2018 Helmholtz – OCPC – Program
for the involvement of postdocs in bilateral collaboration projects

PART A

Title of the project: Electrochemical nanosensor systems for detection of reactive oxygen species in biological systems based on biomimetic reactivity of manganese, copper, and palladium porphyrin complexes and their nanostructures.

Helmholtz Centre and institute: Forschungszentrum Jülich, Institute of Complex Systems, Bioelectronics (ICS-8)

Project leader: Dr. Yulia Mourzina

Web-address: http://www.fz-juelich.de/ics/ics-8/EN/Home/_node.html
http://www.fz-juelich.de/ics/ics-8/EN/Research/Biosensing/BiochemicalSensors/_node.html

Description of the project:
The physiological significance of a series of intermediates of oxygen reduction, reactive oxygen species (ROS), together with a need for better understanding of their generation and utilization in cells and tissue in physiological and pathological processes, and in therapy requires the development of devices for their quantification with high spatiotemporal resolution. ROS include superoxide anion radical, $O_2^{-}\cdot$, hydrogen peroxide, H_2O_2, hydroxyl radicals, HO·, and are associated with the principle of oxidative stress, which suggests ROS damage lipids, proteins, DNA, and induce various pathologies. On the other hand, ROS are also signaling molecules to regulate biological and physiological processes.

ROS extremely reactive and have very short half-lives, which make them difficult to detect. Due to limitations of spectroscopic techniques (fluorescence, electron paramagnetic resonance, and chemilumenescence) electrochemical sensor systems are prospective for the detection of ROS due to their applicability for real time *in vitro* and *in vivo* measurements, miniaturization, cost effectiveness, and high spatiotemporal resolution achieved by electrocatalytic reactions at electrode surfaces and signal amplification techniques. Progress in electrochemical detection of ROS has been achieved with biosensors utilizing metalloporoteins (cyt *c*) and enzymes (superoxide dismutase, horseradish peroxidase). Development of non-enzymatic sensors based on biomimetic metalloporhyrin complexes [1-3] is very prospective due to their lower costs, much higher stability in fabrication and long term use, and compatibility to nanotechnologies.

The project focuses on the development and complex investigation of processes responsible for functioning of the electrochemical nanosensor systems based on novel biomimetic sensor and transducer materials for monitoring ROS in biological systems with high spatiotemporal resolution. The project encompasses:

- Study the biomimetic reactivity of manganese, copper, and palladium porphyrin complexes and their nanostructures as sensor materials for detection of ROS.

- Fabrication and characterization of sensor-transducer devices based on various transducer nanomaterials (carbonaceous and metallic nanomaterials).
- Investigating the structural, morphological, and electrochemical properties of transducer and sensor nanomaterials by analytical and spectroscopic techniques.
- Study of the mechanisms of the sensor response of a series of metalloporphyrin complexes and their nanostructures mimicking catalytic activity of antioxidant enzymes (peroxidase, superoxide dismutase, catalase). Attention will be given to the fundamental challenges of the sensor analysis by modern electrochemical systems. This includes the establishment of the processes and mechanisms responsible for the sensor selectivity, sensitivity, reproducibility, and speed of response, and effectiveness of the electron transfer between metallomacrocycles, analyte, and nanostructured transducer depending on the structure of the porphyrin macrocycle.
- Study the analytical characteristics of the electrochemical sensor systems based on the novel materials for the analysis of ROS in biological systems in normal and pathological conditions: *in vitro* cultured HL-1 cardiomyocyte-like cell line, primary rat cardiomyocytes, and *ex vivo* primary embryonic rat heart tissue. The response of the biological systems to various stimuli such as electrical stimulation, ischemia/reperfusion conditions, and chemical stimulation with drugs will be studied using the developed sensor systems.

[1] K.G. Nikolaev, V. Maybeck, E. Neumann, S.S. Ermakov, Y.E. Ermolenko, A. Offenhäusser, Yu.G. Mourzina (2017) Bimetallic nanowire sensors for extracellular electrochemical hydrogen peroxide detection in HL-1 cell culture. *J Solid State Electrochem*. DOI: 10.1007/s10008-017-3829-3. **[2]** E. Koposova, X. Liu, A.A. Pendin, B. Thiele, G. Shumilova, Yu. Ermolenko, A. Offenhäusser, Yu. Mourzina (2016) The influence of meso-substitution of the porphyrin ring on enhanced hydrogen evolution in a photochemical system. *J. Phys. Chem. C* 120, 13873–13890. **[3]** X. Liu, E. Koposova, A. Offenhäusser, Yu. Mourzina (2015) Self-assembly of platinum nanoparticles and coordination-driven assembly with porphyrin. *RSC Adv.* 5, 86934-86940.

Description of existing or sought Chinese collaboration partner institute:

Chinese collaboration partner institutes who offer their research expertise and resources in nanoelectrochemistry, spectroelectrochemistry, development of (bio)electrochemical nanosensor systems, electrochemical transducers based on carbonaceous nanomaterials, sensor nanomaterials based on metalloproteins and/or porphyrinoid complexes, analytical and bioanalytical electrochemistry.

Required qualification of the post-doc:

- PhD in chemistry, physics, material science
- Experience with electrochemistry
- Additional skills in nanotechnology, coordination compounds

PART B

Documents to be provided by the post-doc, necessary for an application to OCPC via a postdoc-station:

- Detailed description of the interest in joining the project (motivation letter)
- Curriculum vitae, copies of degrees
- List of publications
- 2 letters of recommendation
- Proof of command of English language

PART C

Additional requirements to be fulfilled by the post-doc:

- Max. age of 35 years
- PhD degree not older than 5 years
- Very good command of the English language
- Strong ability to work independently and in a team