

# An overview of Ukrainian thermophysics research (1926 to 2022)

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## Abstract

We provide an overview of Ukrainian thermophysical research, its historical part and current state. The overview is supplemented by a database indexing thermophysical properties for molecular systems and alloys, as well as lists of scientific journals and research centers.

## Introduction

Science is international, but each nation makes its unique contribution, and each contribution deserves appreciation. The world's attention is currently attracted to Ukraine, including attention from academic and research communities [1]. Ukrainian science is surviving one of its hardest times now. We want to show its historic contribution to thermophysics and recent developments, and we hope better times will come soon allowing the resumption and expansion of that research activity, as well as wide international collaboration.

No strict definition of the term ‘thermophysics’ is known to us. We define the scope of our overview as thermodynamic (derived from PVT<sub>x</sub> relations and heat capacity) and transport properties of substances and materials, which is close to the scope of the International Journal of Thermophysics, with the focus on experimental works. As strict boundaries between thermophysics and other sciences cannot be defined, the overview includes a limited amount of closely related thermochemical data (e.g., those related to chemical reactions), properties of separate molecules, mechanical, and electrical properties. The database covers property data within the scope of the two databases maintained by the Thermodynamics Research Center (TRC) at National Institute of Standards and Technology (NIST), the SOURCE database for pure chemical compounds, binary, and ternary mixtures [2], and the publicly available alloys database [3]. It should be noted that an overview of Ukrainian research on liquid crystals [4] has recently been published.

We collected the information for our overview starting from our knowledge of Ukrainian research centers and researchers, as well as Ukrainian publications registered in TRC databases [2, 3], and continued with a cascading search for additional publications by those authors and their colleagues from the same institutions. In addition, we explored Ukrainian organizations in other databases [5, 6]. We also received help from our colleagues who are in Ukraine now, but

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the war made it impossible to reach everyone we wanted. We believe our collection is comprehensive in the scope of the TRC databases [2, 3] and representative of Ukrainian thermophysical research because the seed of our cascading search involved all major contributors. In addition, the data collection (Supplement A) related to this overview, supported by Web resources (as described below), may continue growing in the future.

Our overview covers two periods of Ukrainian history, its USSR period followed by independent Ukraine. We do not separate the two parts since many researchers continued their activities through the time of changes, and the democratic changes, which made Ukrainian science more open to the international community, happened gradually.

Beyond revealing Ukrainian contributions to thermophysics and potential collaboration opportunities, the data collection supplementing this overview can be valuable as a part of a more global data collection allowing interested users to search property data for specified substances or materials. That can be made possible in the context of the public data domain being constructed at TRC [7]. It should be noted that preserving research results for future applications is a serious problem not addressed yet despite continuing efforts [8]. Discovery of the data of interest, accessing historical publications, as well as interpretation of the published data is labor-intensive, error-prone, and may not guarantee sufficient coverage. Making published property data discoverable and available requires significant efforts, and we hope to facilitate it by development of appropriate tools and practices.

## **History and geography**

Our search is conducted using available databases as discussed below. It therefore reflects the presence of relevant records in those databases and does not include, for example, early eminent research in Ukraine's research centers dating back to 18th century (Lviv University was founded in 1773). The oldest document in the SOURCE database [2] with Ukrainian origin [9] is dedicated to the solubility of salts in alcohols and was published in 1925, shortly after a devastating civil war initiated by the collapse of the Russian empire, and has come from Ekaterinoslav (now the city of Dnipro). Similar research, probably not related to that initial report, continued in other Ukrainian laboratories in Kharkiv and Lviv (e.g., [10]). It should be noted that the problem of accurate determination of salt solubilities in organic solvents still exists, and further research is needed. The available solubility data reported by different laboratories worldwide differ by orders of magnitude, which may be caused by difficulties in the accurate determination of small concentrations and the strong influence of uncontrolled moisture. The scientific reports published after 1925 available are more abundant and diverse. 2,205 publications have been collected for this review (Supplement A in the extended RIS [11] format). The numerical data from over 400 of them are available from the TRC Source database [2] and over 40 from the TRC alloys database [3]. The content of the rest has been indexed within the scope of those databases (Supplement A). Indexing information along with identification of one originating institution for each publication is included as an extension of the generic formats in Supplement A. Over 300 articles have been published in different journals of Springer Nature, including 15 in the Int. J. Thermophys. Search in that collection will be available within the context of the TRC public data domain [12]. The distribution of the collected

documents by year of publication is shown in Figure 1. Most of the reports in our possession came from the cities of Lviv, Kyiv, Kharkiv, Odessa, and Donetsk (Figure 2). Many other cities shown in Figure 2 have also contributed to thermophysical research. Resources and publications with more detailed information exist, such as the overview of physical research in Kharkiv [13] and those mentioned in Table 1.

