Chemical engineering as applied to medicine: the new challenges

Tomasz R. Sosnowski

Faculty of Chemical and Process Engineering, Warszaw University of Technology, POLAND, Warsaw, Warynskiego 1, E-mail: tomasz.sosnowski@pw.edu.pl

Abstract – ***Chemical engineering is a versatile scientific discipline that is constantly evolving to meet new challenges. One of the contemporary directions is physiology and medicine, where research methods known from process engineering of dispersed systems are widely applied. Selected concepts and applications in this field are presented.***

Keywords – system engineering, fluid flow, mass transfer, dispersed systems, biomedical applications

Introduction

Chemical engineering (ChE) finds its many applications in the chemical industry and related technologies such as energy, pharmaceuticals, food, advanced materials, environmental protection, etc. This is because ChE is a comprehensive scientific discipline based on quantitative analysis of fluid flows, mass and heat transfer, process systems engineering, surface phenomena, biotechnological processes and others. Thanks to the broad spectrum of methods developed to efficiently solve the above problems, ChE methodological tools are also easy to use in various physiology and medical issues, helping to develop more effective diagnostics or therapies. Today, many chemical engineering departments around the world are expanding their profile, which is sometimes evident in their name changes to "chemical and biological engineering" or "chemical and biomedical engineering." These new areas are also reflected in the activities of the European Federation for Chemical Engineering (EFCE), which established a new Scientific Section "Chemical Engineering in Application to Medicine" (ChE-Med) in 2022. During the first thematic meeting in December 2022 in Paris, organized within the framework of the European Forum for New Technologies (EFNT), several papers were delivered, indicating the broad thematic scope of this Section. Activity on this topic has expanded with webinars announced as "Spotlight Talks" as part of EFCE activities (May 2023). This communication highlights selected "hot topics" to show the main directions of ChE skill set applications in current medical challenges.

New challenges and methodologies

The most important applications of chemical engineering in medicine are listed in Table 1. It can be noted that there is some overlap between some of these topics. For example, in assessing the health effects of inhaled aerosols, the engineering of dispersions must be analyzed along with the phenomena of fluid flow and mass transfer. [1]. The basic requirement for inhalation therapy is a reliable and reproducible method of producing micrometer-sized particles (or droplets) that will effectively introduce a dose of drug into various levels of the respiratory system during the oscillatory airflows typical of breathing [2].

Many other ChE applications in solving problems of medicine can be discussed in more detail, according to the topics shown in Table 1. Several of these problems are studied at the Warsaw University of Technology, and some examples are listed as references. However, it should be noted that discussing the applications of ChE in medicine ignores pharmaceutical technology, which falls under the scope of classical chemical and bioprocess engineering which is focused on industrial production processes and product engineering issues.

Table 1. Main areas of ChE application to physiology and medicine

ChE research area/topic	Methods and their applications to medicine
Process system engineering (PSE)	Quantitative analysis of the human body or selected organs treated as a network of mass exchangers and bioreactors. Diagnosis, prognosis, therapy design, disease control [3]
Mass transfer kinetics	Studies on drug or toxin release and biotransformation for different intake routes. Pharmacology and/or toxicology [4]
Engineering of dispersed multiphase systems	Development of stable dispersions (such as multiple emulsions, liposomes, loaded nanocapsules, functional nanoparticles, nanobubbles) with controlled drug release drug delivery: concept, design, preparation and scaling-up [5, 6]
Engineering of functional materials	Development of materials with hemocompatible and functional surface properties for the use in artificial organs and scaffolds [7]
Fluid flow and CFD	Examples: (i) blood in cardiovascular system [8]; (ii) air/aerosol in the respiratory tract; (iii) bronchial mucus and pulmonary surfactant on the surface of the respirtatory tract [1]

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