

# 49<sup>th</sup> Winter School on Wave and Quantum Acoustics

## **AGENDA AND BOOK OF ABSTRACTS**

Organizers of WSWQA 2020:

**Upper Silesian Division of the  
Polish Acoustical Society**

*in cooperation with*

**The Committee on Acoustics of the  
Polish Academy of Sciences**

24-27 February 2020  
Hotel „Meta”  
Szczyrk, Beskidy Mountains, POLAND

**<https://ogpta.pl>**



**Dear Participants of the 49<sup>th</sup> WINTER SCHOOL  
on WAVE and QUANTUM ACOUSTICS 2020**

The organizers of the WSWQA would like to welcome all of you very cordially to Szczyrk, the heart of the Beskidy Mountains.

The 49<sup>th</sup> Winter School consists of:

- 16<sup>th</sup> Workshop on Acoustoelectronics;
- 16<sup>th</sup> Workshop on Molecular Acoustics, Relaxation and Calorimetric Methods.

We wish all the Participants of the 49<sup>th</sup> Winter School plenty of scientific satisfaction and many professional and social impressions.

Dariusz Bismor  
Secretary, WSWQA Organizing Committee

This book contains Programmes of both Workshops and summaries of works which will be presented within 49<sup>th</sup> WINTER SCHOOL on WAVE and QUANTUM ACOUSTICS 2020.



49<sup>th</sup> Winter School on  
Wave and Quantum Acoustics

**16<sup>th</sup> Winter Workshop  
on Acoustoelectronics (AE)**

**AGENDA AND  
ABSTRACTS**

Organizers of WSWQA 2020:

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# AGENDA OF THE 16<sup>TH</sup> WORKSHOP ON ACOUSTOELECTRONICS

Szczyrk, 24 February – 27 February 2020

<b>24.02.2020 Monday</b>	
13:00	<i>Lunch</i>
<b>14:30-14:35</b>	<b>OPENING CEREMONY of the Conferences</b>  <b>15<sup>th</sup> IOS'2020</b> <b>49<sup>th</sup> WSW&amp;QA</b> <b>48<sup>th</sup> WSEA&amp;V</b>
14:35-16:30	<b>Jubilee Sessions</b>
15:00-15:30	<i>Plenary lecture:</i> <b>Integrated Photonics – Yesterday, Today and Tomorrow</b> <u>R. PIRAMIDOWICZ</u> , S. STOPIŃSKI, A. PAŚNIKOWSKA, M. SŁOWIKOWSKI, A. KAŹMIERCZAK, A. JUSZA, K. ANDERS, W. PLESKACZ, P. SZCZEPAŃSKI
15:30-16:00	<i>Plenary lecture:</i> <b>Nanoparticles-Doped Photonic Liquid Crystal Fibers for Enhanced Efficiency of Electric Field Tunability</b> <u>T. R. WOLIŃSKI</u> , K. BEDNARSKA, D. BUDASZEWSKI, M. CHYCHŁOWSKI, P. LESIAK, B. BARTOSEWICZ, Z.JANKIEWICZ, R.DĄBROWSKI
16:00-16:30	<i>Plenary lecture:</i> <b>Nonlocal Solitons</b> <u>W. KRÓLIKOWSKI</u>
16:30-17:00	<i>Coffee Break</i>

18:30	<i>Supper</i>
19:30	<b>MUSIC GLANCE</b>

<b>25.02.2020 Tuesday</b>	
8:00	<i>Breakfast</i>
13:00	<i>Lunch</i>
<b>15:20- -18:00</b>	<b>SESSION</b>
15:20-15:50	<b>Testing the Application of the Ultrasonic Ring Array Used in Ultrasound Transmission Tomography for Examining Structures Using the Reflection Method</b> W. STASZEWSKI, T. GUDRA, K. J. OPIELIŃSKI
15:50-16:20	<b>Analysis of Possibilities of Reducing the Refraction Phenomenon in Breast Ultrasound Tomography Scanning</b> K. J. OPIELIŃSKI
16:20-17:00	<i>Coffee break</i>
17:00-17:30	<b>Optimal Selection of Multicomponent Matching Layers for Piezoelectric Transducers Using Genetic Algorithm</b> T. GUDRA, D. BANASIAK
17:30-18:00	<b>Location of the Sources and Identification of Acoustic Emission Signals Related to Partial Discharges Generated within Generator Coil Bars</b> F. WITOS
19:30	<i>Festive Supper (Banquet)</i>

<b>26.02.2020 Wednesday</b>	
8:00	<i>Breakfast</i>
13:00	<i>Lunch</i>
<b>15:20- -18:00</b>	<b>SESSION</b>
15:20-15:50	<b>Study on Solid Dielectric Materials Influence on Acoustic Emission Signals Emitted by Surface Discharges</b> M. KUNICKI
15:50-16:20	<b>Measurement and Testing of the Occurrence of Partial Discharges Occurring during the Temporary Electric of Transverse Insulation Barriers Using the Method of UV Radiation Emission and Acoustic Emission</b> P. FRĄCZ, P. SZPULAK, SZ. PASZKIEL
16:20-17:00	<i>Coffee break</i>
17:00-17:30	<b>Identification of the Basic Forms of Electrical Discharge Generated in Insulating Oil Measured by Optical Spectrophotometry</b> M. KOZIÓŁ
17:30-18:00	<b>Experimental and Numerical Analysis of the Steady Stage of a New SAW Structure with RR-P3HT in Detection DMMP with Morphological Model</b> T. HEJCZYK, J. WROTNIAK, P. POWROŹNIK, W. JAKUBIK
18:30-19:00	<i>Poster session – preparation of posters</i>
19:00-20:00	<i>Supper</i>

