

Effects of Sonication on the Physical and Biochemical Properties of Polyalthia Longifolia Leaf Extracts and Sugar Solutions

G. Samuel¹, J. Tharancia Teena Mary¹, I. Johnson¹

¹Department of Physics, St. Joseph's College (Autonomous), Affiliated to the Bharathidasan University, Tiruchirappalli-620 002, Tamilnadu, India.

Corresponding author details

Dr. G. Samuel

Assistant Professor, Department of Physics, St. Joseph's College (Autonomous), Tiruchirappalli – 620002

E-mail: samuel_ph1@mail.sjctni.edu

Abstract

This study investigates the impact of sonication on the physical, biochemical, and antimicrobial properties of Polyalthia longifolia leaf extracts and sugar solutions. Physical parameters, including density, viscosity, ultrasonic velocity, acoustic impedance, and adiabatic compressibility, were analyzed before and after sonication at 5, 10, and 15-minute intervals. Biochemical assays revealed progressive increases in protein and carbohydrate levels after sonication, indicating enhanced extraction efficiency. Structural modifications were confirmed using Fourier Transform Infrared (FTIR) spectroscopy, which showed changes in functional group intensities, and UV-visible spectroscopy, which revealed peak shifts indicative of cell disruption. Particle size analysis demonstrated a reduction in size, attributed to shear forces during sonication. Antimicrobial activity was assessed using the agar well diffusion method. Polyalthia longifolia extracts showed consistent activity against Enterococcus faecalis, with limited impact on Pseudomonas aeruginosa, while sugar solutions exhibited negligible antimicrobial effects. These findings highlight the potential of sonication to optimize the extraction of bioactive compounds and influence physical and structural properties. This method is particularly effective for enhancing molecular interactions and studying the structural transformations in complex biological systems. The study underscores sonication's utility in bioactive compound research and its applications in pharmaceuticals, food, and biotechnology.

Keywords: Sonication, Polyalthia longifolia, sugar solutions, biochemical properties, antimicrobial activity, FTIR spectroscopy.

How to cite this article: Samuel G, Mary JTT, Johnson I. Effects of Sonication on the Physical and Biochemical Properties of Polyalthia Longifolia Leaf Extracts and Sugar Solutions. Int J Drug Deliv Technol. 2026;16(11s): 398-403. DOI: 10.25258/ijddt.16.11s.38

1. Introduction

Polyalthia longifolia, commonly known as the false ash tree, is an evergreen tree species native to the Indian subcontinent. This plant has been traditionally used in various medicinal practices due to its numerous bioactive compounds, including alkaloids, flavonoids, and tannins. These compounds contribute to a range of therapeutic properties, such as antimicrobial, anti-inflammatory, and antioxidant activities. The leaf extracts of Polyalthia longifolia have been studied for their potential in pharmaceutical applications, particularly in the development of natural remedies for various ailments. Despite the promising benefits, the extraction of bioactive compounds from plant materials often presents challenges in terms of yield and efficiency, particularly when dealing with complex plant matrices. Sonication, a process that uses high-frequency sound waves to induce mechanical vibrations in a liquid medium, has been explored as a technique to improve the extraction efficiency of bioactive compounds. This process can enhance molecular interactions and break down cell walls, making it an effective tool for extracting bioactive molecules from plant materials.

Sonication is widely utilized in various fields, including chemistry, biochemistry, and food science, to improve the solubility, dispersion, and extraction of bioactive compounds. It works by generating microscopic cavitation bubbles in the liquid, which collapse upon reaching a critical size, generating localized high temperatures and pressures. These physical effects disrupt cell membranes, thus facilitating the release of intracellular contents such as proteins, carbohydrates, and secondary metabolites. Sonication has been shown to be particularly effective in the extraction of plant-based bioactive compounds, as it can reduce extraction time and improve yield without the need for harmful chemicals or solvents. The impact of sonication on the physical and biochemical properties of plant extracts, however, remains an area of ongoing research. Studies have indicated that sonication can affect various physical properties, such as density, viscosity, ultrasonic velocity, and acoustic impedance, all of which are important for understanding the behavior of plant extracts in different environments.

