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LIFE AND SCIENTIFIC PRIORITIES OF PROFESSOR OLEG NAHURSKY

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Abstract. Stages of professional formation and scientific researches of Professor Oleg Nagursky – higher education, scientific degrees and professional experience are described in the article. The main results of scientific researches and possibilities of their practical application are presented.

Key words: capsulation, plastic waste, mineral fertilizers

Oleg Nagursky, Professor, Doctor of Technical Sciences, is the Head of the Civil Safety Department at Lviv Polytechnic National University. He was born in Lviv on July 29, 1964. He began his scientific career as a student of Lviv Polytechnic Institute. During this period, he worked in the Scientific Research Division at the Department of Processes and Apparatus of Chemical Production. In 1990 he graduated from Lviv Polytechnic Institute, having received a diploma with honours in the specialty “Chemical Processing of Plastics”. At the same time, he was hired as a young professional to work as a teacher trainee at the Department of Processes and Apparatus of Chemical Production. In 1998, at Lviv Polytechnic Institute, he defended his PhD thesis entitled “Mass Transfer of Substances through Polymer Shells to Predict the Functional Properties of Capsulated Products” in specialty 05.05.13 – Machines and Apparatus of Chemical Production. Scientific research of that period was about obtaining capsulated products and the mechanism of their application. In the years of 2002–2013, he worked as an Associate Professor of the Department of Ecology and Environmental Protection. During this period, he began to study the problems of capsulated products application in environmental technologies. Technologies for the use of plastic waste in the production of environmentally friendly capsulated mineral fertilizers have become a priority area of research. From 2004 to 2008, Oleg Nagursky was the scientific secretary of the Specialized Academic Council for the defence of candidate dissertations in specialty 21.06.01 “Environmental Safety”. He took an active part in the training of highly qualified personnel. He was the scientific supervisor for 2 candidates of technical sciences (Ph.D.): Stepova K. V. in specialty 05.17.08 “Processes and Equipment of Chemical Technology”, 2011; Vashchuk V. V. in specialty 21.06.01 “Environmental Safety”, 2013. He is an opponent in the defence of candidate and doctoral dissertations, a member of Specialized Scientific Councils for the defence of candidate (PhD) and doctoral (DSC) dissertations

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in specialties 21.06.01 “Environmental Safety” and 05.17.08 “Processes and Equipment of Chemical Technology”. From 2010 to 2013, he studied for a doctorate at Lviv Polytechnic National University. In 2013 he defended his Doctoral dissertation on “Regularities of Coating on Dispersed Materials and Diffusion Release of Active Components from Capsulated Particles” in specialty 05.17.08 – Processes and Equipment of Chemical Technology. Professor Yaroslav Gumnytskyi was the scientific supervisor of Oleg Nagursky's Candidate and Doctoral dissertations. From 2013 to 2015, he worked at the Department of Ecology and Environmental Protection. In 2015, after the reorganization of the Labor Protection and Life Safety Departments, the Civil Safety Department was created and headed by Oleg Nagursky. In 2016, he received the academic title of Professor of Civil Safety. The Department of Civil Safety, like its predecessors, continued to be a general department after its formation. For all university specialties, the department teachers taught disciplines “Life Safety” and “Fundamentals of Occupational Safety” for bachelor students, as well as “Civil Protection” and “Occupational Safety in the Industry” for masters. Implementing the concept of the department development, accepted at its creation in 2016, a license for training bachelors in specialty 263 “Civil Safety” from the Ministry of Education and Science of Ukraine was obtained. In 2017, the first students of this specialty were enrolled. Continuing the educational activities of the department, under the leadership of Oleg Nagursky, in 2020, training masters in specialty 263 “Civil Safety” started. Work is also underway to establish international cooperation. In 2018, with the direct participation of Oleg Nagursky, a cooperation agreement was concluded between Lviv Polytechnic National University and Joseph Tulishkovsky Scientific and Research Centre of Fire Protection of the Republic of Poland, where Prof. B. Bolibrukh and Assoc. Prof. O. Matskiv had a scientific internship. That year, cooperation between V. Chornovil Institute of Sustainable Development of Lviv Polytechnic National University and Faculty of Technology Fundamentals of Lublin Polytechnic (Poland, Lublin) was organized in order to expand ties in scientific and educational work. According to this agreement, in 2019, within the framework of international academic mobility, student S. Vichysty participated in a joint curriculum in specialty “Engineering Safety”.