<p><b>20:00</b></p>	<p><b>POSTER SESSION</b></p>
<p>20:00</p>	<p><b>POSTER SESSION</b></p> <p><b>Compare Time-Frequency Content of Infrasound Signal in Wind Turbines with Wavelet Coherence</b> T. BOCZAR, D. ZMARZŁY, M. LORENC</p> <p><b>The Application of Selected Hierarchical Clustering Methods for Classification of the Acoustic Emission Signals Generated by Basic Forms of Partial Discharges</b> S. BORUCKI</p> <p><b>Comparison of Acoustic Noise Emitted by Partial Discharges on the Surface of a Clean and Dirty Medium Voltage Isolator Using a Specialised Acoustic Camera</b> M. GRYSZPIŃSKI</p> <p><b>Analysis of Acoustic Wave Velocity in Natural Ester Doped by Fe and Graphene Nanoparticles</b> Ł. NAGI, A. PŁUŻEK, M. KOZIOL, D. WOTZKA</p> <p><b>Acoustic Emission Method Applications for Pipelines Testing</b> A. OLSZEWSKA, F. WITOS, Z. OPILSKI</p>

**27.02.2020 Thursday**

8:00

*Breakfast*



**ABSTRACTS**  
**FOR THE 16<sup>TH</sup> WORKSHOP ON**  
**ACOUSTOELECTRONICS**



# **The Application of Selected Hierarchical Clustering Methods for Classification of the Acoustic Emission Signals Generated by Basic Forms of Partial Discharges**

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Sebastian Borucki, Jacek Łuczak, Marcin Lorenc

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The paper presents the results of application of the hierarchical clustering methods for classification of the acoustic emission (AE) signals generated by eight basic forms of partial discharges (PD) which can occur in paper-oil insulation of power transformers. Based on the registered AE signals from the particular PD forms, using a frequency descriptor in the form of the power spectral density (PSD) of the signal, their representation in the form of the set of points on plane XY was created. Next, these sets were subjected to the analysis using research algorithms consisting of selected clustering methods – single linkage, complete linkage, average linkage and Ward’s method, as well as selected similarity functions – the Euclidean Metric, Standardized Euclidean Metric, Minkowski Metric, City-Block Metric and Mahalanobis Metric. Based on the suggested numeric performance indicators, the analysis of the degree of reproduction of the actual distribution of points showing the particular time waveforms of the AE signals from eight adopted PD forms (PD classes) in the obtained clusters was carried out. As a result of the analyses carried out, the clustering algorithms of the highest effectiveness in identification of all eight PD classes, classified simultaneously, were indicated. Within the research carried out, an attempt to draw general conclusions as to the selection of the most effective hierarchical clustering method studied and the similarity function to be used for classification of the selected basic PD forms in the datasets created for the selected PSD frequency pairs was made.

## **Comparison of Acoustic Noise Emitted by Partial Discharges on the Surface of a Clean and Dirty Medium Voltage Isolator Using a Specialised Acoustic Camera**

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Mirosław Gryszpiński

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The article presents an analysis of the acoustic noise generated by the Partial Discharges on the surface of a medium voltage insulator. The measurements were made with a specialist acoustic camera under constant environmental conditions for a clean insulator and contaminated with a conductive substance. The measurement procedure was presented together with a description of the measurement system. A comparative analysis of measurement results was carried out. Further research plans are described.

## Optimal Selection of Multicomponent Matching Layers for Piezoelectric Transducers Using Genetic Algorithm

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Tadeusz Gudra, Dariusz Banasiak

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One major problem of the ultrasonic transducers design is the huge impedance mismatch between piezoelectric ceramics and the loading medium (e.g. gaseous, liquid and biological media). To solve this problem, the use of matching layer (or layers) is necessary. Optimal selection of materials functioning as matching layers for piezoelectric transducers used in transmitting and receiving ultrasound waves strictly depends on the type of the medium receiving the ultrasound energy.

There are several methods which allow optimal selection of materials used as matching layers. When using single matching layer, its impedance can be calculated based on upon Chebyshev's, DeSilets' or Souquet's criterion. In the general case, the methods using analogy to transmission line in order to calculate transmission coefficient  $T$  are usually applied. In the paper extension of calculation of transmission coefficient additionally with regard to attenuation coefficient of particular layers is presented. The way of optimization of transmission coefficient  $T$  is based on the method using genetic algorithm. The obtained results indicate on essential divergence between classic calculation methods and the method with application genetic algorithm.