Research centers, which produced the reports available to us, are listed in Table 1 along with the number of reports in the scope of the TRC databases [2, 3] originated there. That table also gives names of prominent researchers associated with those centers.

Most contributions summarized here came from Lviv (2 institutions, 871 references), Kyiv (3 institutions, 427 references), Kharkiv (3 institutions, 441 references), and Odessa (3 institutions, 199 references). A remarkable contribution came from Donbas region (2 institutions, 181 references), but there is an ambiguity associating them with cities because those institutions are currently in exile from the temporarily occupied original city of Donetsk.

## **Research centers and activities**

As mentioned, we focused on the thermophysics of molecular substances, mixtures, and alloys. An advanced data search and analysis within the collected publications can be made using Supplement A and the data resources of the TRC Web site [12]. Major research projects in the indicated scope are the following.

Two institutes from Kharkiv (Verkin Institute of Low Temperature Physics & Engineering and Institute of Physics & Technology) studied low-temperature (down to the liquid helium region) thermodynamic and transport properties of hydrogen and of helium, as well as other small molecules and their mixtures.

Odessa National University of Technology (a merger of Odessa National Academy of Food Technologies and Odessa State Academy of Refrigeration) remains actively involved in experimental and theoretical work on thermophysical properties of refrigerants, refrigerant/lubricant systems, and heat transfer fluids. New research programs were developed to study nanofluids and materials for the sustainable economy (Zhelezny, Geller, Mazur, Artemenko, Lydia Yakub). Theoretical research is done in Odessa I.I.Mechnikov National University (Rogankov) and Odessa National Economic University (Eugene Yakub).

A research group at Lviv Polytechnic (Van-Chin-Syan, Dibrivny, et al.) studied thermodynamic and thermochemical properties of organic peroxides and boroorganic compounds since 1970. Recent research involved thermodynamic of organic and elementoorganic compounds and their mixtures.

A group from Karazin Kharkiv National University (Kalugin, Lebed, et al.) studied properties of electrolytes, and recently ionic liquids and their mixtures. The School of Physics and Technology at that University was founded by the Nobel Prize Laureate Lev Landau.

Donetsk National Technical University, presently in exile in Pokorvsk, has a record of thermodynamic research on organic compounds and mixtures (Yarym-Agaev, Matvienko).

A Thermodynamic Center, which was involved in petrochemical research, the development of prediction methods, and the production of reference data (Soldatenko, Ovcharenko, Dregulyas, Stavytsev) operated in Kyiv.

The most productive (based on the number of collected publications) research group in the alloys area is probably that from Lviv Ivan Franko University (Romaka, Plevachuk, et al.). Their research included thermodynamics of alloy formation in different states, structure, mechanical, and electrical properties.

Other similar groups are active at Taras Shevchenko (Kanibolotsky) and Donbas Polytechnic (now in exile in Kramatorsk; Turchanin, Dreval, et al.).

Several scientific journals dedicated to thermophysics or more common areas such as physics and chemistry have been and are published in Ukraine (Table 2). Most of them provide free Web access to the contents and have supported English recent years, removing language barriers for readers.

Ukrainian researchers hosted several international scientific conferences. Some of them are listed in Table 3.

Ukrainian Phase Diagrams and Thermodynamics Commission is a member of the international scientific organization Alloy Phase Diagram International Commission (APDIC) [14].

A repository of historical research reports exists in Cherkassy [15].

## **Conclusions**

The overview demonstrates a rich heritage of Ukrainian thermophysics and its current high potential, as well as opportunities for collaboration on different subjects. The accompanying data resource may be a useful source of information and also a collaboration tool in the future. We believe Ukrainian science will survive its darkest hours caused by the brutal aggression, and the future will be mutual respect and collaboration of all nations for the common progress.

## **Declarations**

### **Competing interests**

No competing interests are declared.

### **Authors' contributions**

V Diky initiated the project, performed research, and wrote the paper.

R Zakusylo: covered Kharkiv region and provided related resources and links.

K Trachenko: participated in the discussion and edited the text.