Among the interests of Professor Oleg Nagursky is the encapsulation of solid dispersed materials in a quasi-liquefied state, industrial and household waste utilization by the technology of creating environmentally friendly encapsulated mineral fertilizers, environmental protection from agrochemical residual contaminants. The results of his scientific work are presented in more than 160 publications, conference proceedings. He is a co-author of 3 textbooks, 6 utility model patents. Many years of scientific investigation of the problems of dispersed materials encapsulation in a quasi-liquefied state and their application is summarized in the monograph “Patterns of Substances Encapsulation in Quasi-liquefied State and their Diffusion Release” (Nagursky, 2012). The main attention in the process of encapsulation dispersed materials in a quasi-liquefied state is paid to hydrodynamics, heat and mass transfer in the solid-liquid-gas system. Studying the hydrodynamics of encapsulation, the mechanism of complex multifactor interaction between solid material particles, film-forming solution and air during encapsulation in the quasi-liquefied state is established. It is shown that the increase in the resistance of the material layer during encapsulation in comparison with the dry one is caused by the increase in friction forces between the particles; the weight of the layer – due to the solvent in the liquid state, which is on the particle surface in the coating area; the diameter and weight of particles – due to the formed shell. Based on experimental results for granular mineral fertilizers (nitroammophos, calcium nitrate, ammonium nitrate, urea), model particles, chemical pharmaceutical tablet forms, seeds of agricultural crops (fodder beet seeds and spinach), the equations are obtained, taking into account the interaction solid–liquid–gas, which allowed to calculate the hydrodynamic parameters of the material layer during encapsulation in a quasi-liquefied state and to determine the energy costs (Nagursky, 2012). An important parameter that quantitatively characterizes the encapsulation efficiency is the heat exchange between the gaseous medium and particle materials. As a result of researches, theoretical dependences were obtained for calculating the combined heat transfer coefficient in conditions of complex heat exchange between air, wet and dry fraction of surfaces dispersed material, which allows to adequately predict the dynamics of heat and mass transfer of encapsulated materials in the quasi-liquefied state (Nagursky et al., 2015). The intensity of heat transfer has a direct effect on the mass transfer between the surface of the solid particle and gaseous medium. The intensity of mass transfer during encapsulation of dispersed materials with film-forming solutions is determined by the solvent evaporation intensity from the film-forming drop on the particle surface, solvent vapour mass transfer from the particle surface to the solvent medium, hydrodynamic conditions of their rinsing by thermal agent and its dry potential. Based on the experimental investigations the heat transfer and mass transfer coefficients during encapsulating depending on the air rate for different layers of dispersed material are determined. The established analogy between external heat transfer and mass transfer during encapsulation in the quasi-liquefied state makes it possible to determine the mass transfer coefficient by the heat transfer coefficient value (Nagursky, Gumnitsky, 2015). The To calculate encapsulating duration in a wide range of substances properties involved in encapsulating process, a generalization in the criterion form of the dependence of the shell building kinetic on the surfaces of particle materials is obtained. It is also established that the encapsulation process is limited by the surface mass transfer, which is determined by the design features of equipment and materials properties.

Any substance placed in the shell at the stage of direct application for its intended purpose in one way or another must be released from the coating. The contents of the capsules are released during the shell destruction in various ways or due to the diffusion of substances through the shell, which is especially typical for micro- and nanocapsules. The shell destruction leads to the almost instantaneous release of the encapsulated substance into the environment of its consumption.