## Testing the Application of the Ultrasonic Ring Array Used in Ultrasound Transmission Tomography for Examining Structures Using the Reflection Method

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Wiktor Staszewski, Tadeusz Gudra, Krzysztof J. Opieliński

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The ultrasonic ring array designed for examining female breasts with the use of ultrasonic transmission tomography has been adapted for reflection method trials. The parameters of the focus were changed by altering the time of activation of ultrasonic elementary transducers with the aim of improving the quality of the obtained ultrasonic image. To achieve this, a phantom made up of rods of varying thickness was analysed, when moving the position of the focus with the use of dynamic focusing along the symmetry axis of the ring array ranging from 30 to 130 mm from central transducers. A series of simulations with identical conditions to the phantom trial were conducted in previous trials that applied an algorithm using the sum of all the acoustic fields. This paper document attempts to improve the parameters of the acoustic field distribution during unconventional focusing.

This research is a continuation of examining the acoustic field distribution inside the ultrasonic ring array.

## Experimental and Numerical Analysis of the Steady Stage of a New SAW Structure With RR-P3HT in Detection DMMP With Morphological Model

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Tomasz Hejczyk<sup>1</sup>, Jarosław Wrotniak<sup>2</sup>, Paulina Powroźnik<sup>3</sup>, Wiesław Jakubik<sup>3</sup>

<sup>1</sup>The Academy of Creative Development - the Foundation,  
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The paper presents the results of numerical analyses of the SAW gas sensor in the steady state. The effect of SAW velocity changes vs. the surface electrical conductivity of the sensing layer is predicted. The conductivity of the roughness sensing layer above the piezoelectric waveguide depends on the profile of the diffused gas molecule concentration inside the layer.

Numerical results for the gas DMMP (CAS Number 756-79-6) for layer (RR)-P3HT in the steady state have been shown. The main aim of the investigations was to study thin film interaction with target gases in the SAW sensor configuration based on diffusion equation for polymers. Numerical results for profile concentration in steady state using design Abbot-Firestone curves have been shown.

The results of numerical analyzes allow to select the sensor design conditions, including the morphology of the sensor layer, its thickness, operating temperature and layer type. The numerical results basing on the code written in Python, are described and analyzed. The theoretical results were verified and confirmed experimentally.

# Study on Solid Dielectric Materials Influence on Acoustic Emission Signals Emitted by Surface Discharges

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Michał Kunicki

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This paper presents analysis on acoustic emission signals (AE) emitted by surface discharges (SD) in insulation oil, on different solid dielectric materials. The main objective of this research is to propose methodology, which allows identifying the dielectric material, that SD are generated on, based on the analysis of AE signals. Three scenarios are compared and investigated, where different solid dielectrics are used for SD generation: pressboard paper, polytetrafluoroethylene and glass-ceramic. Typical measuring setup based on the piezoelectric joint AE sensor is used for signals registration. Matlab software is used for advanced analysis of the registered signals in time, frequency and time-frequency domain, in order to indicate adequate descriptors that allow explicit identification of the dielectric material used for SD generation. As a result, it has been confirmed that material affects the discharge phenomenon, which also is reflected in AE signal emitted by this discharge. Thus, according to this research, proposed methodology confirmed that it is possible to distinguish these materials, analyzing acoustic signals only. Finally, such approach may potentially support the development and extend the abilities of the diagnostic tools and maintenance policy in electrical power industry.

## **Analysis of Acoustic Wave Velocity in Natural Ester Doped by Fe and Graphene Nanoparticles**

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Łukasz Nagi, Aleksandra Płużek, Michał Koziół, Daria Wotzka

Opole University of Technology,  
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Nanoparticles in scientific research and industrial applications are used to improve or change the properties and parameters of many materials and liquids. Studies are also conducted on the influence of nanoparticle doped on electrical and physicochemical parameters of electroinsulating liquids. One of such properties is the rate of propagation of the acoustic wave in a given environment, which in turn is often used in high-voltage diagnostic methods. The article presents the results of measurements of acoustic wave velocity in natural ester doped of nanoparticles such as graphene and iron nanopowder in hydrophobic carbon shells. The measurements were carried out in an ester with nanoparticles of various mass concentrations. For acoustic emission, a piezoelectric transducer was used, which was immersed in the tested liquid. Signals with different frequency ranges and for different distances between the generator and sensor were analysed.

## Acoustic Emission Method Applications For Pipelines Testing

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Aneta Olszewska, Franciszek Witos, Zbigniew Opilski

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The paper presents designed and constructed modelled sources that initiates metal corrosion processes and models gas leaks in pipelines, analyse the results of laboratory tests on pipelines when the made modelled sources were used, and analysis of the results of preliminary studies aimed at preparing for the monitoring of gas pipelines using acoustic emission method.

Laboratory tests carried out, among others on the pipeline in the Technology Hall confirmed the functionality of the constructed modelled sources and showed the possibility of locating the leakage source mounted on the pipeline by means of acoustic emission method using AMSY-6 measuring apparatus operating in the continuous mode.

The tests carried out on selected several real objects allowed to determine the range of different acoustic emission signals for gas pipelines with different types of insulation layers.