Understanding the effects of sonication on the physical and biochemical properties of plant extracts is

Effects of Sonication on the Physical and Biochemical Properties of *Polyalthia longifolia* Leaf Extracts and Sugar Solutions

crucial for optimizing extraction protocols and ensuring the stability and efficacy of bioactive compounds. Moreover, the antimicrobial activity of these extracts, which is often one of their most sought-after attributes, can be influenced by sonication. *Polyalthia longifolia* leaf extracts have demonstrated antimicrobial activity against several pathogens, including bacteria and fungi, making them a promising candidate for use in natural antimicrobial formulations. However, the extent to which sonication affects the antimicrobial potential of these extracts is not fully understood and warrants further investigation. The application of sonication to sugar solutions, another common medium for extracting bioactive compounds, offers an interesting comparison, as sugar solutions can influence the solubility and stability of compounds. By comparing the effects of sonication on both *Polyalthia longifolia* leaf extracts and sugar solutions, this study aims to contribute valuable insights into the role of sonication in enhancing extraction efficiency and improving the functional properties of natural products.

The primary goal of this study is to investigate the impact of sonication on the physical, biochemical, and antimicrobial properties of *Polyalthia longifolia* leaf extracts and sugar solutions. Specifically, this research focuses on how sonication at various intervals (5, 10, and 15 minutes) can alter the physical properties of the extracts, such as density, viscosity, and acoustic properties, as well as the biochemical composition, including protein and carbohydrate levels. Structural changes at the molecular level are also examined using Fourier Transform Infrared (FTIR) and UV-visible spectroscopy to identify alterations in functional groups and absorption characteristics. Furthermore, particle size analysis is employed to observe the effects of sonication on the size distribution of the extract particles. Finally, the antimicrobial activity of both the leaf extracts and sugar solutions is assessed through the agar well diffusion method to evaluate the effectiveness of sonication in enhancing antimicrobial properties.

In addition to its role in enhancing extraction efficiency, sonication has the potential to modify the structural characteristics of bioactive compounds, which may influence their bioactivity and interactions with other molecules. The use of sonication as a method of enhancing molecular interactions has broad implications for the fields of pharmaceuticals, biotechnology, and food science. For instance, sonication has been used in food processing to improve the extraction of bioactive compounds from plant sources, which can lead to the development of functional foods with enhanced health benefits. Similarly, in the pharmaceutical industry, sonication can be employed to optimize the extraction of active pharmaceutical ingredients from plant materials, resulting in more effective and efficient formulations.

This study also highlights the relevance of sonication in the context of sustainable extraction methods. As the demand for plant-based bioactive compounds continues to rise, the need for efficient, environmentally friendly extraction techniques has become more pressing. Sonication offers several advantages over traditional extraction methods, such as reduced solvent usage and shorter processing times, making it a more sustainable alternative. Additionally, the use of sonication can lead to more consistent and reproducible results, which are critical for ensuring the quality and efficacy of natural products. As such, this research seeks to advance our understanding of sonication's potential in optimizing the extraction of bioactive compounds from *Polyalthia longifolia* and sugar solutions, paving the way for more sustainable and efficient extraction practices in the future.

