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On the Creation of an International Terminological Database and Terminology of Materials Science and Chemistry in the Context of the Training of Chemistry Teachers

Pavel B. Shibaev* (a), Engel' R. Galimov (b),
El'mira E. Sharafutdinova (c), Ramilya S. Shajhetdinova (d)

(a), (b), (c) *Kazan National Research Technical University named after A.N. Tupolev, 420111, Kazan (Russia), 10 K. Marx street*

(d) *Kazan National Research Technological University, 420015, Kazan (Russia), 68 Karl Marx skiv22@ya.ru*

Abstract

The relevance of the study of this problem is due to the fact that the accuracy of concepts has always played an important role in cognition. The study of chemistry and materials science, like any other science and / or academic discipline, also needs to start with its terminology. In this regard, this article is aimed at studying the metalanguage of chemical disciplines and materials science in the context of bilingual training of chemistry teachers and materials scientists in the era of globalization, revealing the causes of problems and ways to solve them.

The leading methods in the study of this problem are theoretical methods, analysis and synthesis of the subject of research based on the study of literature on psycholinguistics, linguistics, pedagogy and chemical disciplines, linguistic text analysis, content analysis. As empirical methods used "linguistic experiment", observation, measurement and comparison.

The article revealed that at present a great deal of attention is paid to terminological activity, both theoretically and in practical terms, but there are no terminological databases on materials science containing a unified, structured and internationally approved terminology system for metalanguage of materials science.

The materials presented in the article allow us to propose an approach for the development of terminological databases of metalanguages of chemistry and materials science.

Keywords: metalanguage, terminological system, terminological database, chemistry, materials science, globalization.

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* Corresponding author. E-mail: skiv22@ya.ru

Introduction

The development of any science and / or academic discipline must begin with the study of its terminology.

It is important to distinguish between everyday or object language and the language of science or metalanguage. The object describes the world directly. The concepts of everyday language can be fuzzy and ambiguous. This means that only it cannot be used in the learning process. The metalanguage, on the contrary, is characterized by a certain degree of abstractness, is an exact language. A metalanguage is an artificial language specially developed, but contains elements of an ordinary language (Starzhinskij & Cepkalo, 2010).

The metalanguage describes and studies the properties of another language, which acts in relation to the first object of its study. It is built on the basis of the same language units as the language - object (Komarova, 2016).

A metalanguage is a complex formation, the “cornerstone” of which is its terminology or terminological system, which is a special semiological system used when it is necessary to study the object language (Gvishiani, 2005). The identification of metalanguage and terminology is erroneous, the latter is not just a list of terms, but a semiotic expression of a certain system of concepts that reflects a certain scientific worldview.

Purpose and objectives of the study

The purpose of the study is to reveal the relevance of the development of a unified international terminological database of metalanguages of chemistry and materials science, by revealing the role of metalanguage in the study of chemical disciplines, in the process of training chemistry teachers.

Literature review

The metalanguage is used in the metaspeech, i.e., in the speech that scientists use in communication (Gvishiani, 2005). From the above it follows that without a metalanguage it is impossible either to study any academic discipline or to carry out scientific work in any field of knowledge, including materials science, this is especially true in modern society, in the era of globalization, when a student can get an education at the bachelor's level in one country, and study for a master's course to go to another, which happens very often, and at the same time in the process of training he is faced with the fact that the professional knowledge and terminology that he studied in one country are different, in terms of his definitions, in another country, and he has to re-retrain, almost from scratch.

Mastering the “cornerstone” of metalanguage – scientific terminology – is of particular difficulty, since, as we have already indicated, terminology is one of the stylistic properties of scientific speech in general and disciplines in chemistry, in particular.