# Analysis of Possibilities of Reducing the Refraction Phenomenon in Breast Ultrasound Tomography Scanning

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Krzysztof J. Opieliński

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Wrocław University of Science and Technology,  
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An important problem in imaging the breast by ultrasound tomography is the refraction phenomenon of the scanning ultrasonic beam rays at heterogeneity borders. The boundaries of structures with significantly different ultrasonic speeds are distorted in tomographic images reconstructed with fast transform algorithms due to the failure to maintain a straight-line transmission. The adaptation to the curvilinear transmission is possible through the use of waveform inversion. However, it requires a much greater number of input data and long calculation times. It significantly increases the cost of building the scanner, the data acquisition time and image reconstruction process, causing the limitation of breast testing in vivo.

The paper analyzed the possibility of reducing the refraction phenomenon in breast ultrasound tomography scanning in vivo by properly forming a breast immersed in water and choosing the optimum water temperature.

The research was performed as project POIR.01.01.01-00-1595/15, titled: "Development of a prototype of multi-modal ultrasound tomography system for breast diagnosis" co-financed by European Union from the European Regional Development Fund.

## **Measurement and Testing of the Occurrence of Partial Discharges (PD) Occurring During the Temporary Electric of Transverse Insulation Barriers Using the Method of UV Radiation Emission and Acoustic Emission**

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Paweł Frącz, Szpulak Piotr, Paszkiel Szczepan.

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This article presents the results of research on the occurrence of Partial Discharges (PD) during temporary electrification of transverse insulation barriers in the blade-plate system in order to obtain a visualisation of the distribution of electrical charges on their surface.

Using a corona discharge camera based on a multi-channel spherical matrix, which enables measurements to be made in a limited space, a study of UV radiation emission during the process of temporary electric was carried out, together with simultaneous measurement of acoustic emission with the use of a specialized camera, which enables a multivariate spectral analysis of sound emission in a fragmentary way based on the place of emission, frequency, time and propagation of sound waves accompanying the study.

The measurement system used, the methodology of the measurements performed and the description of the research method used are also presented. The obtained results are presented in the form of recorded spectrograms and illustrations, on the basis of which a comparative analysis of the occurrence of certain relationships and correlations was made.

## **Location of the Sources and Identification of Acoustic Emission Signals Related to Partial Discharges Generated Within Generator Coil Bars**

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The paper presents the results of analysis of acoustic emission (AE) signals recorded during the research of partial discharges (PDs) in generator coil bars. Research were carried out using the AE calibrated method, i.e. in parallel with the AE method and the electric method.

The AE method was used to record signals at selected measuring points of the groove part of the bar. During the tests, supply voltage with selected values from zero to twice the rated voltage was supplied to the bar. An analysis of the recorded signals in the domain of time, frequency, time-frequency and threshold of discrimination was carried out. The location of PDs sources was made using the author's method of determining the stage of signal advancement.

The electric method was used to determine the apparent charge quantity introduced by the PDs sources and the type of PDs sources active at different values of the supply voltage applied to the tested bar.

The results of the AE research were related to the results of the electric method and acoustic images of AE signals recorded at the measurement points closest to the localized PD sources were built at different values of the supply voltage applied to the tested bar.



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# AGENDA OF THE 16<sup>TH</sup> WORKSHOP ON MOLECULAR ACOUSTICS, RELAXATION AND CALORIMETRIC METHODS

Szczyrk, 24-27 February 2020

<b>24.02.2020 Monday</b>	
13:00	<i>Lunch</i>
<b>14:30-14:35</b>	<b>OPENING CEREMONY of the Conferences</b>  <b>15<sup>th</sup> IOS'2020</b> <b>49<sup>th</sup> WSW&amp;QA</b> <b>48<sup>th</sup> WSEA&amp;V</b>
14:35-16:30	<b>Jubilee Sessions</b>
15:00-15:30	<i>Plenary lecture:</i> <b>Integrated Photonics – yesterday, today and tomorrow</b> <u>R. PIRAMIDOWICZ</u> , S. STOPIŃSKI, A. PAŚNIKOWSKA, M. SŁOWIKOWSKI, A. KAŻMIERCZAK, A. JUSZA, K. ANDERS, W. PLESKACZ, P. SZCZEPAŃSKI
15:30-16:00	<i>Plenary lecture:</i> <b>Nanoparticles-doped photonic liquid crystal fibers for enhanced efficiency of electric field tunability</b> <u>T. R. WOLIŃSKI</u> , K. BEDNARSKA, D. BUDASZEWSKI, M. CHYCHŁOWSKI, P. LESIAK, B. BARTOSEWICZ, Z. JANKIEWICZ, R. DĄBROWSKI
16:00-16:30	<i>Plenary lecture:</i> <b>Nonlocal Solitons</b> <u>W. KRÓLIKOWSKI</u>
16:30-17:00	<i>Coffee Break</i>

