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**Economic processes management at macrolevel**

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**CHALLENGES OF GREEN CHEMISTRY IN UKRAINE**

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*The article deals with study of Ukrainian chemical enterprises' ecologisation issues and elaboration of the economic problems to realize principles of green chemistry. Theoretical aspects of green chemistry as a modern interdisciplinary conception, which reveals peculiarities to implement sustainable development paradigm in the chemical industry, are studied. Based on the analysis of essence and effectiveness to introduce international initiatives on sustainable development at the chemical industry enterprises, it is concluded that the implemented measures are only first steps on the way to realize key principles of green chemistry. It is proved that in order to promote conceptual ideas of the green chemistry further, it is reasonable to consider economic and marketing aspects of the ecological innovations: to provide economic effectiveness of green chemical products and technologies, to form ecological culture of consumption, to motivate green demand and to prevent market asymmetry of information.*

**Keywords:** *chemical industry, green chemistry, manufacture, development, greening, product.*

**Introduction.** High toxicity and harm for human's health of many chemicals, lead to consideration of chemistry (more often true) as dirty and dangerous production. Besides, most chemical enterprises consume great amount of raw material, water and energy, produce many waste products, accumulated as wastes and pollute environment. That is why, organization of the rational nature management and increase of chemical production ecological efficiency is an important aspect of the socially responsible approach in the chemical enterprises management.

Traditionally, in Ukraine such directions of the chemistry ecologisation as investigation and production of innovative goods, modernization of technological processes, development of production with low-waste and resource-saving technologies, complex raw material processing, reducing of pollution sources, accumulation waste recycling, wastewater treatment were observed. Such approach caused directions of the proper ecological and economic studies to elaborate nature management economic mechanisms and methodic fundamentals to estimate ecological and economic effects, to investigate a system of ecological and economic tools, particularly on stimulation of the rational nature management and environmental pollution reduction.

At the same time, at the end of the last century new paradigm in the chemical industry appeared, called green chemistry. Its main principles were formed by P. Anastas, one of heads from Environmental protection agency of the USA [1-3]. The conception provides improvement of chemical processes, which positively influences environment. It means that in spite of traditional ecology tasks to defuse negative consequences of chemical industries, green chemistry task is to provide organization of such industries where there are no such consequences.

It is obvious, that such new approach causes many controversial issues on peculiarities, directions and problems of green chemistry paradigm practical realization under native conditions. The given research studies some controversial aspects of this significant scientific and practical task.

**Analysis of recent researches and publications.** Nowadays the conception of green chemistry is fast being developed and extended in various research centers all over the world: Green Chemistry Centre of Excellence (UK) [4], Center for Green Chemistry and Green Engineering at Yale (USA) [5], The Berkeley Center for Green Chemistry (USA) [6], Carnegie Mellon Institute for Green Science (USA) [7], GreenCentre Canada, Interuniversity Consortium – Chemistry for the Environment (Italy), Green Chemistry Network Center (India), Shanghai Key Laboratory of Green Chemistry and Chemical Processes (China), Green and Sustainable Chemistry Network (Japan), Centre for Green Chemistry (Australia).

It is important to understand that interdisciplinary character of this conception, which forms its subject matter at the intersection of different chemical, technical and humanitarian specialties, ecology, nano-, bio- and informational and communicative technologies. American scientists focus their attention just on this aspect, when they consider green chemistry as “an emerging multi-stakeholder community” [6].

On the other hand, green economy is one of Ukrainian economics directions, which is actively being developed in theoretical and applied aspects. Such native scientists as B.V. Burkunsky, T.P. Halushkina, V.Ye. Reutov [8, 9] (studied preconditions and innovative directions of the green (ecologically oriented) economy and ways to activate green growing), L.H. Melnyk, O.V. Kubatko [10-12] (proved peculiarities and main regularities to form green or sustainable economy and defined strategies and mechanisms to provide economy ecologisation), O.V. Prokopenko [13] (proved motivational approach to the innovative activity ecologisation), E.V. Prushkivska, Yu.O. Shevchenko [14] (distinguished the role of green economy in the primary, secondary and tertiary sectors of the national

economy), M.V. Malchyk, O.V. Martynyuk [15] (defined peculiarities of the green marketing conception), S.O. Bila [16] (studied peculiarities to use green economy conception at the regional level) demonstrate their views of conceptual approaches to form green economy.

**Previously unsettled problem constituent.** However, today the problem of green economy in some sectors of national economy remains not enough studied. Single economic studies within the conception of green chemistry in Ukraine are associated with justification of interaction between biotechnologies and chemical industry [17, 18]. However many general controversial questions require scientific study concerning approaches to implement green chemistry conception and to define directions for chemical industry segments ecologisation.

**Main purpose of the article.** The purpose of the article is to study state and directions of chemical industry ecologisation and to define preconditions, problems and perspectives to realize green chemistry principles under conditions of the national industry.