At the same time, the student in studying the disciplines of chemistry will have to understand three “systems” of the term: first, at the level of the terminological system, in order to know the exact meaning of the desired term, and secondly, at the level of the conceptual and terminological system that corresponds to the author’s interpretation term, which is often characteristic of the educational literature of various authors, and is often found in chemistry, chemical technology and materials science, thirdly, at the level of the textbook or other educational and scientific publications, i.e. environment for the existence of a term (Tabanakova, 2004).

Thus, a metalanguage is a second-order language, i.e. language learning and describing another language.

The metalanguage “as a definition of a concept” was first defined by the German mathematician Hilbert (1862-1943) in terms of metatheory.

In the history of philosophical teachings, the idea of metalanguage is already found in the Vedangas of the ancient Indian Brahmins, who created scientific treatises on the Vedic language and Sanskrit. Later, in the Arab Caliphate, Ancient Greece and Rome, the metalanguage finds ways of implementing the development of lexicography. The ancient linguistic philosophers, studying the sacred languages of the Vedas as the religious and moral foundations of society, actually created a metalanguage, that is, a language about language.

With the help of metalanguage, a metatheory is built. An example is methodology as a reflection of activity. The object of consideration of the metalanguage is not the objects themselves or substantive theories that describe them, but activity procedures, methods, values and meanings.

The term "metatheory" arose after the term "metaphysics", introduced by Andronicus of Rhodes, the librarian of the famous Alexandrian library of Ptolemy, as a designation of all that "after physics", where he placed the complex of natural science works of Aristotle.

But more often a more specific meaning is embedded in the term “metaphysics”, the same thing happens with the term “metalanguage”. That is, in the narrow sense, a metalanguage is not understood to be the whole language, but only its basic principles.

In a broad sense, a metalanguage can be qualified even as a certain style of thinking. It manifests itself in certain requirements for discourse: rigor, evidence, accuracy of the terminology used, cautious attitude to broad generalizations, preference for evidence, argumentation, logic.

The science of metalanguage is now becoming the most important sphere of application of human intelligence: with the help of metalanguage lexical corps as a whole, it becomes possible to throw bridges between different areas of knowledge, to establish links between them. The term (stable word-professionalism), that is, the "name of the phenomenon", often helps to penetrate into its very essence, sometimes to find completely unexpected intersections, to reveal its origin.

Thus, the definition of metalanguage established in modern science as a "second-order language", i.e. "Language about language", in principle, none of the researchers of this functional-semantic category of language realizations is not rejected.

Thus, in the study of metalanguage, it is not so much a matter of comprehending supernormal objects, but, first of all, of developing means of describing the language, methods of work in various areas of life.

In this sense, a metalanguage can be considered as part of a nationwide language, but having its own specifics. Unlike the natural language, which occurs spontaneously in the course of everyday communication, the metalanguage does not arise on its own: this requires conscious work - in particular, translation, decoding, interpretation, and word-making.

One day, the director of the House of Human Sciences in Paris, Maurice Emar, said that in a future Europe, which we all want prosperity, you cannot live without knowing the "professional" language, you will not become a professional in your field. "

In ancient Greece they said: "To express a thought more clearly means to really improve something in our unsteady life."

A metalanguage is really a product of the collective experience of creativity, and therefore there is a place for anyone who is able to consciously relate to what, how, to whom and why he speaks. The metalanguage plays a large role as an instrument of thought, a means of forming judgments, the heir to the centuries of scientific discoveries, accumulating knowledge. That is why the study of an object language (conceptual language) is relevant and topical. In this direction, the prospects of a more general topic are visible. We are talking about the relationship in the metalanguage of universal material science with the concrete and historical, the development of the metalanguage structure of material science, the definition of the role of

terms in metalanguage, etc. To master a metalanguage, you need powerful textual and conceptual work, codes of using concepts, inscriptions in the text, in the system of thoughts, that is, high professionalism.

A metalanguage takes various forms of expression, for example, a graphic form.

