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Title:

Investigations of ring nanoelectrodes integrated into microwell arrays for the analysis of isolated mitochondria at the microscale

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Abstract:

Mitochondria are known to be the major cellular source for ATP (through the oxidative phosphorylation pathway) but also to play main roles into cell apoptosis and related disorders (ageing, neurological diseases, cancers,...). Consequently, new methodological approaches are resuired in order to decipher mitochondria metabolisms. In this context, we are investigating the ElecWell (electrochemical microwell) technological platform based on the integration of ring nanoelectrodes into microwell arrays. Similar to ultra-microelectrodes, they exhibit high current density, fast response time, reduced charging current and high signal to noise ratio. In addition, the use of small analysis volumes (< 1 pL) makes them well suited for the detection of exocytotic events or for the analysis of single mitochondrion. Consequently, platinum ring nanoelectrodes (RNE) (surface: 10-15 µm²) were integrated into SiO₂-based microwells (radius: 3 and 4.5 μ m, depth: 5.2 μ m, total volume: < 1 pL, figures 1 and 2). These electrochemical devices were characterized by cyclic voltammetry in Fc(MeOH) solutions using single well or arrayed configurations, and optimised according to COMSOL[™] simulations. Steady-state sigmoidal responses were shown for RNE devices in agreement with theoretical models and design laws were defined for RNE arrays in the frame of mitochondria statistical analysis. Finally, the ElecWell platform was tested for the mitochondrial analysis (figure 3), allowing the electrochemical monitoring of oxygen consumption rate in response of specific drugs (ethanol, ADP, antimycine A) for several thousands of mitochondria (figure 4).





Fig. 1: Integration of platinum ring nanoelectrodes into a SiO₂-based microwell (radius: 3 µm)

Fig 2: Fabrication of RNE-based devices onto glass substrates



Fig. 3: Fluorescent analysis of mitochondria deposited on a RNE-based microwell array