2. Experimental Methodology

Materials used in this study include *Polyalthia longifolia* leaves, which were collected and prepared for extraction. Analytical grade reagents, such as distilled water, anthrone reagent, concentrated sulfuric acid, and Bovine Serum Albumin (BSA), were employed for biochemical assays. Sugar solutions with concentrations of 5 g and 10 g were prepared using commercially available sugar. Several instruments were utilized in the study, including an ultrasonic bath sonicator for sonication, specific gravity bottles for density measurements, an Oswald viscometer for viscosity determination, an ultrasonic interferometer for ultrasonic velocity and acoustic impedance measurement, an FTIR spectrometer for structural analysis, a UV-visible spectrophotometer for absorption studies, a particle size analyzer for size distribution analysis, and equipment for antimicrobial assays. For sample preparation, the leaves of *Polyalthia longifolia* were separated, cleaned, and boiled in distilled water for 30 minutes. The solution was filtered using Whatman filter paper to obtain the leaf extract. Two samples were prepared: one remained untreated, while the other was subjected to sonication at intervals of 5, 10, and 15 minutes. Additionally, sugar solutions were subjected to the same sonication intervals for comparative analysis. Physical property measurements were performed to assess the impact of sonication on the extracts and sugar solutions. The density of the samples was measured using a calibrated specific gravity bottle, which was immersed in a temperature-controlled water bath to ensure consistent experimental conditions. Viscosity was determined using an Oswald viscometer, which was thoroughly cleaned and equilibrated to the required temperature. The time taken for the liquid to flow between two marked points was recorded for viscosity calculations. Ultrasonic velocity and acoustic impedance were measured using an ultrasonic

Effects of Sonication on the Physical and Biochemical Properties of *Polyalthia Longifolia* Leaf Extracts and Sugar Solutions

interferometer by noting the distance between maxima, and velocity was calculated based on the appropriate equation. Adiabatic compressibility was calculated from the relationship involving density and ultrasonic velocity. **Fig.1** shows the UV-POLYALTHIALONGIFOLIA:

3. Characterization analyses

Carbohydrates were quantified using the anthrone method. One milliliter of the sample was mixed with four milliliters of anthrone reagent, boiled for 10 minutes, cooled, and then the absorbance was measured at 620 nm. Protein content was determined using the Lowry method. The samples were treated with Lowry reagent and Folin's reagent, followed by incubation. The optical density (OD) was recorded at 620 nm to assess the protein levels. FTIR spectroscopy was employed to observe functional group changes in the samples. The spectra were recorded before and after sonication, revealing shifts in peak positions and intensities, indicating structural modifications. FTIR (Fourier Transform Infrared) spectroscopy was employed to analyze the structural changes in *Polyalthia longifolia* leaf extracts and sugar solutions before and after sonication. FTIR spectra provide a molecular fingerprint by identifying absorption peaks corresponding to various functional groups, offering insights into structural modifications. The analysis procedure involved scanning samples using an FTIR spectrometer within the range of 4000 cm^{-1} to 400 cm^{-1} . Spectral data were collected for untreated samples as well as those subjected to sonication at 5, 10, and 15 minutes.

UV-visible spectroscopy was used to record the absorption spectra of both untreated and sonicated samples. Shifts in wavelength peaks were monitored, providing evidence of structural changes induced by sonication. The particle size distribution was analyzed to evaluate the effect of sonication-induced shear forces on the size reduction. Measurements were taken at each sonication interval to assess any changes in the particle size. The antimicrobial activity of the samples was assessed using the agar well diffusion method. Stock cultures of *Enterococcus faecalis* and *Pseudomonas aeruginosa* were maintained on nutrient agar slants. Nutrient agar was prepared, sterilized, and poured into Petri dishes. After solidification, wells were made using a cork borer. A total of 60 μL of the sample and a positive control (Streptomycin, 1 mg/mL) were loaded into the respective wells. The plates were incubated at 37°C for 24 hours, and the zone of inhibition was measured to determine the antimicrobial activity of the extracts.