Even the ancient Greeks distinguished in the "idea" ("essence") of the visual and beloved sides. Those who follow the ancient tradition, offers to interpret visibility as a specific unity of feeling and reason, as a contemplative property of the mind, that is, "thinking vision of the essence" (according to Plato). Therefore, the visualization of knowledge is not its primitivization.

On the contrary, psychologists prove that a visual image as a product of visual thinking is "this is knowledge, corrected by action", therefore it is more preferable, because the information contained in it is easier to digest and more understandable.

That is why graphic articles are actively using graphic metalanguage, which can be easily seen by looking at several articles.

Typically, the concept of graphic metalanguage includes the most diverse types of visibility:

- letter symbolism (α , β , Δ);
- abbreviations, indices and formulas;
- and etc.

Especially widely graphic metalanguage is widespread in chemical educational disciplines and materials science, as a symbiotic science, consisting of chemistry, physics, mechanics and other sciences.

In the terminological system of any metalanguage, such elements as the term and concept can be distinguished. A term is a word. A concept is an invariant that is preserved during the transition from one language to another. The concept is absolutely impossible to express.

The development and functioning of a structured system of special terms and concepts is one of the indicators of the transition of scientific knowledge to a qualitatively new theoretical and methodological level, and "concepts acquire a fixed content and are included in the terminological system" (Koshkina, 2010). Chemistry has its own terminology.

The viability of a terminological system is determined, first of all, by its orderliness and the sequence of the ratio of content and expression. A terminological system that meets these requirements can grow out of the scientific direction that generated it and enter the modern metalanguage of this science (Shibaev et al., 2011).

Students and specialists studying various chemical disciplines, such as inorganic and organic chemistry, chemical technology, materials science, are increasingly faced with the phenomenon of ambiguity and synonymy of terms, their excessive length, the absence of popular terminological systems, which is especially common in the field of pedagogy.

It is ambiguity that is the most significant factor that impedes effective professional communication and understanding of the conceptual apparatus of a special field by students. If earlier ambiguity and synonymy were more often found in terms of the humanities and social sciences, today, in the natural sciences, this disadvantage, unacceptable for standardized terms, has become more common.

Methodology

Research methods: theoretical methods, analysis and synthesis of the subject of research based on the study of literature on psycholinguistics, linguistics, pedagogy and chemical disciplines, linguistic analysis of the text, content analysis. As empirical methods used "linguistic experiment", observation, measurement and comparison.

The problem of research. The paper investigates the metalanguage problems of chemical disciplines and materials science, in the context of the training of chemistry teachers, the reasons for their occurrence and ways to solve them.

Results

Let's look at the problem of ambiguity on the example of the term "competence". The solution to the problem of the ambiguity of the term may lie in the field of psycholinguistics, namely, in the semantics section. The concept of competence, and similar ones, are symbolic images. They do not carry a denotation of the really existing objects behind them, in contrast to a specific image, such as the concept of "steel", "material", "hardness" or any other term used in chemistry.

However, a number of concepts, such as, for example, "competence", "round square", or in chemistry - "polycrystalline single crystal", can have a designate, but not have a denotate.

Behind all attempts to determine the meaning of the word “competence” there are no concrete examples that could be used as a starting point, only indirect indications in the works of specific individuals who were engaged in research in this area. It is impossible to indicate competence, and in itself it does not exist, but only represents an interpersonal construct. The variety of definitions of competence is the result of the symbolic nature of a given concept (Angela et al., 2004).

It is much easier to come to an agreement in what to call “steel” or “cast iron” than in how to define “competence” or “love”.

