The Phenomenon of Life in the Eyes of a Chemist: Addy Pross

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Introduction: a short (pre)history of trying to understand the nature of life

The phenomenon of life has attracted the attention of naturalists from time immemorial [1, 3][1]. Over the centuries, attempts to know its essence and give accurate and complete definition were taken repeatedly [2]. Because life, as a biological phenomenon, is unique and, undoubtedly the most complex phenomenon of nature, a precise definition has turned out to be an extremely difficult task [3, 4][2]. This variety of content of the animated being has made scholars of different centuries attempt to answer the question: what is life? [5] In the 17th, 18th and 19th centuries, heated dispute was taking place between representatives of the two opposing positions: "mechanistic" and "vitalistic" [6]. The 20th century took over the dispute as a legacy of the previous centuries [7]. The mechanists denied the existence of any intentional causality, both in the inanimate and animate spheres of nature [8]. For them, living organisms were nothing but complex machines or highly complex physical and chemical systems [9]. At the other extreme position, there were the vitalists. They claimed that life was caused by a special life force that was significantly different from dead matter [1, 4]. At the same time, they made attempts to determine the nature, characteristics and functioning of this specific factor in life [7].

Since the end of the 1930s, a growing interest in living organisms and biological issues has been noted among physicists [6]. Earlier, from the 17th century, many eminent physicists showed a clear lack of understanding of both the biological methods and problems. Among the well-known physicists interested in biology and its relationship to physics, there were, e.g. Niels Bohr and Erwin Schrödinger. They took the position alternative both to vitalism and mechanism. Their views on biology can be considered both anti-vitalist and anti-mechanistic.

Niels Bohr did not see an opportunity to explain life on the basis of physical laws [10, 11]. He included life in the category of primitive concepts, just like quantum operation in quantum mechanics. In his speeches, seminars he organized, and numerous publications about biological issues, this outstanding physicist inspired some young physicists to address the problems of life sciences [6]. One of them was a German physicist Max Delbrück who, mainly due to Bohr's influence, turned into an experimental biologist, conducting pioneering research on the induction of mutations by the action of X-rays.

On the other hand, Erwin Schrödinger, co-creator of wave mechanics, in his book *What is Life*, dedicated to biological problems, formulated general laws of thermodynamics of life processes and found it fully possible to completely explain the phenomena of life on the basis of the laws of physics [10]. In his published work, he also drew attention to a number of issues, whose detailed explanation was only provided a by molecular biology. The change of interests of the co-founder of the quantum theory was significant and drew the attention of many physicists [12]. Under the influence of Schrödinger's book, many physicists were interested in biological issues, and some, e.g. Arthur Kornberg and Francis Crick, even began carrying their own fruitful biological research [6].

A modern scholar, who, inspired by the Schrödingers' book, focuses his research on the nature of life, is a professor of chemistry at the Ben-Gurion University in Beer Sheva, Addy Pross. According to this scientist, finding a specific answer to the question in the title of the book by E. Schrödinger is not to be underestimated, as shall it let us find out not only who we really are, but also to better understand the universe as a whole [13]. He notes that although since the publication of the work by the Austrian physicist sixty-five years passed, despite the huge advances in molecular biology, documented by a long list of Nobel Prize winners, we still have not found any answers to the simple question posed by Schrödinger. The Israeli scholar again tries to answer this fundamental question posed years ago by the Austrian Nobel Prize winner. He is of the opinion that we shall never understand what life is until we can solve the paradox concerning its inception. To understand this paradox and, consequently, the very phenomenon of life, one does not refer to physics or even biology, but to chemistry, the science that bridges the gap between physics and biology [14]. Pross' aim is to show that the answers to some of the key questions relating to life, including the classic question raised by Schrödinger, finally became available. In this article, we will briefly present the views of this Israeli chemist on the nature of life.

Modern biology and the nature of life

Pross reveals the difficulties faced by modern biology, in order to understand the nature of life. It is about two fundamental questions that this science cannot fully answer: *what is life*? and of *how did life originate*? [13, 15] Although these questions seem to be a seemingly independent, they are inextricably bound. To be able to answer one of these questions, you should in advance know the answer to the second. We do not know what life is, because we do not understand the laws that had led to its appearance. Thus, despite the spectacular advances in molecular biology made in the last sixty years, the essence of what biology studies have remained unclear.