4. Results and discussion

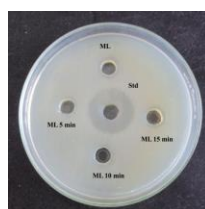
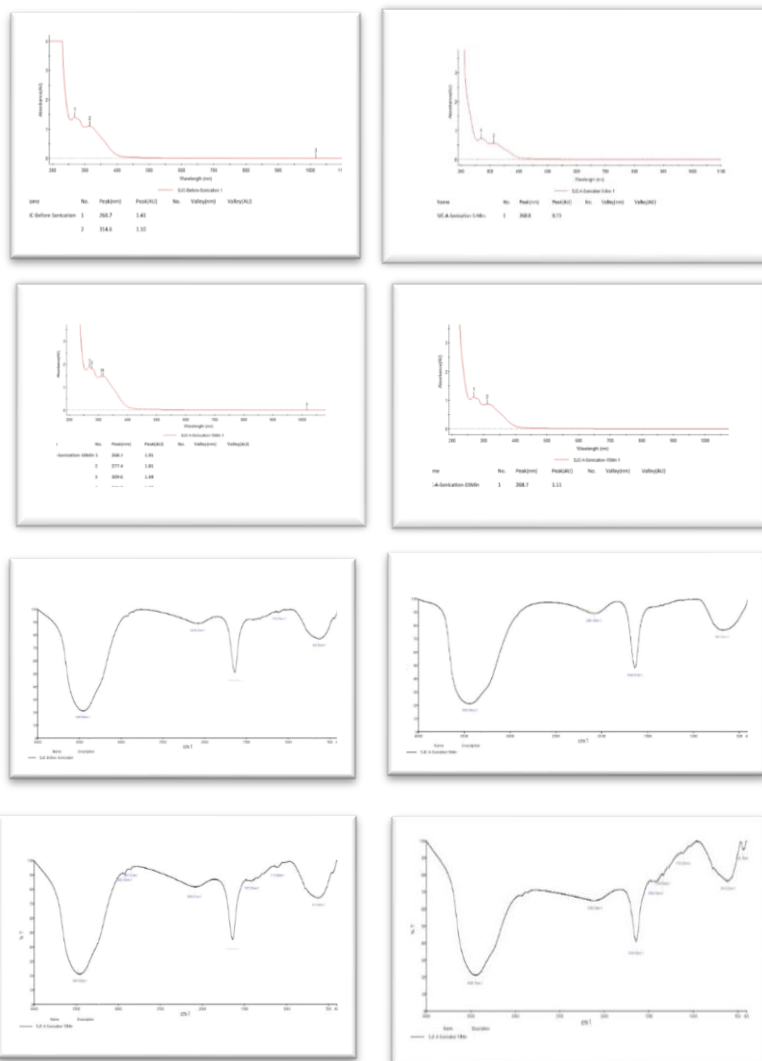


Fig:4.9.1

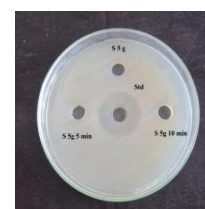


Fig:4.9.2

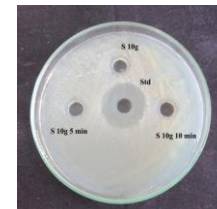


Fig:4.9.3

1. POLYALTHIALONGIFOLIA
2. SUAGR SOLUTION5g
3. SUGARSOLUTION10 g

Effects of Sonication on the Physical and Biochemical Properties of Polyalthia Longifolia Leaf Extracts and Sugar Solutions

4.1 Particle Size Analysis Interpretation

The particle size analysis of both Polyalthia longifolia leaf extracts and sugar solutions revealed significant reductions in size as a result of sonication. For Polyalthia longifolia leaf extracts, the particle size was relatively large before sonication, indicating intact cellular structures and limited dispersion of bioactive components. After 5 minutes of sonication, there was a marked reduction in particle size, reflecting the initial breakdown of cellular structures due to cavitation forces. At 10 minutes of sonication, the particle size continued to decrease, suggesting enhanced dispersion and improved mass transfer, which facilitated the release of intracellular components. However, after 15 minutes of sonication, a slight increase in particle size was observed, possibly due to the re-aggregation of smaller particles under prolonged sonication.

For sugar solutions, the particle size distribution was uniform before sonication, indicating that the sugar molecules were well-dissolved in the solution. After 5 minutes of sonication, minimal changes in particle size were observed, suggesting that shear forces primarily affected molecular interactions rather than causing physical size reduction. After 10 minutes of sonication, a slight reduction in particle size was noted, indicating improved homogenization. After 15 minutes, minor increases in particle size were observed, which could be attributed to molecular rearrangements or interactions among sugar molecules. Sonication effectively reduced particle sizes in Polyalthia longifolia extracts, enhancing the dispersion of bioactive compounds. In sugar solutions, the effect was less pronounced but still indicated improved homogenization and minor structural changes. The optimal sonication time is crucial to balancing size reduction and preventing the re-aggregation of particles.