Thus, the phenomenon of ambiguity and synonymy of terms for a particular science, including chemistry, is unacceptable due to the fact that they relate to real-life objects behind them. Therefore, it is unacceptable that the terms in chemistry be ambiguous. However, not all definitions are able to reveal the essence of the term by 100%. This leads to the fact that we observe in different educational and scientific publications the same terms that have different definitions, which are essentially true, but reveal the essence of the term only by 20 %, 50%, 70%, but not 100%. This gives rise to a problem for a student studying chemical disciplines to be able to master them “perfectly” and get a mark of “5” (the highest mark is 100, according to a point-rating system), for this he must master the terminology of this science. However, in order to accomplish this, i.e. in order to reveal all aspects of the term in chemistry or materials science and to understand its essence, 100% of students have to study dozens of different books and dictionaries, since none of them contain comprehensive information, or, as practice shows, they choose the easy way, and quite they don't try to master the terminology system in chemistry and materials science, as it requires, from their point of view, too much effort, and teachers often turn a blind eye to this.

In everyday life, we use ambiguous terms, correctly understanding their meanings from the context and due to the emotional coloring. Scientists need precision and clarity. Words used in science must have emotionally expressive neutrality and consistency (Slozhenikina, 2010). Such words are commonly called terms. A term is a word or phrase that precisely and unambiguously names a concept, and its relationship with other concepts within a special sphere. According to the Grinev (1993) and Lejchik (2006): “Terminologies and terms, as their constituent parts, are a tool with which scientific theories, laws, principles and regulations are formed”. The deep attribute of the terms allows you to separate them from other units of the language and to dismember the whole set of terms. This deep feature of terms is their designation of general concepts. Since there are several types of general concepts, different types of terms can be identified.

The terms of categories, general scientific and general technical terms, intersectoral terms, special terms are distinguished.

The terms are distinguished by the correspondence of its name and the resulting association with the object of the term:

- Orienting - the meaning of the term is clear from its name (for example, the terms deformation, detail, sharpening, melting, coating, fracture);
- Neutral - the meaning of the term is not clear from its name and requires explanation (anisotropy, allotropy, austenite, segregation, ligatures, solidus, liquidus, martensite);
- Disorient - the meaning of the term does not correspond to its name (cell, vacancy, grain, rest, vacation, mustache) (Lejchik, 2006).

The term should be meaningful and appropriate to the subject or phenomenon that it describes. If a certain concept can be defined, but it is not known how the described object appears in the real world, then such a concept is meaningless. In scientific terminology, you can go along the chain to determine the phenomenon you need through other terms, that is, each term can include either unambiguous definitions, or another term, the definition of which is unambiguous. If it is impossible to build such a chain, then the word in question is not a scientific term, and the statement containing it is not related to science. So, by the way, it is easy to determine whether we are talking about science or pseudoscience. The requirement to use only terms is a direct result of the desire for clarity. If you need to introduce a new concept, then you must first give its definition, and then use it. It is important that this definition includes previously known concepts, the only way to achieve clarity.

Characteristics are described in definitions using other terms, therefore, to understand this term, you need to know not only its definition, but also the definitions of the terms used in its definition. "Drawing - cold plastic deformation, in which the preform is pulled through a hole of a certain shape with dimensions smaller than the original dimensions of the preform." "Cold deformation - occurs at temperatures below the recrystallization temperature, is characterized by a change in shape, hardening of the metal and a change in physicochemical and mechanical properties." "Metal recrystallization is the process of nucleation and growth of new grains in the volume of a deformed metal, which most often acquire equiaxial shape." "Grain is a part of the structure of a metal or alloy having a certain direction in the formation of a crystal lattice." "A crystal lattice is a kind of imaginary spatial network in the nodes of which ions or molecules of matter are located" (Os'kin et al., 2007). Obviously, in order to understand what dragging is, it is necessary to know not only the first definition, but also all subsequent ones. Definition should only be given in terms. It is unacceptable to use the concepts of natural language in it, because they are always vague. Here there is one contradiction. Since the definition always uses terms that, in turn, must also be defined,

regressus ad infinitum (endless descent) arises, in order to avoid which we have to leave some basic concepts without definitions (the so-called undetectable concepts), introducing them nevertheless through life experience, by showing.