### **Funding**

Not applicable.

### **Availability of data and materials**

The data are available as supplementary materials in the plain text form.

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Table 1. Research centers<sup>5</sup>.

Institution	Location	Areas of research	Researchers	Publications	References
Ivan Franko National University <a href="https://lnu.edu.ua/en/">https://lnu.edu.ua/en/</a>	Lviv	Alloys	Yu. Plevachuk A. Kovalchuk	631	
B. Verkin Institute of Low Temperature Physics & Engineering of the National Academy of Sciences of Ukraine <a href="https://www.ilt.kharkov.ua/">https://www.ilt.kharkov.ua/</a>	Kharkiv	Low temperatures	V. Manzhelii B. Eselson N. Berezhnyak	218	
Lviv Polytechnic National University <a href="https://lpnu.ua/en">https://lpnu.ua/en</a>	Lviv	Organic; alloys	Yu. Van-Chin-Syan (Wang, Ching Hsiang) V. Dibrivnyi V. Serheyev I. Sobechko V. Kochubei N. Kachurina	240	
Frantsevich Institute for Problems of Materials Science, National Academy of Sciences of Ukraine <a href="http://www.materials.kiev.ua/science2.0/index.jsp">http://www.materials.kiev.ua/science2.0/index.jsp</a>	Kyiv	Alloys		202	
Kyiv National Taras Shevchenko University <a href="http://www.univ.kiev.ua/en/">http://www.univ.kiev.ua/en/</a>	Kyiv	Alloys	D. Kanibolotsky	205	
Odessa National University of Technology (Est. 1902) <a href="https://www.ontu.edu.ua/">https://www.ontu.edu.ua/</a>	Odessa	Refrigerants, Hydrocarbons, Heat transfer Fluids, Nanofluids	<a href="#">Y. Kazavchynsky</a> V. Geller V. Zhelezny V. Mazur O. Rogankov S. Artemenko L. Yakub	154	<a href="#">Department of Ecoenergy, Thermodynamics and Applied Ecology;</a> <a href="#">Department of Oil and Gas Technologies, Engineering and</a>

<sup>5</sup> The content of the Web links can be instantly translated to English by browsers such as Google Chrome.

					<a href="#">Power Engineering</a>
Kharkiv Institute of Physics & Technology of the National Academy of Sciences of Ukraine <a href="https://www.kipt.kharkov.ua/en.html">https://www.kipt.kharkov.ua/en.html</a>	Kharkiv	Low temperatures	N. Rudenko V. Slyusar V. Konareva Yu. Blagoi N. Berezhnyak	112	
V. N. Karazin Kharkiv National University <a href="https://karazin.ua/en/">https://karazin.ua/en/</a>	Kharkiv	Nuclear physics, Plasma, Electrolytes	O. Kalugin N. Mchedlov- Pertosyan A.Riabchunova	111	<a href="#">School of Physics and Technology of University of Kharkiv</a>
Donbass State Engineering Academy <a href="http://eng.dgma.donetsk.ua/">http://eng.dgma.donetsk.ua/</a>	In exile in Kramatorsk	Alloys	M. Turchanin L. Dreval	105	
Donetsk National Technical University <a href="https://donntu.edu.ua/en/donetsk-national-technical-university">https://donntu.edu.ua/en/donetsk-national-technical-university</a>	In exile in Pokrovsk	Organics	N. Yarym- Agaev V. Matvienko	76	
Odessa National Maritime University <a href="https://onmu.odessa.ua/en/home-en-gb/">https://onmu.odessa.ua/en/home-en-gb/</a>	Odessa	Refrigerants, Corrosion	<a href="#">O. Vasserman</a> V. Tsymarny	33	
Thermodynamic Center	Kyiv	Petroleum and organic compounds	Yu. Soldatenko E. Dregulyas A. Stavtsev	20	
Ukrainian State University of Chemical Engineering <a href="https://udhtu.edu.ua/en/">https://udhtu.edu.ua/en/</a>	Dnipro			4	
Poltava National Pedagogical University <a href="http://pnpu.edu.ua/">http://pnpu.edu.ua/</a>	Poltava			4	
Physico-Technological Institute of Metals and Alloys, N.A.S of Ukraine	Kyiv	Alloys			
National Technical University – Kharkiv Polytechnic Institute <a href="https://www.kpi.kharkov.ua/eng/">https://www.kpi.kharkov.ua/eng/</a>	Kharkiv	Alloys			
Odessa National University of Economics <a href="http://oneu.edu.ua/en/">http://oneu.edu.ua/en/</a>	Odessa	Theoretical research	E. Yakub		
Institute of Superhard Materials, N.A.S of Ukraine <a href="http://www.ism.kiev.ua/index.php">http://www.ism.kiev.ua/index.php</a>	Kyiv	Superhard materials	Lisovsky, A. F. Turkevich, V. Z		