4.2 UV-Visible Spectroscopy

The UV-visible spectroscopy analysis revealed significant changes in the absorption characteristics of both Polyalthia longifolia leaf extracts and sugar solutions due to sonication. For the Polyalthia longifolia leaf extracts, the UV spectra before sonication (Fig. 2.1) displayed distinct absorption peaks, indicating the presence of bioactive compounds in their native form. After sonication for 5 minutes Fig. 2.2, noticeable shifts in peak positions and an increase in peak intensities were observed, suggesting the initial stages of cell disruption and the release of intracellular bioactive compounds. After 10 minutes of sonication, enhanced peak intensities and further shifts indicated increased extraction efficiency and potential structural modifications in the released compounds. However, after 15 minutes of

sonication, peak broadening and intensity reduction were observed, indicating aggregation or degradation of certain compounds due to

SAMPLE CONCENTRATION	AMOUNT OF CARBOHYDRATE (µg)
BEFORE SONICATION	390
AFTER SONICATION (5mins)	540
AFTER SONICATION (10mins)	570
AFTER SONICATION (15mins)	600

PROTEIN ESTIMATION	
SAMPLE CONCENTRATION	AMOUNT OF PROTEIN(µg)
BEFORE SONICATION	760
AFTER SONICATION (5mins)	850
AFTER SONICATION (10mins)	880
AFTER SONICATION (15mins)	880

PHYSICAL PROPERTIES	BEFORE SONICATION	AFTER SONICATION (5MINS)	AFTER SONICATION (10MINS)	AFTER SONICATION (15MINS)
Density (kg/m ³)	1768	1768	1767	1768
Viscosity (NSm ⁻²)	1.4098	1.3861	1.4023	1.5319
Ultrasonic velocity(m/s)	1524	1527	1518	1525
Acoustic Impedance (kgm ⁻² s ⁻¹)	2.6977×10 ⁶	2.7009 ×10 ⁶	2.6836×10 ⁶	2.6973 ×10 ⁶
Adiabatic Compressibility (m ² /N)	2.4308×10 ⁻¹⁰	2.4235×10 ⁻¹⁰	2.4235×10 ⁻¹⁰	2.4307× 10 ⁻¹⁰

prolonged sonication. For the sugar solutions, before sonication, the spectra showed baseline absorption, characteristic of the unaltered sugar molecules. After 5 minutes of sonication, an emerging peak at 224 nm suggested minor structural changes, possibly due to shear forces. After 10 minutes of sonication (Fig. 2.3), the peaks became sharper, reflecting enhanced solubility or slight chemical rearrangements. After 15 minutes (Fig. 2.4), subtle changes in peak intensity indicated molecular interactions or limited degradation under extended sonication. UV-visible spectroscopy confirmed that sonication facilitates the release of bioactive compounds in *Polyalthia longifolia* and induces structural changes in sugar solutions. However, prolonged sonication may lead to compound degradation or aggregation, emphasizing the importance of optimizing sonication duration for the desired outcomes.

4.3 FTIR analysis

Before sonication (Fig.3), the *Polyalthia longifolia* extract exhibited peaks at 3455.95 cm^{-1} (N-H stretching, primary amine), 1628.45 cm^{-1} (C=C stretching, alkene), and 1116.74 cm^{-1} (C-N stretching, amine). The sugar solution showed peaks at 3417.36 cm^{-1} (O-H stretching, alcohol), 2924.37 cm^{-1} (C-H stretching, alkane), and 1643.34 cm^{-1} (C=C stretching, alkene). After sonication for 5 minutes, the *Polyalthia longifolia* extract displayed shifts in peaks, with the N-H stretching group diminishing and the O-H stretching peak at 3432.80 cm^{-1} , indicating alcohol formation. The sugar solution revealed a new peak at 1268.97 cm^{-1} (C-N stretching, aromatic ester).

