Sense and sensitivity: SERS-based assessment of mitochondrial bioenergetics

N. A. Brazhe[1], E. I. Nikelshparg[1], A. A. Semenova[2], E. A. Goodilin[2,3], A. A. Baizhumanov[1], S. M. Novikov[4], G.V. Maksimov[1], O. Sosnovtseva[5]*

[1] Biophysics Department, Biological Faculty, Moscow State University, Moscow, Russia
[2] Department of Nanomaterials, Faculty of Material Sciences, Moscow State University, Moscow, Russia
[3] Department of Inorganic Chemistry, Faculty of Chemistry, Moscow State University, Moscow, Russia
[4] Laboratory of Nanooptics and Plasmonics, MIPT, Dolgoprudny, Russia
[5] Department of Biomedical Sciences, Faculty of Health and Medical Sciences, University of Copenhagen, Denmark
[*] E-mail olga@sund.ku.dk

Selective and sensitive investigation of components of the electron transport chain in functional mitochondria is important for fundamental biophysical research and for development of new biomedical diagnostic tools. Up-to-day methods – fluorescent microscopy, absorption spectroscopy and registration of oxygen consumption – provide only indirect information about the redox state of electron transport chain complexes. We suggested a novel label-free approach based on the surface-enhanced Raman spectroscopy (SERS) to monitor conformational changes and redox state of cytochrome *c* in electron transport chain of functional mitochondria [1]. We demonstrated that hierarchical silver nanostructures ensure intensive enhancement of Raman scattering of cytochrome *c* in mitochondria without affecting their morphology and respiration [2]. Our studies revealed:

- High *sensitivity* of SERS spectra of cytochrome *c* in mitochondria to the activity of complexes of electron transport chain, to the rate of ATP synthesis, to mitochondrial membrane potential, and to mitochondria morphology;
- High *selectivity* of different wavelength laser excitation to access certain alterations: (i) redox transitions in cytochrome *c* (488 nm); (ii) conformational and motility changes in heme of cytochrome *c* (514 and 532 nm), (iii) redox and conformational properties of cytochromes a/a3 (633 nm), and (iv) state of outer mitochondrial membrane (785 nm);
- High *detectability* of pathological changes; SERS methodology allowed to trace the differences in cytochrome *c* of functional heart mitochondria in control and spontaneously hypertensive rats. This opens new perspectives for development of SERS-based tools to follow the progression of cardiovascular diseases.

References

[1] N. A. Brazhe, A. B. Evlyukhin, E. A. Goodilin, A. A. Semenova, S. M. Novikov, S. I. Bozhevolnyi, B. N. Chichkov, A. S. Sarycheva, A. A. Baizhumanov, E. I. Nikelshparg, L. I. Deev, E. G. Maksimov, G. V. Maksimov, O. Sosnovtseva, S*cientific Reports* **5,** 13793 (2015).

[2] A. S. Sarycheva, N. A. Brazhe, A. A. Baizhumanov, E. I. Nikelshparg, A. A. Semenova, A. V. Garshev, A. E. Baranchikov, V. K. Ivanov, G.V . Maksimov, O. Sosnovtseva, E. A. Goodilin, *J. Mater. Chem. B* **4**, 539-546 (2016).