			Maistrenko, A. L. Pashchenko, E. A.		
Shostka Institute of Sumy State University <a href="https://shinst.sumdu.edu.ua/">https://shinst.sumdu.edu.ua/</a>	Shostka	Thermodynamics of explosives	Lukashev, V. K.		
Sikorsky Kyiv Polytechnic University <a href="https://kpi.ua/en">https://kpi.ua/en</a>	Kyiv				
E. O. Paton Electric Welding Institute, NAS of Ukraine <a href="https://paton.kiev.ua/en/">https://paton.kiev.ua/en/</a>	Kyiv	Alloys			
Odessa Polytechnic National University <a href="https://op.edu.ua/en">https://op.edu.ua/en</a>	Odessa				

Table 2. Ukrainian journals related to thermophysics

Journal	Articles <sup>a</sup>
Powder Metallurgy and Metal Ceramics - Frantsevich Institute for Problems of Materials Science, National Academy of Sciences of Ukraine, Kyiv, Ukraine <a href="https://www.springer.com/journal/11106/editors">https://www.springer.com/journal/11106/editors</a>	153
Ukrainian Journal of Physics ISSN 2071-0186 <a href="https://ujp.bitp.kiev.ua/index.php/ujp">https://ujp.bitp.kiev.ua/index.php/ujp</a>	101
Ukrainian Chemistry Journal <a href="https://ucj.org.ua/index.php/journal">https://ucj.org.ua/index.php/journal</a>	88
Low Temperature Physics - published by the B. Verkin Institute for Low Temperature Physics and Engineering of the National Academy of Sciences of Ukraine ISSN 0132-6414 <a href="https://fnt.ilt.kharkov.ua/">https://fnt.ilt.kharkov.ua/</a>	28
Chemistry & Chemical Technology - Lviv Polytechnic National University <a href="http://science2016.lp.edu.ua/chcht">http://science2016.lp.edu.ua/chcht</a>	15
Visnyk Lviv. Univ. (Scientific Bulletin of the Lviv University, Series Chemistry) <a href="http://prima.lnu.edu.ua/faculty/Chem/visnykk/">http://prima.lnu.edu.ua/faculty/Chem/visnykk/</a>	6



Pharmaceutical Journal <a href="https://pharmj.org.ua/index.php/journal">https://pharmj.org.ua/index.php/journal</a>	4
Nanosistemi, Nanomateriali, Nanotekhnologii - Kurdyumov Institute of Metallophysics of the National Academy of Sciences of Ukraine <a href="http://www.imp.kiev.ua/nanosys/">http://www.imp.kiev.ua/nanosys/</a>	2
Functional Materials - National Academy of Sciences of Ukraine, Institute for Single Crystals <a href="http://www.isc.kharkov.com/journal/">http://www.isc.kharkov.com/journal/</a>	1
Casting processes <a href="https://plit-periodical.com.ua/">https://plit-periodical.com.ua/</a>	
French-Ukrainian Journal of Chemistry - published by Taras Shevchenko National University of Kyiv <a href="http://kyivtoulouse.univ.kiev.ua/journal/index.php/fruaic/issue/archive">http://kyivtoulouse.univ.kiev.ua/journal/index.php/fruaic/issue/archive</a>	
Issues of Chemistry and Chemical Technology - published bimonthly by the Ukrainian State University of Chemical Technology <a href="http://www.vhht.dp.ua/">http://www.vhht.dp.ua/</a>	
Journal of Physical Studies - Ivan Franko University <a href="http://physics.lnu.edu.ua/jps/index.html">http://physics.lnu.edu.ua/jps/index.html</a>	
Kharkiv University Bulletin. Chemical Series <a href="http://chembull.univer.kharkov.ua/">http://chembull.univer.kharkov.ua/</a>	
Metallofizika i Noveishie Tekhnologii (Metallophysics and Modern Technologies) <a href="https://mfint.imp.kiev.ua/en/index.html">https://mfint.imp.kiev.ua/en/index.html</a>	
Physics and Chemistry of Solid State - Vasyl Stefanyk Precarpathian National University <a href="https://journals.pnu.edu.ua/index.php/pcss/index">https://journals.pnu.edu.ua/index.php/pcss/index</a>	
Refrigeration Engineering and Technology (ISSN 0453-8307 / 2409-6792) <a href="https://reftech.onaft.edu.ua/uk/site/archives">https://reftech.onaft.edu.ua/uk/site/archives</a> <a href="http://journals.uran.ua/reftech/issue/archive">http://journals.uran.ua/reftech/issue/archive</a>	
Reports of the National Academy of Sciences of Ukraine <a href="https://dopovidi-nanu.org.ua/ojs/index.php/dp">https://dopovidi-nanu.org.ua/ojs/index.php/dp</a>	
Scientific Bulletin of the Uzhgorod University, Series Chemistry <a href="http://visnyk-khim.uzhnu.edu.ua/">http://visnyk-khim.uzhnu.edu.ua/</a>	
Superhard Materials - Institute of Superhard Materials <a href="http://www.ism.kiev.ua/stm/">http://www.ism.kiev.ua/stm/</a>	

