivan Guia, Scott Downes	Royal College of Surgeons Ireland
6	The isotonicity of pharmaceutical solutions – why does it matter?	Salih Kahraman	Plovdivski Universitet "Paisii Hilendarski"