Pross, as an astute researcher, looks for the causes of the crisis modern biology has been facing [13]. It has walked a hard road from Darwin to modern biology. Darwin's monumental achievement was to bring biology from the world of the supernatural to the natural world. Darwin irreversibly changed, our perception of ourselves and the world around us. However, this was not without problems. Nearly eighty years had to pass since the publication of *The Origin of Species*, when Darwin's theory was finally included in the framework of what we call the modern evolutionary synthesis in the 1930s. This was due to the integration of Darwin's theory of evolution with Mendel's theory of population genetics.

However, another revolution was approaching – the revolution in molecular biology. It was a half-century of dramatic discoveries, from the structural explanation of DNA in 1953, to the discovery

[1] The fact that Aristotle already took up these issue proves that they have been occupying scientists since ancient times.

[2] Some of current authors, for example J. Chmurzyński, who are aware of difficulties accompanying each attempt to provide a precise and exhaustive definition of life, use the term 'life' instead of an adjective 'alive'. As a result, they are of the opinion that it is enough to define the term 'alive' or 'living' ('alive' means is somebody that can be described by features enumerated in the definition of a living body) to answer the question: "What is life?" [4].

of DNA replication, RNA transcription, protein translation, to the explanation of the plan of the entire human genome sequence. The "biologists dream" to explore the nature of life seemed to be coming true. The solution to greatest puzzle of biology seemed to be at hand.

It quickly became clear, however, that biologists' hope for the final understanding of the nature of life was definitely premature. Life turned out to be more complicated than its manifestation in the form of the three billion letters that make up the human genome. The gap between the knowledge of the human genome sequence and the understanding of the meaning of this sequence turned out to be huge. Discovering the increasingly structured and mechanistic information on the living cell has not explained what life really is.

So what is the problem? For Pross, the answer is obvious: the cause of all the problems is the organizational complexity of what we call life.

Systems chemistry and the nature of life

In view of the difficulties faced by contemporary biology, in order to understand the nature of life, Pross calls for looking to the answer to Schrödinger's fundamental question in another area, namely – modern chemistry [13]. He suggests using simple chemical concepts to explain why life has unique properties and features, and identify the rules explaining the process by which life came to be from non-living matter.

The Israeli scientist argues that the recent exciting results of the newly established field of chemistry – systems chemistry – may finally give us a concrete answer to the question about the nature of life. He attempts to show that the gap between biology and chemistry can be overcome, and that Darwin's theory can be integrated into a more general chemical theory of matter, while biology is just chemistry, or to be more specific, a branch of chemistry [13].

The aim of this new field of chemistry is to find chemical sources of biological organization, which explains its name being also a play on words referring to systems biology. If we see biology as a field examining highly complex chemical systems capable of replication and reproduction, then systems chemistry is a relatively simple chemical system that also has a unique ability to self-replicate. In this way, science is trying to fill the gap that still divides the biology and chemistry. In contrast to systems biology, which, in its quest to explain the complexity of life, uses a "top-down" approach, while systems chemistry is based on a "bottom-up" approach. While the top-down approach starts from the information and goes down to the understanding of the manner in which individual elements influence the whole, the bottom-up approach starts from a potential beginning and then goes up. In the context of the life, it means that studying its complexity is to examine the process in which this complexity arises step-by-step. Thus, we start from a simple initial unit and move up. Therefore, the biggest challenge of systems chemistry is setting the rules that govern the process of the emergence of complexity from relatively simple chemical systems to highly complex biological systems.

According to Pross, there are many factors advocating the bottom-up approach. Firstly, it is in line with general assumption that life comes from non-living matter, i.e. that life emerged from non-life. It follows that the beginnings of life were simple and that its complexity arose gradually, step by step, for a specified period of time [13, 16]. Is highly likely that several billion years ago, a replication system of unknown origin, but with low complexity, set off on the long road leading to the high complexity, and that the historical path of increasing complexity eventually passed from the world of chemistry in the world of biology. Secondly, logically speaking, if life began its existence in a simple form, then it would be easier to understand its fundamental nature by exploring the early, and so, consistently simpler prototypes. The bottom-up approach aimed at solving the mystery of life assumes that life began its existence in a simple form, and that there was a process that led to the creation of its more complex form.