18:30	<i>Supper</i>
19:30	<b>MUSIC GLANCE</b>

<b>25.02.2020 Tuesday</b>	
8:00	<i>Breakfast</i>
13:00	<i>Lunch</i>
<b>15:20-18:00</b>	<b>SESSION</b>
15:20-15:50	<b>Investigation of the thermophysical properties of nematic liquid crystals in a wide range of state parameters</b> <u>VYACHESLAV N. VERVEYKO, MARINA V. VERVEYKO</u>
15:50-16:20	<b>The study of structure of magnetic fluids and their composites by X-ray and neutrons</b> <u>PETER KOPČANSKÝ</u>
16:20-17:00	<i>Coffee break</i>
17:00-17:30	<b>Dielectric and rheological properties of a transformer oil-based magnetic fluid</b> <u>MILAN TIMKO</u>
17:30-18:00	<b>Particle-stabilized emulsions – acoustical properties and applications</b> <u>RAFAŁ BIELAS, ZBIGNIEW ROZYNEK, TOMASZ HORNOWSKI, ARKADIUSZ JÓZEF CZAK</u>
19:30	<i>Festive Supper (Banquet)</i>

<b>26.02.2020 Wednesday</b>	
8:00	<i>Breakfast</i>
13:00	<i>Lunch</i>
<b>15:20-18:00</b>	<b>SESSION</b>
15:20-15:50	<b>Sono-Magnetic Heating with Nanoparticles</b> KATARZYNA KACZMAREK, TOMASZ HORNOWSKI, IRYNA ANTAL, MICHAŁ RAJNAK, MILAN TIMKO, <u>ARKADIUSZ JÓZEFCZAK</u>
15:50-16:20	<b>Long-Term Stability and Thermal Conductivity of Multi Walled Carbon Nanotubes Dispersed in 1,2-propanediol by Sonication</b> <u>KAROLINA BRZÓSKA</u> , EDWARD ZOREŃSKI, MARZENA DZIDA
16:20-17:00	<i>Coffee break</i>
17:00-17:20	<b>Electrochemical Impedance Spectroscopy of Ionic Liquids. Own and Literature Research</b> <u>PAWEŁ GANCARZ</u> , EDWARD ZOREŃSKI
17:20-17:40	<b>IoNanofluids – Preparation and Characteristics</b> <u>KRZYSZTOF CWYNAR</u> , ADRIAN GOLBA, ŁUKASZ SCHELLER, EDWARD ZOREŃSKI, MARZENA DZIDA
17:40-18:00	<b>Volumetric Properties of 1-butyl-1-methylpyrrolidinium bis(trifluoromethylsulfonyl) imide Modified by Carbon Nanostructures</b> <u>JUSTYNA DZIADOSZ</u> , KRZYSZTOF CWYNAR, MARZENA DZIDA, EDWARD ZOREŃSKI, SŁAWOMIR BONCEL, ANNA KOLANOWSKA, ANNA KUZIEL

18:00-18:20	<p><b>Viscosity of Ionanofluids Composed of 1-butyl-1-methylpyrrolidinium bis(trifluoromethylsulfonyl)imide with Carbon Nanostructures Measured by Classical and Ultrasonic Methods</b></p> <p><u>ADRIAN GOLBA</u>, EDWARD ZORĘBSKI, JUSTYNA DZIADOSZ, MARZENA DZIDA, SŁAWOMIR BONCEL, BERTRAND JÓŹWIAK, RAFAŁ JĘDRYSIAK, ANNA KOLANOWSKA</p>
18:20-18:40	<p><b>Effect of Modification of Ionic Liquids by Carbon Nanostructures on Thermal Conductivity</b></p> <p><u>ŁUKASZ SCHELLER</u>, EDWARD ZORĘBSKI, JUSTYNA DZIADOSZ, MARZENA DZIDA, SŁAWOMIR BONCEL, BERTRAND JÓŹWIAK, RAFAŁ JĘDRYSIAK, ANNA KOLANOWSKA</p>
18:40-19:00	<i>Poster session – preparation of posters</i>
19:00-20:00	<i>Supper</i>
<b>20:00</b>	<b>POSTER SESSION</b>
20:00	<p><b>POSTER SESSION</b></p> <p><b>Speed of Sound and Isentropic Compressibility of Triethylsulfonium and 1-(2-hydroxyethyl)-3-methylimidazolium bis(trifluoromethyl sulfonyl) imides</b>  <u>MAGDALENA BABA</u>, EDWARD ZORĘBSKI</p> <p><b>Speed of Sound and Isentropic Compressibility of 1-methyl-1-propylpiperidinium and 1-butyl-1-methylpiperidinium bis(trifluoromethylsulfonyl)imides</b>  <u>IZABELA CHLEBIK</u>, EDWARD ZORĘBSKI</p> <p><b>Direction-Specific Release from Capsules with Homogeneous or Janus Shells Using an Ultrasound Approach</b>  TOMASZ KUBIAK, JOANNA BANASZAK, ARKADIUSZ JÓZEF CZAK, <u>ZBIGNIEW ROZYNEK</u></p>

**27.02.2020 Thursday**

8:00

*Breakfast*



**ABSTRACTS**  
**FOR 16<sup>TH</sup> WORKSHOP ON**  
**MOLECULAR ACOUSTICS,**  
**RELAXATION AND CALORIMETRIC**  
**METHODS**



## Speed of Sound and Isentropic Compressibility of Triethylsulfonium and 1-(2-hydroxyethyl)-3-methylimidazolium bis(trifluoromethylsulfonyl)imides

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Magdalena Bąba, Edward Zorębski

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The speeds of sound and densities of the two hydrophobic ionic liquids containing a large hydrolysis-stable fluorinated anion were measured at atmospheric pressure in the temperature ranges (293.15-338.15) K and (288.15-363.15) K, respectively. The speeds of sound were measured using DSA 5000M, whereas densities were measured using DMA 5000M. Temperature dependencies of speeds of sound, densities and calculated isentropic compressibilities are typical (two first properties decrease monotonically, whereas the last increases monotonically with temperature).