**Results and discussions.** Theoretical base of the carried out research are scientific works of L. Melnyk and O. Kubatko, who determine 4 stages of sustainable needs development on the basis of theoretical investigations and EU countries experience generalization:

1. The first stage is associated with the means to control environmental destruction ("the end of pipe").

2. The second stage refers to environmental improvement of technology ("wasteless technology").

3. The third stage is associated with substitution of undesirable goods and service by "greener" ones ("more efficient goods"). 4. The fourth stage is associated with production and consumption of goods for sustainable development ("sustainable life stile") [10, p. 39].

Another important result of the mentioned scientific work is associated with main marketing strategies of greening and eco-innovations fostering study. Authors analyzed three main strategies ("push-strategy", which influence demand, "pull-strategy", which influence supply, and "interface-strategy", which influence interaction between producers and consumers) and concluded that "The demand (push-strategy) in eco-innovation fostering is appeared to be more effective than the supply (pull-strategy) as it can be seen from EU countries experience" (p. 41).

Analysis of the Ukrainian chemical industry ecologisation current state shows that most enterprises are at the first and (in the best case) at the second stage of the conception introduction. Leaders of the ecological management in chemical industry are large enterprises-exporters. Anyway, this result was possible as a result of market powers pressure, necessity to support international competitive positions and certification of producing, security and ecological systems according to the international standards.

The most important direction of the ecological policy during the last decade consisted in joining of Ukrainian producers to the voluntary international programs on sustainable development. For example, to the new European system REACH [19], which in 2007 substituted a number of norms, standards and rules, which regulated chemical products

turnover in EU economy. REACH stands for Registration, Evaluation, Authorisation and Restriction of Chemicals.

According to REACH regulation, compounds, which are used in the chemical industry, have to be checked for safety, to be substituted by secure alternative materials. Production of ferrous and nonferrous metallurgy, oil refining, chemical, machine building, textile, glass and other sectors are influenced by this program. In 2018 the last third authorization stage of industrial production access to the EU market is finished. It consists in certification of the proper production.

One more direction to fulfill ecologically oriented management at the chemical industry enterprises is to realize the program “Responsible care of chemical industry of Ukraine”. This program is oriented to implement principles of the international initiative Responsible Care, which aims at responsible, caring attitude to the environment and human’s health, improvement of chemical security and open communication with interested sides concerning chemicals and their production processes [20]. UNO program on the environment approved it as a program, which provides stable development of the enterprise and the whole chemical industry.

Nowadays the leading enterprises of chemical industry in Ukraine (OJSC “Odesa port plant”, Cherkasy OJSC “Azot”, OJSC “DniproAzot”, OJSC “Rivneazot”, CJSC “Severodonetsk association Azot”, OJSC Concern Stirol”, OJSC “Sumykhimprom”, OJSC “Ukrplastik”) implemented complex measures on introduction of modern systems to regulate production processes security, to decrease productive and ecological risks, to reduce load over environment, to pass audit and certification procedures on the side of international certification bodies.

At the same time over 3 thousand small and medium-sized enterprises are working (mostly in production of paints and vanishes, soap, cleaning material, plastic goods). Being influenced by the market conditions, some of them try to realize separate tools to provide production quality, to control ecological risks, to reduce production waste, to increase technological processes security, energy efficiency, to improve working conditions. But it is a slow process and requires systematic approach, collective self-regulation and organizational support from sectoral institutions.

Thus, today chemical industry achieved some results of the sustainable development paradigm implementation, which have to be the base to move to the next stages. Ecological innovations are key elements of the last.

Our experience to create and to introduce ecological innovations proves that successful promotion of green chemicals and development of green technologies depend in many cases on the competent management of economic and marketing constituents of the innovative process, particularly demand control. Let us observe some aspects of this complex task on the example of painting system in chemical industry.

Nowadays the Ukrainian paint and vanishes industry keeps sufficient market potential, demonstrates high rates of reconstruction (+17,6% in 2016) and has perspectives in development, associated with increase of its technological, economic, security features and reducing of negative impact on the environment. Producers pay attention to the energy-saving and low-waste technologies. It can be seen that paint and vanishes industry

production is reduced on the basis of organic solvents for water-dispersed paints, production of the protectoral coverings and materials with special peculiarities (for defense, air, shipbuilding, oil and gas, chemical industries), development of “intellectual” multifunctional paints and vanishes.

At the same time, investigation of the ecological innovations faces the problem of effective demand fall and its moving to the market segments “econom” and ”subeconom”. Ukrainian producers must solve a complicated and contradictory task: to increase production amount of cheap paints and vanishes while giving qualitative and ecologically secure features of the more expensive production by it. The task is complicated by the fact that qualitative ecologically secure production has high value and it is reduced owing to the cheap dangerous raw material use in production.

Thus, one of the main economic problems for green chemical productions is associated with the fact that they (except ecological efficiency) have to provide some profitability degree. It is necessary to identify spheres and potential of ecological innovations impact in the right way, i.e. estimation of effects has to comprise not only direct current benefits, but also postponed and implicit results and those, which are associated with new market possibilities.