Pross wants to demonstrate that the study of systems chemistry can lead to a simple connection of living and non-living systems, which will create a uniform program for chemistry and biology. This combination will have significant value because it will put biology in the broader context chemistry. It will be able to provide a description of living systems using chemical, not biological, concepts. The Israeli scientist is convinced that it is the only effective way to obtain an answer to the fundamental question: "What is life?

The chemical theory of life

Now we are going to present the fundamental elements making up the chemical theory of life proposed by an Israeli researcher who pays special attention to the term "dynamic kinetic stability", DKS for short, which is a fundamental feature of replicating systems. In accordance with DKS, all replicating systems, both animated and inanimated, represent replicator's space [17,18]. In contrast to non-replicating systems (all of which are inanimated), in case of which natural selection generally takes on a thermodynamic character, natural selection in the replicator's space is of a kinetic character. In other way, according to Pross, all animated systems (in contrast to traditional thermodynamic systems dominating the inanimated world) make up the kinetic state of matter. Having this in view, key Darwinian terms, such as *fitness* and natural selection, are special expressions of a more fundamental physicochemical terms, such as kinetic stability and kinetic selection [19].

Life as a „network" of chemical reactions

The functioning of living systems is associated with a large number of chemical reactions, but the essence of life, the process that started it was, according to Pross, replication [13]. In turn, what makes the replication reaction so unique is not the product, but the amount of this product. To emphasize the exceptional nature of the replication process, the Israeli scientist is considering a single replicating molecule with the weight of 21 g. If it replicated once a minute, then, within five hours of this process, the molecule would grow to a weight greater than the size of the entire universe. The process of replication is unique and entirely different from any other chemical reaction [13, 20]. This is due to the awe-inspiring kinetic force that overturns the conventional rules of chemistry upside down. The second law of thermodynamics is of course fully applicable to self-replicating systems, but the enormous kinetic force of replication circumvents this ubiquitous law. The concept of stability in chemistry plays a fundamental role, but the exceptional kinetic force creates stability, which is entirely different from the kinds of stability we know. In "ordinary" chemistry, the matter is stable, if does not participate in a reaction. However, in the world of self-replicating systems matter is stable if it is involved in a reaction, in order to fulfill its potential. This is the essence of the concept of "dynamic kinetic stability." In "replication chemistry", populations with less efficient replicators constantly carry out reactions in order to create more efficient (more stable) replicators. The type of chemistry that results from these reactions in this "other world", i.e. the world of replication, is different from the one in the "normal" world. As a result, biology is only a particular kind of the complex chemistry of replication, and the state of living can be seen as a new state of matter (the "replicative" state of matter), the properties of which are derived from a unique kind of stability that characterizes replicating units – DKS [13]. Life in this context is seen as a unique expression of "kinetic control" [21].

Based on the previous considerations, Pross formulates the following definition of life: *life is a self-sustaining, kinetically stable,* *dynamic response network formed as a result of replication* [13]. Although life is a very complex phenomenon, the principle of life is surprisingly simple. Life is an extremely complex network of chemical reactions that maintain their autocatalytic capability. This complex network gradually emerged from a simpler network. The driving force behind this process is striving towards greater DKS, based on the kinetic power of replication and allowing the replicating chemical systems to thrive in ever-increasing, complex and continuous forms. Life is more of a process than a thing.

Transformation of non-living matter into living matter

The transformation of inanimate matter into a complex living form is traditionally presented as a two-step process [13]. The first stage, known as the chemical phase (or abiogenesis – the process through which life came to be from non-living matter), is a source of endless debate and controversy. The second phase – biological – starts with the creation of the simplest forms of life. This simple unit would mean a system having something that many would refer to as the most important feature of living organisms: the ability to replicate and evolve in a self-sustaining manner. Having reached this critical point, the system would be considered to be biological and its subsequent transformation into more complex forms of life – unicellular eukaryotes and multicellular organisms – would be led by the epochal theory put forward one hundred and fifty years ago by Darwin.