At 10 minutes of sonication (Fig.3), the *Polyalthia longifolia* spectra showed the emergence of peaks at 2551.21 cm^{-1} (O-H stretching, carboxylic acid) and 1417.62 cm^{-1} (C-H bending, alkane), signifying new functional group formations. The sugar solution exhibited enhanced intensities in the O-H bending peaks at 1415.96 cm^{-1} and new peaks at 1053.12 cm^{-1} (C-O stretching, sulfoxide). After sonication for 15 minutes, the *Polyalthia longifolia* spectra displayed prominent peaks at 3445.73 cm^{-1} (O-H stretching, alcohol) and 1643.04 cm^{-1} (C=N stretching, imine), indicating significant structural alterations. The sugar solution exhibited peaks at 1384.24 cm^{-1} (C-H bending, aldehyde) and 1053.95 cm^{-1} (C-O stretching, primary alcohol).

The FTIR spectra indicated notable structural modifications in both *Polyalthia longifolia* and sugar solution samples post-sonication. The appearance of new peaks and shifts in existing ones highlighted cell disruption, the release of bioactive compounds, and transformations in functional groups. The formation of alcohol and carboxylic acid in *Polyalthia longifolia* suggests enhanced bioactive compound extraction. For

the sugar solutions, new ester and sulfoxide peaks imply chemical interactions and rearrangements facilitated by sonication. These findings confirm that sonication induces substantial structural and chemical changes, enhancing the accessibility and extraction of functional molecules.

4.4 Antimicrobial Analysis

The antimicrobial activity of *Polyalthia longifolia* leaf extracts and sugar solutions was assessed using the agar well diffusion method. For *Polyalthia longifolia* leaf extracts, before sonication, the extracts exhibited a 12 mm zone of inhibition against *Enterococcus faecalis*, indicating moderate antimicrobial activity. No antimicrobial activity was observed against *Pseudomonas aeruginosa*. After sonication for 5 minutes, the zone of inhibition against *Enterococcus faecalis* remained consistent at 12 mm, suggesting that short-duration sonication did not significantly enhance antimicrobial properties. After sonication for 10 minutes, similar results were observed, with no significant changes in activity against *Enterococcus faecalis*, and activity against *Pseudomonas aeruginosa* remained absent. After 15 minutes of sonication, the antimicrobial activity against *Enterococcus faecalis* persisted, indicating that prolonged sonication did not degrade or enhance the bioactive compounds responsible for inhibition.

For the sugar solutions, no measurable antimicrobial activity was observed against either *Enterococcus faecalis* or *Pseudomonas aeruginosa* before or after sonication, highlighting the inert nature of the sugar solutions in this context. *Polyalthia longifolia* extracts demonstrated consistent antimicrobial activity against *Enterococcus faecalis*, unaffected by sonication duration. The absence of activity against *Pseudomonas aeruginosa* underscores the specificity of the antimicrobial properties. Sugar solutions exhibited no antimicrobial effects, further confirming their lack of bioactivity in this experiment.

5. Conclusion

The study of sonication's effects on the physical, biochemical, and antimicrobial properties of *Polyalthia longifolia* leaf extracts and sugar solutions is of great significance for advancing the field of bioactive compound extraction. By examining the changes in physical properties, biochemical composition, and antimicrobial activity following sonication, this research provides valuable insights into the optimization of extraction techniques and the enhancement of bioactive compound yields. The findings of this study are expected to have broad applications in the pharmaceutical, food, and biotechnology industries, where sonication may be employed to improve the extraction, stability, and bioactivity of plant-based

compounds. The liquid state is a unique phase of matter, characterized by molecular interactions that exhibit properties intermediate between solids and gases. Understanding these interactions provides insight into molecular arrangements and thermodynamic behavior. Polyalthia longifolia, an evergreen tree with medicinal properties, and sugar solutions were studied to evaluate the effects of sonication on their physical, biochemical, and antimicrobial properties. This work aims to explore how sonication can optimize the extraction of bioactive compounds and modify structural properties. This study demonstrates that sonication significantly influences the physical, biochemical, and structural properties of Polyalthia longifolia extracts and sugar solutions. The technique enhances the extraction of macromolecules, induces functional group transformations, and slightly modifies antimicrobial activity. These findings underline the potential of sonication as an effective tool for bioactive compound extraction and molecular interaction studies.