While organizing the production, based on the green chemistry technologies, sources of productive cost, energy saving and materials reduce also appear, particularly while decreasing of production stages or with no necessity to recycle or to dispose harmful products.

For example, while using of polymeric pigments, investigated by us [21] in different paints production (alkyd, pentaphthalic, water-emulsion etc), one excludes using of dispersing equipment. It allows to save time for technological operations, to reduce specific cost for water and electricity. Using of investigated goods essentially improves oil consumption and excludes pigments migration.

Essential role in promotion of the ecologisation conception, must be played by tools of awareness increase and raising of consumption ecological culture, particularly social advertisement. It is necessary to form image of the modern responsible consumer, who understands sources of new consumer’s use value and necessity to pay for high qualitative, ecologically clean and secure production. Broadly speaking it concerns one of directions of the green marketing paradigm implementation [15].

An important factor of the green markets profitable functioning is to prevent market information asymmetry, to give signals about additional consumers’ features of ecological goods to consumers and existence of “consumer’s prize”. In this context among various tools to motivate ecological innovations consumption [13] at the paints and vanishes market, it is necessary to pay attention to the ecological labeling.

Today the imported and mostly domestic paint and vanishes production has GHS Hazard pictograms, which are the part of Globally Harmonized System of Classification and Labelling of Chemicals [22]. However consumers’ awareness in GHS Hazard pictograms is not enough, and relative complexity of the system prevents its use as eco-labeling in the producers’ marketing activity. The investigation of the simplest and the clearest eco-labeling system (e.g. under the aegis of Association of Ukrainian paintings and vanishes

production consumers) for average consumer would assist clear positioning of the green production and its active promotion to the target groups.

**Conclusions and further researches directions.** Green chemistry is a modern interdisciplinary conception, which shows peculiarities of the sustainable development paradigm implementation in the chemical industry. Investigations of processes and joining results to international programs on the sustainable development proved that leading chemical enterprises implemented a number of actions to develop ecological management system and other directions of the chemical industries ecologisation. However, the implemented approaches can be estimated only as first steps on the way to realize key principles of the green chemistry. Attention is paid to economic and marketing aspects of ecological innovations: to provide economic effectiveness of green chemicals and technologies, to form ecological culture of consumption, to motivate green demand and to prevent market information asymmetry. Consideration of the above aspects in the marketing provision of green innovations will assist activating of green products markets and increasing the chemical industry efficiency. **Further studies** in the observed directions will be associated with studying of state regulation mechanisms and green chemistry development support.

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**ПРОБЛЕМИ РОЗВИТКУ «ЗЕЛЕНОЇ» ХІМІЇ В УКРАЇНІ**

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*Стаття присвячена дослідженню питань екологізації українських хімічних виробництв та опрацюванню економічних проблем реалізації принципів «зеленої» хімії. Вивчено теоретичні аспекти «зеленої» хімії як сучасної міждисциплінарної концепції, яка розкриває особливості імплементації парадигми сталого розвитку у хімічному виробництві.*

*На підставі аналізу сутності та результатів впровадження міжнародних ініціатив зі сталого розвитку на підприємствах хімічної промисловості зроблено висновок, що вжиті заходи є лише першими кроками на шляху до реалізації ключових принципів «зеленої» хімії.*

*Обґрунтовано, що для подальшого просування концептуальних ідей «зеленої» хімії важливе значення мають економічні та маркетингові аспекти екологічних нововведень: забезпечення економічної ефективності «зелених» хімічних продуктів і технологій, формування екологічної культури споживання, мотивування «зеленого» попиту та подолання ринкової асиметрії інформації.*

***Ключові слова:** хімічна промисловість, «зелена» хімія, виробництво, розвиток, екологізація, продукція.*

**ПРОБЛЕМЫ РАЗВИТИЯ «ЗЕЛЕНОЙ» ХИМИИ В УКРАИНЕ**

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*Статья посвящена исследованию вопросов экологизации украинских химических производств и экономических проблем реализации принципов «зеленой» химии. Изучены теоретические аспекты «зеленой» химии как современной междисциплинарной концепции, раскрывающей особенности имплементации парадигмы устойчивого развития в химическом производстве.*

*На основе анализа сущности и результатов внедрения международных инициатив по устойчивому развитию на предприятиях химической промышленности сделан вывод, что осуществленные мероприятия являются только первыми шагами на пути к реализации ключевых принципов «зеленой» химии.*

*Обосновано, что для дальнейшего продвижения концептуальных идей «зеленой» химии важное значение имеют экономические и маркетинговые аспекты экологических нововведений: обеспечение экономической эффективности «зеленых» химических продуктов и технологий, формирование экологической культуры потребления, мотивирование «зеленого» спроса и преодоление рыночной асимметрии информации.*

***Ключевые слова:** химическая промышленность, «зеленая» химия, производство, развитие, экологизация, продукция.*