Although we do not have any direct information on the early prebiotic era, there is one thing we can be certain about [13]. During the last few billions of years, the laws governing chemical behaviors have not changed, which means that research in "chemistry proper" today can provide us information on events which took place billions of years ago. This "chemistry proper" is, according to Pross, systems chemistry that studies chemical reactions of self-replicating molecules, and the networking opportunities they create. Such research may allow us to understand different types of reactions that are carried out by the prebiotic replicators, and therefore, among others, the early processes of increasing complexity.

To make use of a deeper insight into one continuous process of evolution, we must describe the two phases in one language [13]. The only question is, which of the languages, the biological or chemical one, should be used. For Addy Pross, the answer is clear: the whole process, so both the biological and chemical phases, must be described using the concepts of chemistry.

Natural selection and kinetic selection

The continuity of the two worlds: the biological and chemical one is exemplified by the concept of selection. Where several self-replicating molecules are mixed with their molecular material, these molecules compete with each other in the same way in which biological entities compete for a limited amount of food [13]. In other words, the two-replicating molecules are fighting for the same chemical building blocks, and the result of this "battle" can be explained by the process which chemists call kinetic selection. In everyday language, it can be defined as follows: "the faster one wins." Due to the fact that the faster replicator is able to make up the building blocks into new molecules replicating in a more efficient manner, the number of the faster replicators increases rapidly, while the number of slower replicators drops down to total extinction.

This strictly chemical process seems to be very familiar to biology. It resembles the way of natural selection. If two biological species fight for the same resources, the species, which is better able to use them, makes the other one die out. In this case, natural selection and kinetic selection are the same concept (natural selection = selection kinetic).

Biological natural selection only mimics chemical kinetic selection. This is due to the fact that the chemical explanation is more fundamental and examines selection in a more profound way. The chemical concept is easier to calculate than its biological equivalent, because chemical systems are inherently simpler. It is this greater simplicity allows a further breakdown of complex chemical steps of replication into individual steps that make up a reaction. On the other hand, biological systems are much more complex, and so consequently less open to close scrutiny. The assumption that natural selection is basically rooted in chemical, well-understood phenomena is – for Pross – an important link connecting chemistry and biology [20].

Fitness and its chemical origin

Addy Pross, also focuses on another important biological concept, namely the concept of fitness [13]. What is the chemical equivalent of the term? According to Darwin, fitness is merely the ability to survive and reproduce, and its optimization is considered as the main aim of the process of evolution. Despite this, the concept formulated by Darwin has caused endless discussion in a strictly qualitative sense. This is due to the fact that scientists are constantly trying to formally define it quantifiably. According to Pross, the combination of chemistry and biology can help us explain at least some aspects of the troublesome aspects of "fitness". A fundamental feature of self-replicating systems is the dynamic kinetic stability. The ability of a replicating system to survive for a long period of time reflects its stability, but it is a stability of another type than the conventional thermodynamic stability. Fitness is a biological expression of a more general and basic chemical concepts (*fitness = dynamic kinetic stability*). Recognizing a biological entity as fit, one really defines it as a constant, in the sense of being continuous. However, this kind of stability is only applicable to a population, and not to individual replicators belonging to this population. Calling the population fit (or constant) we mean that it is able to keep up the ongoing replication/reproduction.

A direct result of the combination of fitness and DKS is the fact that the first is best regarded as a feature of the population, not an individual characteristic. At the individual level, the concept of DKS has no meaning. If we focus on the individual unit, we will lose the essence of life and its dynamic nature, and thence the continuous rotation of the individual units forming a concrete replicating population. Therefore, to understand the essence of life we should focus not on the individual but on the population aspect of life. Life is a phenomenon of evolution, and evolution is not based on individual units, but populations. Individuals are born and died.

The chemical theory of life and the characteristics of life

Pross, focusing on the key question "What is life?" briefly examines several unique features that make living organisms significantly different from inanimate objects. By exposing these qualities of life, he proposes to explain them within the developed theory of life.

The organized complexity of life

Living organisms are extremely complex [13]. Unlike the world of non-living entities, in the world of life, complexity is strictly defined. Even the smallest structural change in the organized complexity can bring dramatic consequences. For example, a single change in the human DNA sequence, one of the three billion units, can potentially lead to thousands of genetic diseases.

