Popular-science summary of the research project

Imagining a world of the future for us and our children, we see a reality in which there are no diseases and suffering, and people are beautiful and completely happy. In this world, all medicines work effectively and are delivered painlessly, and cosmetics actually have the same effect as producers provide us. In order for this vision to become a fact, it is necessary to develop not only pharmaceutical and cosmetic preparations themselves, but also methods of delivering them to the organisms. The goal of this project is to develop an effective method of applying bioactive substances through skin contact alone, without the need for a needle and syringe. This is particularly important when administering vaccines for various types of incurable diseases and implementations of other drugs. More than twenty percent of the society shows an innate fear of the needle, which in many cases results in deliberate avoidance of vaccination. In addition, the introduction of medicines using a traditional, over 160-year-old method poses a serious risk of cross-infection, especially in the so-called third world, where hygiene rules can't always be maintained. According to the World Health Organization, such infections cause over 1.3 million deaths annually. Non-injection drug introduction also creates the opportunity to reach those areas of the human body where the effect of these substances is increased. Thanks to this, for the preparation to show its medicinal properties, a smaller amount will be needed. This will significantly reduce the costs of using expensive medications, and thus enable the treatment of those people who previously could not afford it.

The rapid development of civilization meant that people are increasingly exposed to stress, sleep disorders and fatigue. In order to ensure a healthy, vital look, they are looking for better and better pharmaceutical and cosmetic products ensuring the highest clinical effectiveness. To meet the ever-growing needs, it is necessary to determine how the preparations behave in contact with the human body, and above all, how fast, in what quantity and at what depth they are able to penetrate it. With this knowledge, it will be possible to design new generation cosmetics that are able to reach specific layers of the skin. The value of such preparations will no longer be based on creating hope in customers through relevant advertising slogans, but on actual effects.

Human skin consists of several layers and is a powerful barrier to the passage of substances through it into the body, which protects our bodies from various dangerous compounds with which we can come into contact. However, if we want a given preparation to penetrate deep into the body through the skin, we must somehow overcome this natural obstacle. One such method is to place the active substance in suitable carriers and transport it to selected layers of the skin in this form. According to research, micro- and nanoemulsions are one of the best carriers of the active substances. Such carriers, due to their specific properties, are able to penetrate deeper into the skin than the active substance would be able to. Despite the knowledge about the effectiveness of such carriers, quantitative descriptions of their transport mechanisms in skins are unknown. There are also no effective methods developed that enable the practical application of such carriers to increase the penetration of selected substances.

Considering the importance of the issues concerned, the aim of this project is to develop a method for delivering the bioactive substance contained in emulsified carriers into skin structures. This goal will be achieved by conducting extensive research using the most modern instruments and research methodologies. Research will include tracking the transport of emulsified carriers through model skin structures in both two-dimensional systems - the use of special microcapillaries - and three-dimensional systems - the use of structures created on 3D printers. It is planned to conduct experiments at various scales, which will allow observation of mechanisms occurring during the flow, which cannot be studied using traditional methods of diffusion chambers and the idea of black boxes. However, to provide a full picture of phenomena, it is also planned to carry out diffusion tests. Parallelly, numerous computer simulations will be carried out, which will take into account those parameters that could not be studied during the experiments. The results of this work will provide full information on the studied issue and will allow to determine an effective method of transporting bioactive substances, using emulsified carriers, through the skin deep into the body, what will ensure the assumed effectiveness. In the long run, these achievements may become the basis for the development of new medical and pharmaceutical preparations that will meet the constantly developing civilization diseases.