Comparing the densities and speed of sound of the two ionic liquids tested, it can be seen that the values measured for 1-(2-hydroxyethyl)-3-methylimidazolium imide are higher; the values of isentropic compressibility are higher for triethylsulfonium imide. Moreover, the speed of sound values for triethylsulfonium bis(trifluoromethylsulfonyl)imide were compared with literature and results are comparable (max. deviation 0.89%).

The introduction of the hydroxyl functional group in the imidazolium cation, as in the case of 1-(2-hydroxyethyl)-3-methylimidazolium imide, leads to the speed of sound increase, and isentropic compressibility decrease relative to 1-ethyl-3-methylimidazolium bis(trifluoromethylsulfonyl)imide (without a functional group).

## Particle-Stabilized Emulsions – Acoustical Properties and Applications

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The stabilization of emulsion systems by solid particles rather than surfactants has gained scientific attention in the last decades. Different types of particles are used to form a mechanical barrier around emulsion droplets and hence to provide kinetic stability against coalescence, including polystyrene, polyethylene, magnetite and those with bio-origin such as cellulose. In this context, the use of magnetic particles is attractive due to the potential of controlled release from droplets in the external magnetic field and magnetic hyperthermia treatment.

In the presentation, we will show results from studies on emulsions stabilized by different types of particles. We investigated the emulsions formed by using high-intensity ultrasound and the electric field. We used a non-destructive ultrasonic technique that allowed us to control the process of formation without special sample treatment. During the talk, the potential applications for emulsions stabilized with magnetite and polystyrene particles, including the formation of colloidal capsules, will be presented.

## **Long-Term Stability and Thermal Conductivity of Multiwalled Carbon Nanotubes Dispersed in 1,2-propanediol and 1,3-propanediol by Sonication**

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The homogenously dispersed nanoparticles in base-liquid are required to realize the desired properties of nanofluids. The nanofluids under study are composed of non-functionalized multiwalled carbon nanotubes (MWCNTs) and 1,2-propylene glycol or

1,3-propylene glycol. The polyvinylpyrrolidone was used to increase the stability of nanofluids. The dispersions were prepared by two-step procedure using non-pulsonic sonication method. The presence of polymer in dispersion prevents aggregation of MWCNTs and causes strong stabilisation effect. The long-term stability of studied nanofluids was found, which has lasted for over three months up to now.

In this paper thermal conductivity, density, rheological properties and FTIR spectroscopy of nanofluids are presented. Storage in different temperature conditions used to assess the stability of nanofluids contained 0.5%, 1.0%, 1.5%, 2.0% wt. of MWCNTs. No agglomeration was found after mixing nanofluids with demineralized water in 1:1 ratio.

# Speed of Sound and Isentropic Compressibility of 1-methyl-1-propylpiperidinium and 1-butyl-1-methylpiperidinium bis(trifluoromethylsulfonyl)imides

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Two aprotic ionic liquids, 1-methyl-1-propylpiperidinium and 1-butyl-1-methylpiperidinium bis(trifluoromethylsulfonyl)imides, were studied. The speeds of sound and densities were determined at atmospheric pressure in the temperature range (293.15 K – 338.15 K) and (288.15 K – 363.15 K), respectively.

Temperature dependencies of speeds of sound and densities are typical, i.e., both decrease monotonically with the increasing temperature, whereas isentropic compressibilities determined from the speed of sound and density data increase monotonically with the increasing temperature. It was also found that the speeds of sound for tested ionic liquids are very similar, while the density of 1-methyl-1-propylpiperidinium bis(trifluoromethylsulfonyl)imide is higher than those of homolog with 1-butyl side carbon chain in the cation. In the case of isentropic compressibility, the values are higher for 1-butyl-1-methylpiperidinium bis(trifluoromethylsulfonyl)imide.

Speed of sound values were compared with the available literature data only for 1-butyl homolog (max deviation 0.41%) because no data were found for 1-propyl homolog. The results were also compared with imides containing the same side carbon chains (1-propyl and 1-butyl) in cations with imidazolium, pyridinium and pyrrolidinium rings.

## IoNanofluids – Preparation and Characteristics

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IoNanofluids, ionic liquids with dispersed nanoparticles, due to their unique physicochemical properties can be applied as heat transfer fluids. Stability is a major factor that should be considered in such systems. Many factors influence stability of IoNanofluids such as a base-liquid, nanoparticle characteristics, and dispersing method. IoNanofluids were prepared using the two step-method, i.e. by dispersing different weight concentrations of carbon-based nanostructures in ionic liquid. There are two main ways of dispersing nanoparticles - sonication with ultrasonic bath or using sonicator. In this work there were compared various dispersing methods of preparation of systems consisting of 1-butyl-1-methylpyrrolidinium bis(trifluoromethylsulfonyl)imide and multiwalled carbon nanotubes. Stability and dispersion rate varied depending on preparation procedure. The best results were found for samples prepared using combination of magnetic stirring, sonication in ultrasonic bath and sonication using sonicator afterwards.