Acknowledgments

The authors thank, the management of St. Joseph's College, Tiruchirappalli for SJCRG and DST-FIST, Government of India for funding towards Infrastructure and Instrumentation facilities at ACIC, St. Joseph's College (Autonomous), Tiruchirappalli.

Conflict of Interest Statement

The authors state no conflict of interest.

Data Availability Statement

On reasonable request, the corresponding author will make the whole datasets created and/or analysed during the current work available

Authors Contribution

G. Samuel: The conception and design of the study, or acquisition of data.

J. Tharancia Teena Mary: Drafting the article or revising it critically for important intellectual content.

I. Johnson: Final approval of the version to be submitted.

References

- [1] Prusty, D., Gallegos, A., & Wu, J. (2024). Unveiling the Role of Electrostatic Forces on Attraction between Opposing Polyelectrolyte Brushes. *Langmuir*, 40(4), 2064-2078
- [2] Riera, M., Talbot, J. J., Steele, R. P., & Paesani, F. (2020). Infrared signatures of isomer selectivity and symmetry breaking in the Cs⁺ (H₂O)₃ complex using many-body potential energy functions. *The Journal of Chemical Physics*, 153(4).
- [3] Horstmann, R., Hecht, L., Kloth, S., & Vogel, M. (2022). Structural and dynamical properties of liquids in confinements: A review of molecular dynamics simulation studies. *Langmuir*, 38(21), 6506-6522.
- [4] Ulusoy, U. (2023). A review of particle shape effects on material properties for various engineering applications: from macro to nanoscale. *Minerals*, 13(1), 91.
- [5] Tanasheva, N. K., Dyusembaeva, A. N., Bakhtybekova, A. R., Minkov, L. L., Burkov, M. A., Shuyushbayeva, N. N., & Tleubergenova, A. Z. (2024). CFD simulation and experimental investigation of a Magnus wind turbine with an improved blade shape. *Renewable Energy*, 237, 121698.
- [6] Zelenski, M., Simakin, A., Taran, Y., Kamenetsky, V. S., & Malik, N. J. G. E. C. A. (2021). Partitioning of elements between high-temperature, low-density aqueous fluid and silicate melt as derived from volcanic gas geochemistry. *Geochimica et Cosmochimica Acta*, 295, 112-134.
- [7] Zhang, D., Ronson, T. K., Zou, Y. Q., & Nitschke, J. R. (2021). Metal-organic cages for molecular separations. *Nature Reviews Chemistry*, 5(3), 168-182.
- [8] Špadina, M., Dufrière, J. F., Pellet-Rostaing, S., Marčelja, S., & Zemb, T. (2021). Molecular forces in liquid-liquid extraction. *Langmuir*, 37(36), 10637-10656.
- [9] Moradpour, N., Yang, J., & Tsai, P. A. (2024). Liquid foam: Fundamentals, rheology, and applications of foam displacement in porous structures. *Current Opinion in Colloid & Interface Science*, 101845.
- [10] Gao, S., Yang, Y., Falchevskaya, A. S., Vinogradov, V. V., Yuan, B., Liu, J., & Sun, X. (2024). Phase transition liquid metal enabled emerging biomedical technologies and applications. *Advanced Science*, 11(37), 2306692.
- [11] Lee, W. T. C., Yin, Y., Morten, M. J., Tonzi, P., Gwo, P. P., Odermatt, D. C., ... & Rothenberg, E. (2021). Single-molecule imaging reveals replication fork coupled formation of G-quadruplex structures hinders local replication stress signaling. *Nature communications*, 12(1), 2525.
- [12] Saini, A., Prabhune, A., Mishra, A. P., & Dey, R. (2021). Density, ultrasonic velocity, viscosity, refractive index and surface tension of aqueous choline chloride with electrolyte solutions. *Journal of Molecular Liquids*, 323, 114593.