It should be borne in mind that, with the exception of mathematics, which is, in fact, the universal language of formalizing the phenomena of nature, all other sciences are engaged in describing nature and the definition of the term in them always has a certain set of material objects or interactions. This is a very important point. A definition has a purely service function – it defines many objects and interactions. The definition must be known so that when pronouncing the term it is clear that it is what is being discussed. But the main thing nevertheless is to imagine the material reality that is behind this term.

Science seeks clarity by using terminology. If a term is not defined in this science, then you cannot use it. But nothing prevents first from defining, and then using the new term thus obtained. Thanks to this, scientific terminology does not stand still, but develops along with science.

It is very important to realize that when we talk about science, we do not use the words of a natural language, but scientific terms, and we must understand them in the context of this science, even if these terms sound like words in a common language. We give examples that most vividly reflect this phenomenon. In material science, the term vacancy is used, which in the context of this science means a point defect in the crystal lattice, in which there are no ions in the lattice sites. In everyday life, the term vacancy means a free position in an institution, so a person who does not encounter material science in everyday life may not understand what is being discussed.

Not many material scientists, authors of scientific works and textbooks, recognize the special role of terms in the functioning and development of materials science as a science. In addition, many underestimate their importance in organizing the educational process in higher education. Only in some textbooks and methodological literature does the proper place be given to the terminology of materials science (Rzhevskaya, 2006; Sirotkin, 2007). A differentiated approach to the language of scientific and technical works, taking into account the macrostructure of the text, is especially important when analyzing texts on materials science, since they contain special vocabulary from different thematic groups. At the same time, this vocabulary does not form a certain continuous terminological flow, but is distributed precisely depending on the types of macrostructure of the text. For example, in books on materials science, some terms are used to describe the crystal structure of metals, while others are used to describe the structure of polymers. Its distribution of terms depending on the structure of the text even appears within individual topics of the discipline. So, in materials science, when describing the process of crystallization of a metal,

the terms of physics (free energy, entropy, metastable, amorphous), chemistry (chemical bond, metal bond), crystallography (unit cell, crystal lattice, syngonium) etc. prevail first, and then its own, special terminology is used – a mold, a shrink shell, etc.

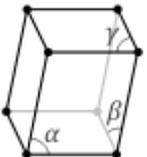
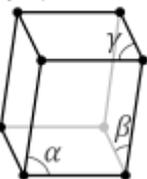
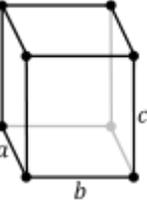
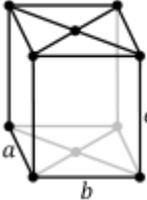
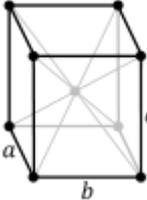
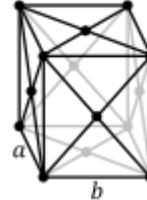
For students who are just starting to learn a new subject or science, terms play an important role. They help students accelerate the process of understanding the essence of the subject. The correct and clear understanding of the definition of each term is especially important. And since in the absence of an unambiguous definition, an intuitive exchange of one concept by another, more familiar, students can easily get confused in the meaning of the terms. Therefore, it is extremely important for teachers and authors of methodological and reference literature to give correct, reliable meanings, to explain a dual understanding of certain terms, for example, syngony, which arose due to historical circumstances. Only with this approach to the study of the discipline of materials science is it possible for students to more fully and correctly understand it.