*This work was financially supported by the National Science Centre (Poland) Grant No. 2017/27/B/ST4/02748.*

# Volumetric Properties of 1-butyl-1-methylpyrrolidinium bis(trifluoromethylsulfonyl) imide Modified by Carbon Nanostructures

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The ionic liquid-based nanofluids (IoNanofluids) characterize high thermal conductivity, non-volatility, and non-flammability. Therefore, they can be considered as advanced fluids for heat exchange in cooling technologies, in solar systems and chemical engineering. However, besides their thermal properties, knowledge of the temperature dependence on density is important as well.

The investigations focus on density and isobaric thermal expansion of dispersions of 0.2 wt%, 0.5 wt%, 0.75 wt%, and 1wt% Nanocyl-NC7000TM multiwalled carbon nanotubes (MWCNTs) in 1-butyl-1-methylpyrrolidinium bis(trifluoromethylsulfonyl) imide. Density of samples was measured in temperature range from 5 oC to 80 oC. The temperature dependence on density was used to calculate the isobaric thermal expansion. The density of IoNanofluids increases linearly with increasing weight concentration of Nanocyl-NC7000TM MWCNTs. The isobaric thermal expansion is approximately temperature independent for IoNanofluids containing 0.75 wt%, and 1wt % Nanocyl-NC7000TM.

*This work was financially supported by the National Science Centre (Poland) Grant No. 2017/27/B/ST4/02748.*

## Electrochemical Impedance Spectroscopy of Ionic Liquids. Own and Literature Research

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Electrochemical impedance spectroscopy (EIS) is a very versatile and powerful technique that can be used among others to characterize electrochemical phenomena in the analysis of the double-layer capacitance under the charging current or voltage. It can also provide information about the materials' bulk phase (e.g., conductivity, dielectric constant).

This paper presents both the review of literature works describing EIS applied to the study of ionic liquids and our preliminary research in this field. As model systems, bis(trifluoromethylsulfonyl)imides with piperidinium, pyrrolidinium, imidazolium, and sulfonium cations were examined by the EIS technique considering electric double-layer structure at the electrode-ionic liquid phase; ionic liquids were studied using platinum, gold and glassy carbon electrodes. The EIS spectra were recorded in the frequency range from 0.1 Hz to 1000 kHz at room temperature. Various equivalent circuits for the different electrode-ionic liquid pairs at forced DC polarization within the electrochemical window of the respective ionic liquid were fitted and analyzed. Based on the fitted models, the double layer capacitances were calculated and compared with the available literature.

## Viscosity of IONanofluids Composed of 1-butyl-1-methylpyrrolidinium bis(trifluoromethylsulfonyl)imide With Carbon Nanostructures Measured by Classical and Ultrasonic Methods

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Addition of carbon nanoparticles into ionic liquids improves thermal properties and enhances the viscosity. The rheological studies of IONanofluids are particularly important in determining the convective heat transfer and the pumping power required for practical applications. The investigations of viscosity of three dispersions composed of 1-butyl-1-methylpyrrolidinium bis(trifluoromethylsulfonyl)imide and 0.2wt%, 0.5wt% or 0.75wt% Nanocyl - NC7000TM multiwalled carbon nanotubes (MWCNTs) was conducted in temperature range from 25 °C to 75 °C using Ubbelohde viscometers, rheometer as well as ultrasonic viscometer. The obtained results show, that IONanofluids are non-Newtonian, viscoelastic with shear thinning and thixotropic behavior.

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## Sono-Magnetic Heating with Nanoparticles

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In conventional ultrasonic hyperthermia, the ultrasound-induced heating is achieved by the absorption of the wave energy and converting it into heat. However, to obtain appropriate temperatures in a reasonable time the high ultrasound wave intensities, which can result in a negative impact on healthy tissue, are required. Magnetic nanoparticles can work as a sonosensitizer, i.e. the substance that can enhance the operation of ultrasound. Additionally, magnetic nanoparticles on their own can produce localized heating in the alternating magnetic field. Magnetic and ultrasonic heating may work synergistically to produce a more efficient treatment. To investigate the magneto-ultrasonic thermal effect tissue-mimicking phantoms, doped with magnetic particles, were simultaneously irradiated with the focused ultrasonic wave and the alternating magnetic field. The results have shown that a more effective thermal effect can be observed during magneto-ultrasonic heating than in magnetic or ultrasound hyperthermia because of the synergistic interaction between the two mechanisms. The ultrasound sonication improves the thermal effect of magnetic hyperthermia through unblocking Brown's relaxation.