<sup>a</sup>Missing numbers of articles mean we do not possess those in the scope of our present data collection (thermophysical properties of pure chemical compounds or their mixtures with specified compositions).

Table 3. Conferences

V International Scientific and Practical Conference "Chemical Technology: Science, Economics and Production", October 20-22, 2021 Shostka, Shostka Institute of SSU <a href="https://himtec.sumdu.edu.ua/arhiv2021g.html">https://himtec.sumdu.edu.ua/arhiv2021g.html</a>
7th International Conference "Physics of Liquid Matter: Modern Problems", Kyiv, Ukraine, May 27–31, 2016 <a href="https://link.springer.com/book/10.1007/978-3-319-61109-9">https://link.springer.com/book/10.1007/978-3-319-61109-9</a>
VIII International Conference on Crystal Chemistry of Intermetallic Compounds 25-28 September 2002, Lviv, Ukraine

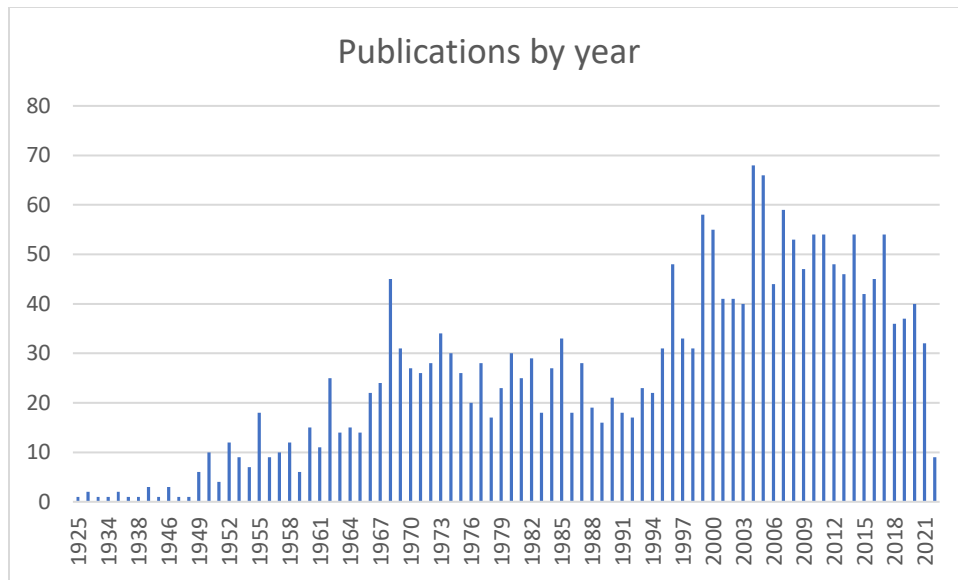


Figure 1. Distribution of the publications (Supplement A) by year



Figure 2. Major research cities on the map (with numbers of corresponding publications in Supplement A)

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<https://www.elsevier.com/connect/elsevier-condemns-russian-invasion-of-ukraine>  
Accessed 9/16/2022.
- Royal Society of Chemistry statement on the invasion of Ukraine  
<https://www.rsc.org/news-events/articles/2022/mar/rsc-ukraine-statement/>  
Accessed 9/16/2022.
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