How was this basic organization in living beings initiated? [13] According to the Israeli researcher, the Darwinian theory of evolution is unable to explain the emergence of biological complexity. It can fully explain how the simple, unicellular living organisms have gradually become the human being. However, it does not respond to the question of how the simple organism was able to evolve? Darwin's theory is a biological one, therefore applying to biological organisms, and the origin of life is a matter of chemistry, and according to Pross, it is best to answer this question by referring to chemical theories, in particular with reference to the key concept of DKS [13]. The mechanism by which nature increases DKS through the process of increasing complexity is of fundamental importance here. When a simple unit originates (in the view of DKS, it is unstable), it tends to increase complexity to increase DKS. Each step of this process leads to a somewhat more complex unit characterized by increased replication. The principle of maximizing DKS allows us to understand evolutionary processes both at the chemical and biological level.

Instability of life

Another aspect of the nature of life that still surprises many researchers is that it is far from balanced. The simplest form of life, a bacterial cell, from the thermodynamic point of view, is unstable, and therefore in order to maintain itself, it needs to constantly consume energy that is constantly supplied by the environment [13]. The world is completely engulfed by these thermodynamically unstable units [13]. How is this possible? Should not unstable organisms gradually disappear? In response, Pross states that all living organisms are actually stable. Their stability is, however, one of a different kind. He means the concept of DKS, the stability of the organisms that effectively utilize their capabilities. In the world of replicators, only DKS counts, not the thermodynamic stability. Why are specimens that are stable in the context of DKS also always unstable in the context of thermodynamics? DKS is simply dependent on the reactivity of the system, continuously maintained to allow replication and realize its potential. To make this possible, the system must be reactive, and therefore also unstable. Thermodynamically stable specimens do not conduct reactions. In order for a living system to be a highly effective replicator, it must be stable in the context of DKS and to be thermodynamically unstable.

The dynamic nature of life

The amazing feature of any living organism is its dynamic nature [13]. Its parts are constantly changing. Each molecule in the body is periodically replaced by another molecule.

How do you explain the dynamic nature of living systems? [13] In response, Pross uses the analogy between the replicating population and a fountain. The fountain is stable, even though the water that fills it is constantly flowing. The fountain is the same, all the time, but the water is not. The same behavior is also typical of any replicating entity. It is population that population is stable, secure, and individuals that make up the system die so that other, newly formed specimens take their place. This continuity takes place at all levels of complexity. It is found in molecules present in cells, in cells forming organisms, and in all organisms.

The purposeful nature of life

Another feature that makes life so unique and different from inanimate matter is its intentional character [13, 23]. Biologists have called this aspect of life teleonomy. In the world of inanimate matter, there is no question of any purpose or program, but only of fixed laws of nature [22]. In a sense, we are always simultaneously in two worlds, governed by different rules. In the world of the inanimate, there are the principles of physics and chemistry, while the biological world is ruled by the principle of teleonomy [13, 10].

How is this possible? According to the Israeli chemist, once again the concept of DKS shall allow us to solve this puzzle [13]. Reactions of simple replicating molecules would be thermodynamically driven in a similar way a car without an engine is subject to the force of gravity, so it is only able to move downhill. However, when a replicating entity acquires the ability to store energy, then it is "liberated" from the thermodynamic limitations, and can be targeted kinetically. It can now strive for the increased DKS. A replicating entity that has the ability to store energy is like a car that has an engine – it can also drive uphill. This means that a replicating system capable of generating energy seems to have a program to operate. It seems that the system behaves in a targeted manner, as if it is not restricted to a thermodynamic path, but its path seeks to increase the DKS.

Conclusion

Addy Pross, a world specialist in the field of chemistry, has set himself a very ambitious goal. In the absence of a satisfactory response to Erwin Schrödinger's historical question *What is life?* In modern biology, which has attracted naturalists for decades, the Israeli chemist decided to tackle this question by using the concepts and achievements of other, more fundamental area which is the systems chemistry. This young branch of modern chemistry is to be able to determine the rules that govern the process of creating complexity from relatively simple chemical systems to highly complex biological systems. The chemical theory of life developed in its framework is intended, according to the author, not only to explain why life has unique properties in simple chemical terms such as organized complexity, instability, dynamic nature, and purposeful character, but also to bring up the principles responsible for the process by which life originated from inanimate matter. The concept of *dynamic kinetic stability*, which is a fundamental feature of replicating systems, will be particularly helpful in explaining the mystery of life, as the Israeli researcher believes.

