Electro-conducting nanoarchitectures to assemble (bio)electrocatalytic structures as basis for efficient and stable biofuel cells.

The past decade has witnessed an exponential growth in research related to wearable devices that provide continuous information to the wearers. The global wearable technology market size is projected to grow from USD 116.2 billion in 2021 to USD 265.4 million by 2026. The major limiting factor to the growth of the wearable technology market is the absence of a reliable and efficient battery system that could be easily worn without compromising on the compactness and ease of use of the device. Biofuel cells are devices that use biocatalysts (enzymes, organelles or whole cells) to convert chemical energy into electricity. Enzymatic biofuel cells (EBFCs) have high current and power densities and are an interesting alternative energy source for wearable devices.
The most popular EBFC is a glucose biofuel cell. It is composed of two bioelectrodes: a bioanode where the electrochemical oxidation of glucose occurs, and a biocathode where oxygen is electrochemically reduced to water. Multicopper oxidases i.e. laccase, bilirubin oxidase or ascorbate oxidase catalyze the reduction of dioxygen to water without generating oxygen intermediates. Glucose oxidase or glucose dehydrogenase is used as an anodic enzyme. Both, glucose and oxygen are present in body fluids, e.g. sweat, and can be used to feed biofuel cells for wearable devices. The main goal of research in this field is to improve the stability and efficiency of the biofuel cell and to adapt the composition and structure of the bioelectrodes to work as ready-to-use epidermal wearables. The use of flexible and mechanically stable materials safe for the skin is equally important in the construction of biofuel cells.
In this proposal, we intend to improve the glucose-oxygen biofuel cell performance by adopting three main approaches: the proper electrode support, chemical functionalization of bioelectrodes and automated production method.

One of the most important parameters in constructing new devices is their reproducibility. The electrode system will be prepared using the direct-printing technique by means of PROPlus/PRO Series Automated Dispensing Systems (microdosing robot), located in IBBE PAS. We are pioneers in Poland of this technique for biosensors manufacturing. The advantage of this technique is a full control at each stage of the electrode (or set of electrodes) preparation, starting from the possibility of modifying the composition of the pastes from which the electrode will be made by controlling the dosing process, and ending with the possibility of building multi-layer systems. Such automated process assures high reproducibility, low cost of single electrode and easiness of modifications of existing protocols. New designs and architectures for increased energy efficiency of biofuel cells are proposed in the project.