State-of-the-art mass spectrometry for biomedical research and practice

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The solution of the Nobel Prize-worthy problem of "*development of soft desorption ionization methods for mass spectrometric analyses of biological macromolecules*" [1] found by physicists at the end of the XXth century seems to be a deep history now. During the twenty years past the invented tools were successfully applied to advancement of both basic natural sciences and commercialization of analytical applications. A set of so-called "Omics" sciences, first of all Proteomics [2], followed by Lipidomics, Metabolomics, Glycomics, Peptidomics, Genomics, etc., based on mass spectrometric identification of the corresponding classes of biomolecules, has been formed, and basic studies of biopolymers in the gas phase are currently in progress. The main up-to-date challenges are miniaturization of mass spectrometric instruments for field applications, development of "ambient" mass spectrometry, and imaging techniques.

Various methods of sputtering or desorption of biomolecules from real biological samples, such as cells, tissues, parts of plants, human skin and even small insects and animals directly at ambient (atmospheric) conditions are passing tests. The approaches under elaboration are harnessing the "*Nobel*" achievements, e.g. extraction of material from biogenic surfaces into droplets of aerosol produced by electrospray or dissolution of the species sputtered by a laser from the biological matter into electrosprayed droplets. Noticeable funding of the related biomedical projects is provided by cancer research organizations; the most challenging application here is distinguishing of healthy and malignant tissues on the basis of mass spectrometric analysis of biomarkers, on-line laser ablated directly from the organism in the course of surgical operation.

Mass spectrometric imaging techniques, complimenting spectroscopic imaging, permit to establish distribution of various biomolecules over the surface of any object of inorganic, plant or animal origin. The most interesting basic information obtained using these techniques includes monitoring of appearance of new compounds in the course of development of animal embryos or growth of plans from seeds, movement of nutrients over a plant, expansion and distribution of drugs and their metabolites in different organs of a human body, production of antibiotics by microorganisms. Special attention is given to cancer research, including establishing of the disease molecular biomarkers.

In forensic sciences research mass spectrometry permits detection of explosives, chemical hazards, drugs at the level of imaging of fingerprints or a single hair. An exciting topic is origin of life, where mass spectrometry contributes both to identification of products of model experiments on prebiotic organic synthesis and to search of organics in meteorites and samples delivered from space missions.

The contribution of biophysicists of the ILTPE of NAS of Ukraine to this area consists in the mass spectrometry-based elucidation of molecular mechanisms of biomolecule-drug interactions, investigations of biomolecules interactions with nanomaterials [3], and cryobiophysics-related model experiment at low temperatures.

[1] Advanced information on the Nobel Prize in Chemistry 2002. [Cited 2020]. Available from URL: https://www.nobelprize.org/uploads/2018/06/advanced-chemistryprize2002-1.pdf .
[2] A. T. Lebedev, K. A. Artemenko, and T. Yu. Samgina, Osnovy Mass-Specktrometrii Belkov i Peptidov (Tekhnosfera, Moscow 2012).
[3] V. A. Karachevtsev (Ed.), Nanobiophysics: Fundamentals and Applications (Pan Stanford Publishing, Singapore 2016).