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POLYANILINE NANOBIODETECTOR

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Abstract. Specific changes in the electrical conductivity of a polyaniline micro- and nanofibril network in the presence of microorganisms have been observed. The electrical conductivity of polyaniline (PANI) micro- and nanofibrils is strongly dependent on the temperature and the chemical environment. Both are locally modified by living cells, and this makes it possible to use polyaniline micro- and nanofibril networks as highly sensitive single cell biodetectors. The electrical response depends on the number of cells deposited on the PANI nanonetwork (e.g. from far below 100 to 2000) and is specific for different kind of microorganisms. The sensor is designed to apply in search for extraterrestrial life, but it also can be used to detect any kind of bio-contamination on the Earth.

1. INTRODUCTION

Biodetectors are still in the centre of interest in many laboratories. They are constructed as devices with semiconductor silicone nanowires [1-4], carbon nanotubes [5-7] or polyaniline nanofibrils [8-15]. Nanosystems have also been used mainly as biosensors which are able to detect a number of biologically important compounds. These sensors have been fabricated as systems of nanofibrils intentionally modified with biologically active components covalently linked to nanofibrils [8,9]. Some of them work on a basis of quantum effects. Similar effects are expected to be responsible for a very high sensitivity of our PANI nanosensor which is not specifically modified. The device is simple and universal. Polyaniline is well known as one of polymers used in biosensors [8-15]. Polyaniline micro- and nanostructures have already been examined in our laboratory and applied in a choline sensor [8,9].

2. EXPERIMENTAL

The main part of the biodetector, a free standing polyaniline micro- and nanofibril network of a good electrical contact with two gold electrodes, has been fabricated with an electrochemical method at the potential of 0.8-1.2 V (vs. Ag/AgCl).

A small amount (2,5 mL) of a suspension of living cells in distilled water (e.g. yest at the concentration of 40000-780000 cells/cm^3) was dropped onto the working (PANI nanonetwork, below 2 mm^2 in size) and the number of cells deposited 100 to 2000. Then the electrical conductivity was measured in a function of time with an accuracy of ± 0.01 mS using a

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conductivity meter CC-501 (Elmetron). The values measusred were within the range of 10-3500 mS.

The same has been done with pure water (without any microorganisms) as a blank test. The results of measurements were plotted and analyzed *vs* a blanck test as an electrical response of the detector.

3. RESULTS AND DISCUSSION

The electrical conductivity of polyaniline as a bulk sample changes strongly with the temperature and the chemical treatment (doping) [16]. PANI micro- and nanofibries are exceptionally sensitive owing to their negligible heat capacity, extremely low volume and mass. The microenvironment (in a sub-micrometer scale) around the fibrils is easy to be modified by influence of single cells. On the other hand, PANI nanofibrils are highly anisotropic because of their reduced dimensionality owing to a very small thickness. The quantum effect makes nanofibrils highly conducting along the main axis, but not in a perpendicular (transversal) direction. Any changes in size in this direction caused by cells deposited break the quantum blocade and result in an increase in the electrical current flow between nanofibrils. Changes in the current flow in PANI nanofibrils caused by a field effect (FET) in the presence of cells (cell membrain-PANI fibril interactions) should also be taken into account [17].

All the effects are multiplied by the number of cells deposited on PANI (Fig. 1) and can be measured as global changes in the electrical conductivity of the nanonetwork. Direct electrical contact of the surface of cells and PANI nanofibrils (Fig. 2A, B) enables us to measure a specific contribution of the cells to the total electrical conductivity of a system. The system is based on a relatively low number of direct electrical contacts with isolated cells (a small PANI micro- and nanofibril network, below 2 mm^2 in size, has been used as a working area of

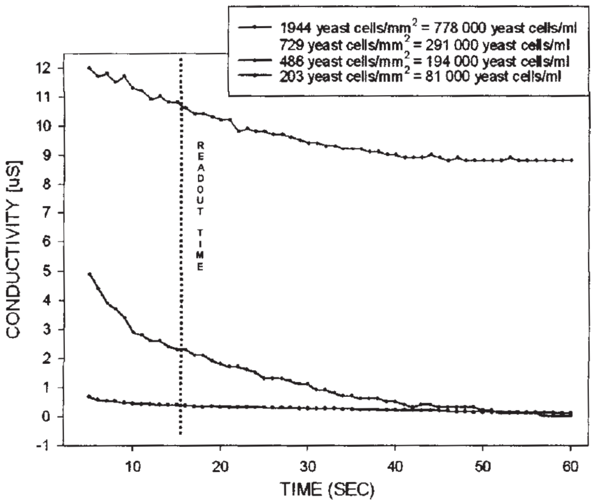

Fig. 1. The measured electrical conductivity of the nanonetwork is changed by the number of cells deposited on PANI nanofibrils.