The chemical theory of life by Addy Pross is part of a long history of the still present and unrelenting dispute about the nature of life. The attempt to answer the fundamental question *What is life?* outlined in this article contains a number of new, original themes. The key thesis: life has a chemical nature, is justified by the author and supported by factual arguments. Pross is undoubtedly an inquisitive researcher who impresses us in his professionalism and the deep insights into the essence of the problem with the question of the nature of life.

Pross is convinced that the answers to some of the key questions relating to life, including the classic question raised by Schrödinger, have finally become available. Time will tell whether the proposed chemical theory of life will find general acceptance in the scientific community of naturalists and become an inspiration for further independent search for the full understanding of life.

Literature

1. Favrholdt D.: *Introduction*, in: Niels Bohr. Collected Works. Vol. 10. Complementarity beyond Physics (1928–1962), D. Favrholdt (ed.). Elsevier Amsterdam 1999, [3]-[26].
2. Ślaga S.: *Próba uściślenia Tomaszowego określenia istoty życia*. Studia Philosophiae Christianae 1974, **10**, 67–99.
3. Urbanek A.: *Horyzonty intelektualne biologii współczesnej*. Kosmos 1989, **48**, 183–199.
4. Chmurzyński J.: *W poszukiwaniu istoty życia*, w: Organizm jednostka biologiczna, T. Zabłocka (red.). Wydawnictwo Szkolne i Pedagogiczne, Warszawa, 1977, 5–66.
5. Zięba S.: *Istota życia w monistycznych i pluralistycznych teoriach bytu*. Roczniki Filozoficzne 1976, **24**, 77–88.
6. Urbanek A.: *Biologia XX wieku – główne nurty rozwoju*. Kosmos 2000, **248**, 305–319.
7. Rutkiewicz B.: *Witalizm metodologiczny i witalizm metafizyczny*. Przegląd Filozoficzny 1931, **34**, 171–179.
8. Ścibor-Rylska T.: *Celowość w życiu komórki*. Studia Philosophiae Christianae 1980, **16**, 5–64.

9. Hempel C.: *Podstawy nauk przyrodniczych*. Tłum. B. Stanosz. Wydawnictwo Naukowo-Techniczne. Warszawa. 1968.
10. Wolkensztein M.: *Biologia i fizyka*. Problemy 1974, **6**, 44–46.
11. Vajskopf V.: *Fizika v dvadcatom stoletii*. A. Davydov, Atomizdat, Moskva, 1977.
12. Allen G.: *Life Science in the Twentieth Century*. John Wiley & Sons, New York, 1975.
13. Pross A.: *What is Life? How Chemistry becomes Biology*. Oxford University Press, Oxford, 2012.
14. Pross A.: *Toward a general theory of evolution: Extending Darwinian theory to inanimate matter*. Journal of Systems Chemistry 2011, **2**, 1–14.
15. Pross A.: *Seeking the Chemical Roots of Darwinism: Bridging between Chemistry and Biology, Chemistry*. A European Journal 2009, **15**, 8374–8381.
16. Wagner N., Pross A., Tannenbaum E.: *Selection advantage of metabolic over non-metabolic replicators: A kinetic analysis*. BioSystems 2010, **99**, 126–129.
17. Pross A., Khodorkovsky V.: *Extending the concept of kinetic stability: toward a paradigm for life*. Journal of Physical Organic Chemistry 2004, **17**, 312–316.
18. Pross A.: *On the emergence of biological complexity: Life as a kinetic state of matter*. Origins of Life and Evolution of Biospheres 2005, **35**, 151–166.
19. Pross A.: *Stability in Chemistry and Biology: Life as a Kinetic State of Matter*. Pure and Applied Chemistry 2005, **77**, 1905–1921.
20. Pross A.: *The Driving Force for Life's Emergence: Kinetic and Thermodynamic Considerations*. Journal of Theoretical Biology 2003, **220**, 393–406.
21. Pross A.: *Causation and the origin of life. Metabolism or replication first?* Origins of Life and Evolution of the Biospheres 2004, **34**, 307–321.
22. Pross A.: *How can a chemical system act purposefully? Bridging between life and non-life*. Journal of Physical Organic Chemistry 2008, **21**, 724–728.
23. Pross A.: *On the chemical nature and origin of teleonomy*. Origins of Life and Evolution of Biospheres 2005, **35**, 383–394.