The substance diffusion through the shell allows removing components from the capsule with a certain intensity. Controlled release is widely used for chemical and pharmaceutical preparations, mineral fertilizers, etc. In this case, the capsule, in addition to the functions of substance isolation from external influences, plays its main role – slowing down the dissolution rate and extending the encapsulated substance shelf-life. Therefore, the encapsulated substance under diffusion extraction conditions acquires new properties, without a clear prediction of which the use of such substances becomes ineffective. Results of studies of the diffusion release components from the encapsulated substance are a mathematical model of the mass transfer components from the encapsulated spherical particle (Nagursky, Gumnitsky, 2012). Theoretical model of compounds release out of capsulated particles and its experimental check. Chemistry & Chemical Technology, 6(1), 101–103.

The application of this model allowed: to determine limiting stages of the release process depending on the particle and shell material properties; to obtain simplified, convenient for practical calculations of the dependence of Bi value on the particle size at which the encapsulated fertilizers are characterized by an appropriate shelf-life; to establish a method for the theoretical description of the release of components from polydisperse mixtures of encapsulated particles.

Generalization of the experimental and theoretical research results of hydrodynamics, heat and mass transfer of the encapsulation process of dispersed materials in a quasi-liquefied state and diffusion release of target components from the polymer capsule allowed to develop a method for calculating technological parameters of the encapsulation process taking into account the interaction in the solid-liquid-gas system; to calculate the technological parameters of the encapsulation process of granular mineral fertilizers (nitroammophos, calcium nitrate, ammonium nitrate, urea) developed film-forming compositions; to develop a constructive-technological concept of the quasi-liquefied state apparatus for encapsulation granular mineral fertilizers. Oleg Nagursky dedicated a significant part of his research to the encapsulation of granular mineral fertilizers.

Encapsulated mineral fertilizers are characterized by active components with controlled release for plant nutrition. This property leads to better absorption of fertilizers by the plant root system and reduces environmental pollution by residual agrochemicals. However, the production of encapsulated mineral fertilizers is small, mainly nitrogen fertilizers and in world production is only 0.4–0.5 %. Such a small production of encapsulated mineral fertilizers is associated with their much higher cost compared to conventional granular fertilizers, due to the cost of film-forming compositions. A promising way to increase the availability of encapsulated mineral fertilizers in mass agriculture is the use of polymer waste. Polymeric materials, which are part of household waste, are characterized by low permeability to mineral nutrients. This property allows the application of the covering of minimum thickness on the surface of mineral fertilizer granules. For the safe use of polymer waste as a base film, it is necessary to prevent soil contamination. Neutralization of spent polymeric cover encapsulated fertilizers is achieved by their complete destruction to H_2O and CO_2. For research, Oleg Nagursky chose such types of plastic waste as polystyrene and polyethylene terephthalate (Nagursky et al., 2015; Malovanyy et al., 2020). Polystyrene is widely used for the production of disposable tableware and in foam form (expanded polystyrene) as a packaging material. These products are used for their intended purpose in a short time and are immediately converted into waste. Polystyrene, like most polymeric materials, is biologically inert and accumulates in landfills, which leads to persistent environmental pollution. Polyethylene terephthalate (PET) is widely used for the production of beverage containers, which after use is quickly converted into waste. The total Ukrainian capacity for PET waste recycling is a maximum of 1 thousand tons per month. Everything else accumulates in landfills and dumps. An important aspect of PET waste use is the currently organized centralized collection and primary recycling. The polymer waste use studies for encapsulation of mineral fertilizers were to create a film-forming composition based on polystyrene waste and modified polyethylene terephthalate, determined the technological parameters of encapsulation in a quasi-liquefied state and shell destruction after mineral fertilizers dissolution under environmental factors. Patents of Ukraine for a utility model were obtained for the developed film-forming compositions (Malovanyi et al., 2020; Malovanyi et al., 2013). The main environmental function of encapsulated fertilizers is to reduce contamination with easily soluble plant nutrients. Such contaminants include nitrogen compounds. Soil and water contamination with nitrates is an important issue that is the subject of much scientific work and is reflected at the highest legislative level in the EU Nitrates Directive (Council Directive 91/676/EEC of 12 December 1991 concerning the protection of waters against pollution caused by nitrates from agricultural sources). Investigation in the field of reducing the negative impact of agricultural chemicals on the environment remains a relevant area of research today.

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