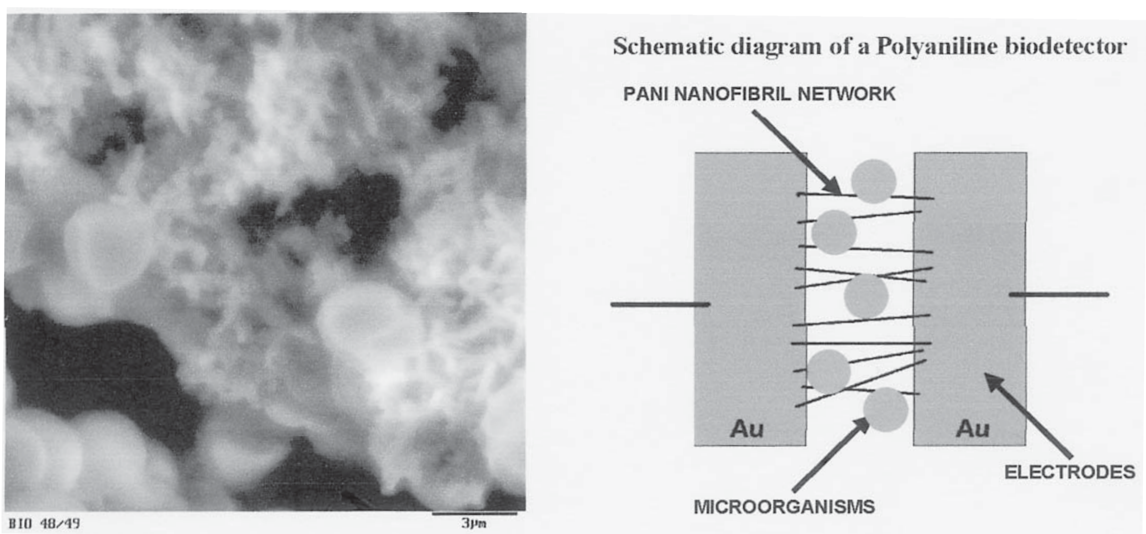

Fig. 2. (A) A direct electrical contact of the surface of cells and PANI nanofibrils enables to measure a specific contribution of the cells to the total electrical conductivity of a system. (B) The system is based on a relatively low number of direct electrical contacts with isolated cells.

the sensor), what makes it highly sensitive (below 100 cells can be detected).

Specific properties of cells, including their biological activity, give a potential to distinguish between different type of cells. This is a very important feature of the sensor which is currently examined.

The dynamic electrical response of the sensor for yeast cells depends almost linearly on the number of cells deposited (e.g. 100-2000) which is a function of their concentration in water suspension used in the experiments: 40000-780000 cells/cm^3 (Fig. 3). This Is a proof that the signal observed (changes in the electrical conductivity of PANI nanonetwork) is really linked to the presence of living cells. Minimum number of cells to be detected by the sensor examined is below 100 and it is expected to be lower in the future.

The samples for testing are in the form of a suspension in water or an aerosol. The results can be obtained within 15 s or even less. Thus, the method is very fast and It can be applied in the field, when the instrument is designed as a small, light and easy to handle device.

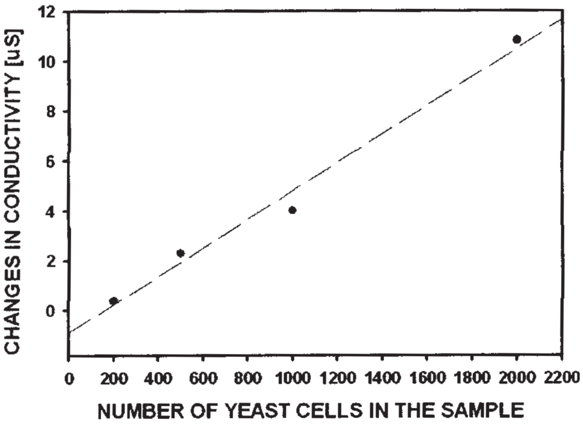

Fig. 3. The electrical response of the sensor for yeast cells depends almost linearly on the number of cells deposited.

4. CONCLUSIONS

Changes in the electrical conductivity of polyaniline nanofibril network, caused by microorganism cells are almost linear function of the concentration of the cells deposited. High sensitivity of our nanobiodetector is very promising, implying a use.

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