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Z prasy światowej – innowacje: odkrycia, produkty i technologie

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Procesy biokatalityczne w farmacji

Chiralne alkohole drugorzędowe są ważnym budulcem w chemii medycznej; co najmniej 17 ze 100 najpopularniejszych leków na receptę w USA w 2010 r. należało właśnie do tej grupy związków chemicznych. Opracowanie wydajnych i przyjaznych środowisku metod enancjoselektywnej syntezy tych alkoholi jest więc wysoce pożądane. Ostatnimi czasy uwagę naukowców skupiły procesy biokatalityczne, które okazały się niezwykle skuteczne w syntezie wielu chiralnych półproduktów. Za przykład służyć może enzymatyczna asymetryczna redukcja prochiralnych ketonów z użyciem reduktazy karbonylowej (CRED) – obecnie dobrze znane narzędzie do efektywnego wytwarzania chiralnych alkoholi z wysokim nadmiarem enancjomerycznym. Chociaż technologia CRED ma wiele zastosowań w procesach chemicznych i jest łatwa do przeniesienia na dużą skalę, to nie jest powszechnie stosowana w laboratoriach farmaceutycznych. Badania przedstawione na łamach *Tetrahedron: Asymmetry* przez angielskich i amerykańskich naukowców mają na celu pokazanie, jak łatwo technologia CRED może zostać wykorzystana w celu zwiększenia puli związków chemicznych posiadających rusztowania z chiralnych bloków enancjomerycznych alkoholi. Zademonstrowane zostało, w jaki sposób szybko generować dodatkowe ilości tych i podobnych alkoholi. Badania wykazały, iż wykorzystanie technologii CRED pozwala na wyeliminowanie potrzeby stosowania chromatograficznych lub chemicznych metod rozdziału mieszanin racemicznych, co w znaczny sposób przyspiesza proces opracowywania nowych leków. *(kk)*

(A.S. Rowan, T.S. Moody, R.M. Howard, T.J. Underwood, I.R. Miskelly, Y. He, B. Wang: Preparative access to medicinal chemistry related chiral alcohols using carbonyl reductase technology, Tetrahedron: Asymmetry 24 (2013), 1369–1381)

Fotokataliza w materiałach cementowych

Zastosowanie fotokatalitycznych właściwości dwutlenku tytanu w materiałach cementowych jest obiektem licznych badań, bowiem technologia ta może skutecznie przyczynić się do usuwania zarówno organicznych jak i nieorganicznych zanieczyszczeń powietrza. Ponadto, w oparciu o hydrofilowość TiO_2 możliwe jest uzyskanie łatwych do czyszczenia, a nawet wykazujących właściwości samoczyszczące, powierzchni.

Badania prezentowane na łamach prestiżowego *Materials Characterization* prezentują nowe zastosowanie dwóch różnych metod powlekania TiO_2 w celu otrzymania betonu komórkowego posiadającego aktywność fotokatalityczną w kierunku usuwania toluenu z powietrza. Okazało się, że zastosowanie metod *liquid flame spray* (LFS) oraz *low temperature synthesis* (LTS) dało materiały charakteryzujące się podobną, równą ok. 60%, skutecznością w oczyszczaniu powietrza.

Obie metody mają swoje zalety: cząstki katalizatora zsyntetyzowane z wykorzystaniem technologii LFS składają się z mieszaniny rutylu i anatazu, która powoduje zwiększenie aktywności fotokatalitycznej, z kolei cząstki otrzymane metodą LTS charakteryzują się znacznie większą powierzchnią aktywną. Technologie te mogą być z łatwością zastosowane nie tylko jako modyfikatory materiałów świeżo wytwarzanych, mogą również być stosowane w istniejących budynkach. *(kk)*

(A. Maury-Ramirez, J.-P. Nikkanen, M. Honkanen, K. Demeestere, E. Lev¨anen, N. De Belie: TiO_2 coatings synthesized by liquid flame spray and low temperature sol-gel technologies on autoclaved aerated concrete for air-purifying purposes, Materials Characterization (2013), doi:10.1016/j.matchar.2013.10.025)