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## The Study of Structure of Magnetic Fluids and Their Composites by X-Ray and Neutrons

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Magnetic fluids constitute a compromise to achieve the magnetic state in liquid form as the problem of liquid magnetism is not solved so far. The partial solution lies in a preparation of colloidal suspensions based on liquids with solid magnetic entities. Properties of magnetic fluids depend on the applied magnetic field and their fluidic state provides many technical as well as biomedical applications. Standard examples are sealing arrangements, separation procedures, cooling in transformers and bio applications such as drug targeting, MRI imaging, hyperthermia or bio-separation. The most important for understanding of physical properties of magnetic fluids and their composites is the knowledge about their inner structure and behaviour at the interfaces. Small Angle scattering methods (X Ray, neutrons) as well as reflectometry are suitable methods to study such properties at the nanoscale.

In tall will be given the application of SANS and SAXS scattering techniques for structural diagnosis of certain magnetic fluids (biomedical, oil based technical), specific protein aggregates (amyloids with nanoparticles), synthetic biological complex - magnetoferritin, as well composite systems with liquid crystals.

## ***Direction-Specific Release From Capsules with Homogeneous or Janus Shells Using an Ultrasound Approach***

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A variety of approaches have been developed to release contents from capsules, including techniques that use electric or magnetic fields, light, or ultrasound as a stimulus. However, in the majority of the known approaches, capsules are disintegrated in violent way and the liberation of the encapsulated material is in random direction. This greatly limits the use of microcapsules in applications where targeted and directional release is desirable. Here, we present a convenient route for controllable and unidirectional release of encapsulated substance. This is achieved by using MHz-frequency ultrasound that enables the inner liquid stretching, which imposes mechanical stress on the capsule's shell. This leads to the puncturing of the shell and enables smooth liberation of the payload in one direction using low acoustic intensities. Various aspects of our ultrasonic route, including the role of capsule size, ultrasound wavelength, and the acoustic intensities needed for shell puncturing, are studied in detail. We also show that the additional control of the release can be achieved by using capsules having patchy shells. The presented method can be used to facilitate chemical reactions in micro- and nano-litre droplets and various small-scale laboratory operations carried in bulk liquids in microenvironment.

## Effect of Modification of Ionic Liquids by Carbon Nanostructures on Thermal Conductivity

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The modification of ionic liquids by adding carbon nanostructures creates loNanofluids characterized by exciting properties such as improved thermal properties, non-flammability, non-volatility. Therefore, the loNanofluids are considered as efficient heat transfer fluids in heating and cooling systems and in chemical engineering. In this work thermal conductivity was measured for several loNanofluids consisting of 1-butyl-1-methylpyrrolidinium bis(trifluoromethylsulfonyl)imide and in-house multiwalled carbon nanotubes (MWCNTs) or Nanocyl - NC7000TM MWCNTs. Thermal conductivity of loNanofluids was analyzed as a function of the mass fraction of MWCNTs and temperature. Research shows that the addition of carbon nanoparticles into the ionic liquid leads to the increase of thermal conductivity in comparison with those of pure ionic liquid.

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## Dielectric and Rheological Properties of a Transformer Oil-Based Magnetic Fluid

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The used magnetite nanoparticles were prepared by co-precipitation method and coated with oleic acid as a stabilizing agent. It was shown that dielectric response exhibits remarkable relaxation effects related to the interfacial polarization. Dielectric breakdown tests were performed on magnetic fluid samples of various nanoparticle concentrations. The evaluation of the breakdown voltage is based on the statistical approach. It was found that low particle concentrations have a positive impact on the breakdown voltage. In comparison to pure oil, the breakdown voltage increases quasi linearly with increasing nanoparticle concentration. The detected increase is interpreted in accordance with the free charge scavenging model, taking into account the effective nanoparticle polarization and subsequent charge trapping and streamer development velocity reduction.

From rheological point of view, it was clearly shown that the increasing nanoparticle concentration results in a significant increase in the viscosity. It is found that the viscosity of magnetic fluid can be controlled not only by external magnetic field, but with an electric field too. This phenomenon was associated with structural changes in nanofluid induced by the electric field.

## Investigation of the Thermophysical Properties of Nematic Liquid Crystals in a Wide Range of State Parameters

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The nematic liquid crystals (NLC): MBBA (n-methoxybenzylidene-n-butylaniline), EBBA (n-ethoxybenzylidene-n-butylaniline), and their eutectic mixture N-8 - MBBA + EBBA (2:1) were studied.

Specific heat capacities at constant pressure  $c_p$  and constant volume  $c_v$ , the heat capacities ratio  $c_p/c_v$  of the investigated objects were determined by known thermodynamic equations based on the experimental data of ultrasonic velocity and density in the temperature range from 293 K to 403 K and pressures 0.1–200 MPa.

An analysis of the dependence of the obtained data on the state parameters was carried out.

Some features of the dependencies of thermophysical properties of NLC on pressure and temperature are revealed.

The  $c_p$  and  $c_v$  of all NLC increase with increasing temperature in isobars and decrease with increasing pressure in isotherms, both in the nematic phase and in the isotropic phase.

The  $c_p$  and  $c_v$  depend on the degree of the molecules order and the interaction forces between them.

The change of value  $c_p/c_v$  of NLC depending on pressure up to 200 MPa was studied for the first time.

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