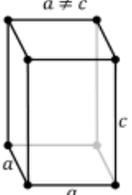
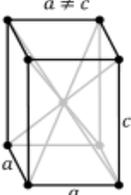
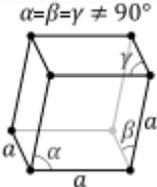
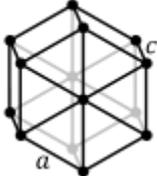
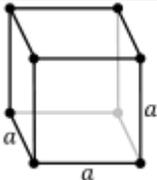
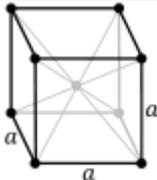
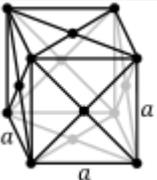
Also, for the sake of simplicity, important textbooks often omit important determinants of the behavior of the described object, if these determinants require some effort of intelligence from the reader for their understanding. In this case, the text becomes at first glance simple to understand, but at the same time, it is often impossible to understand from this text why the object behaves this way and not otherwise, which is found in a number of books (Rzhevskaya, 2006). This situation occurs when clarity is impeded by incomplete statements. It is necessary to strive precisely for clarity, because a clear but complex text will be understood even by those who have sufficient intelligence for this, while a simple but obscure text, by definition, cannot be understood.

For a correct understanding of the scientific term, clarity and simplicity of definition are necessary. The simplicity of the term does not mean its comprehensibility and clarity for all. Often, in order to achieve clarity, it is necessary to give a complete and unambiguous description of the facts and conditions that determine this phenomenon. The requirement of uniqueness is that each word in the description should have one and only one meaning, and the definition as a whole should be interpreted in one and only one way. The authors of textbooks on materials science have a different understanding of the meaning of terms, which leads to the fact that a single term has several definitions, in which the essence of the term is often lost. As an example, we give the definition of one of the terms of material science – syngony. One of the authors gives this definition: “Syngonia” (crystal system) is a classification attribute of the symmetry of a unit cell of a crystal, characterized by the relationships between its parameters ”(Rzhevskaya, 2006). “Syngonia (crystal family) is one of the divisions of crystals according to the shape of their unit cell” (McMahon, 2006; Laves, 1966; Trotter et al., 1976; Wondratschek et al., 1971). In Russian specialized

literature there is a confusion of two concepts – syngony (crystal family) and crystalline or crystallographic system (crystal system), both of these terms are found in Russian educational literature on materials science, which are often used as synonyms. The partition into crystalline systems is performed depending on the set of symmetry elements describing the crystal. Such a division leads to seven crystalline systems, two of which – trigonal (with one axis of the 3rd order) and hexagonal (with one axis of the 6th order) - have the same unit cell in shape and therefore belong to the same hexagonal syngony. And in foreign literature, these two concepts are clearly distinguished: 6 syngonies and 7 crystalline systems are distinguished for three dimensions, as can be seen from Table 1 (McMahon, 2006; Laves, 1966; Trotter et al., 1976; Wondratschek et al., 1971).

Table 1. Types of syngonias and crystalline systems for three dimensions.

Syngonia (crystal family)	Crystalline (crystallographic) system (crystal system)	Lattice Bravais			
		Simple	Base-centered	Volume-centered	Face-centered
Triclinic	Triclinic (parallelepiped) $a \neq b \neq c; \alpha \neq \beta \neq \gamma$ $K_2Cr_2O_7$	$\alpha, \beta, \gamma \neq 90^\circ$ 			
Monoclinic	Monoclinic (correct prism with parallelogram at the base) $a \neq b \neq c; \alpha = \gamma = 90^\circ \neq \beta$ S_b	$\alpha \neq 90^\circ$ $\beta, \gamma = 90^\circ$ 	$\alpha \neq 90^\circ$ $\beta, \gamma = 90^\circ$ 		
Rhombic	Rhombic (orthorhombic) (rhombohedral) $a \neq b \neq c; \alpha = \beta = \gamma = 90^\circ$ Fe_3C, S_a	$a \neq b \neq c$ 	$a \neq b \neq c$ 	$a \neq b \neq c$ 	$a \neq b \neq c$ 

