FEATURES OF BIOSENSOR APPLICATION FOR MONITORING AND CONTROL OF BIOPHARMACEUTICAL PROCESSES

Luhova K.V., Belinska A.P., Bielikh I.A.
National Technical University
"Kharkiv Polytechnic Institute," Kharkiv

Modern biosensors are highly sensitive analytical devices that combine a biological recognition element with a physicochemical transducer, enabling real-time monitoring of key biotechnological process parameters [1]. Their application in industrial biotechnology is a promising direction for improving the efficiency of biopreparation production, as they provide continuous control of physicochemical and biochemical indicators without the need for sampling. In modern biotechnological production, various types of biosensors are utilized: enzymatic (based on immobilized enzymes), microbial (using whole cells), immunological (relying on antibody-antigen interactions), and DNA sensors [2]. The most effective approach is the combined use of different biosensor types at critical points of the technological process: in the fermentation system – for monitoring substrate and product concentrations; in the purification line – for controlling the efficiency of target product isolation; and in the sterilization system – for detecting microbial contamination.

Automated control systems (ACS) based on programmable logic controllers (PLCs) with integrated biosensor modules allow real-time adjustment of bioprocess parameters [1]. Particular attention is given to optical biosensors that utilize surface plasmon resonance, enabling high measurement sensitivity without the need for substance labeling. A key challenge in biosensor application is their instability during prolonged fermentation processes, which may lead to calibration drift. To address this issue, situational control systems (SCS) are recommended, integrating data from biosensors, conventional pH, temperature, dissolved oxygen sensors, and machine vision systems [1]. Such systems employ artificial intelligence algorithms to compensate for measurement errors and predict bioprocess dynamics. An important aspect of biosensor technology implementation is the development of specialized bioreceptor elements stabilized using nanoparticles or polymer matrices. The introduction of wireless biosensor systems with remote monitoring capabilities significantly enhances the flexibility of biotechnological production management.

Research has shown that the use of biosensors combined with modern ACS can increase biotechnological process efficiency by 25 – 30 % and reduce analytical control costs by 40 – 45 %. Further development of microfluidic biosensor platforms and systems based on synthetic biology opens new prospects for creating "smart" biotechnological production facilities.

References:

1. Kumar M. A. Biosensors and Automation for Bioprocess Monitoring and Control / A. M. Kumar. – Lund : Media-Tryck, 2011. – 160 p.
2. Gerzon G. Process Analytical Technologies – Advances in bioprocess integration and future perspectives / G. Gerzon, Y. Sheng, M. Kirkitadze // Journal of Pharmaceutical and Biomedical Analysis. – 2022. – Vol. 5. – P. 1-11.