<p>Tetragonal</p>	<p>Tetragonal (straight box) $a = b \neq c; \alpha = \beta = \gamma = 90^\circ$ $\text{TiO}_2, \text{Sn}_b$</p>				
<p>Hexagonal</p>	<p>Trigonal (rhombohedral) (equilateral rhombohedron As, Bi) $a = b = c; \alpha = \beta = \gamma < 120^\circ, \neq 90^\circ$</p>				
	<p>Hexagonal (prism with hexagon base) $a = b \neq c; \alpha = \beta = 90^\circ; \gamma = 120^\circ$ Zn, Cd</p>				
<p>Cubic</p>	<p>Cubic (correct cube) $a = b = c; \alpha = \beta = \gamma = 90^\circ$ Cu, Fe, NaCl</p>				

Also, when translating into Russian from foreign languages, the meaning of the concept may be distorted. But since science is one, regardless of language, the meaning of terms should not change. Here are examples of the recording of the terms ledeburite and perlite in Russian, English, German, Italian, Spanish and French, table 2.:

Table 2. Examples of recording terms are ledeburite and perlite in Russian, English, German, Italian, Spanish and French.

Language	Term	
Russian	Ледебурит	Перлит
English	Ledeburite	Pearlite
German	Ledeburit	Perlit
Italian	Ledeburite	Perlite
Spanish	Ledeburita	Perlita
French	Lédéburite	Perlite

Discussions

Of course, at present, there are several dozens of large terminological databases (LDS). In Russia there is a bank of standardized terms in standardization bodies, for example, at the All-Russian Research Institute of Classification, Terminology and Information on Standardization and Quality (VNIKI), etc. At VNIKI terminological dictionaries are based on the Russian Terminology database, it contains more than 140 thousand terminological articles from GOST, GOST R, ISO and IEC standards . The cost of the ROSTERM database is 300,000 rubles. In addition, the most relevant terms from the dictionaries of the Committee of Scientific Terminology in the field of basic sciences and from the thematic dictionaries of domestic and international scientific societies and associations have been introduced into the ROSTERM

database. However, in VNIKI there are no terminological dictionaries for materials science, and the existing dictionary for metallurgy, at the time of writing, costs 10,170.00 rubles, for mechanical engineering – 21,360.00 rubles, which makes them inaccessible for acquisition by university students, with an average scholarship in the Russian Federation 2000 rubles. per month (Russian Scientific and Technical Center for Information on Standardization, Metrology and Conformity Assessment , 2020).

All of the above allows us to conclude that at present a great deal of attention is paid to terminological activity throughout the world, both theoretically and in practical terms. This is due to the fact that scientists and industrialists have realized the fact that the success of their scientific, technical, commercial and economic activities largely depends on rational, accurate, well-developed terminology. Despite all the variety of LTDs presented in the world, the authors have not found more than one LTD in materials science, which contains a unified, internationally approved, structured and available in free public access, terminology metalanguage of materials science.

In this regard, there is a need to create a unified, structured, terminology system for the metalanguage of materials science, in the form of a LTD or a glossary of terms on materials science, which will contain several definitions for one term from various sources, if necessary, and thereby reveal the essence and specificity of the term by 100 %

Conclusion

Thus, at present, much attention is paid to the expansion of terminological activity, both theoretically and in practical terms. This is due to the fact that scientists and industrialists have realized the fact that the success of their scientific, technical, commercial and economic activities largely depends on rational, accurate, well-developed terminology. Despite all the variety of LTDs presented in the world, there is no LTD for materials science, which contains a unified, structured and internationally approved, available in free free access, terminology metalanguage of materials science.

In this regard, we believe that it is imperative to create a free, unified, structured, terminology metalanguage of materials science, in the form of a LTD and / or glossary of terms, which will contain several definitions for one term, from various sources, if necessary, and thereby disclose the essence and specificity of the term is 100%, which will solve the pool of problems that exist today in the metalanguage of materials science.

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