Nanoantenna Project Publishable summary
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Development of a nanobiosensor dedicated to early disease diagnosis

www.nanoantenna.eu

Project context and Objectives

Despite some recent advances, the detection of traces of biological species in medical diagnosis remains a challenge at the European level. Biological sensors able to detect specific biological species need further progress, not only new technical solutions but also applications of new ideas and more sensitive methods. Indeed, the detection of biomarkers specific to some diseases for example can be of real importance for medical diagnosis. A large number of disease biomarkers are proteins and their presence in body fluids (blood, plasma, saliva…) are considered as indicators of the presence of some diseases. Thus, their detection is a key point in order to enable physicians to provide quickly the right therapy and their detection in low concentration could enable the early diagnosis of serious diseases.

Low-cost label free detection devices with a very high sensitivity and selectivity will help remove that bottleneck if used on a wide scale. Due to their complexity, the design of such devices requires an interdisciplinary collaboration as well as complementary expertises between research groups that cannot be found at a single laboratory level.

It is in this context that the Nanoantenna consortium made of twelve partners combining physicians, biologists, chemists and physicists was created. Taking profit of the most recent advances in nanotechnologies, surface engineering and biotechnologies, the Nanoantenna project is a three-year European multidisciplinary project aiming at developing a highly sensitive and specific nanobiosensor based on extraordinary vibrational signal enhancement of molecules dedicated to the in vitro proteins detection and disease (cancer, cardiovascular or infectious diseases) diagnosis.

The project is based on a three-step principle as follows:

Nanoantennas

High sensitivity is reached with metallic nanoparticles, used as nanoantennas. When excited by an incident light, they have the ability to enhance locally the vibration signal of molecules deposited on the nanoparticle surface. For one resonantly excited nanoparticle, this enhancement enables the observation of a very few quantity of proteins.

Bioreceptors

High molecular selectivity is reached with the functionalisation of the nanoantenna with specific bioreceptors. Such functionalisation will selectively catch the protein to be detected at the vicinity of the nanoparticle surface, providing the best enhancement and then the detection of the targeted protein.

Nanobiosensor

Each functionalised nanoantenna device is an individual and specific nanobiosensor of proteins. As a consequence, the nanobiosensor will allow the detection and the analysis of the targeted proteins and thus can be integrated in a diagnosis process.

The following figure gives an illustrative explanation of the sensor principle:

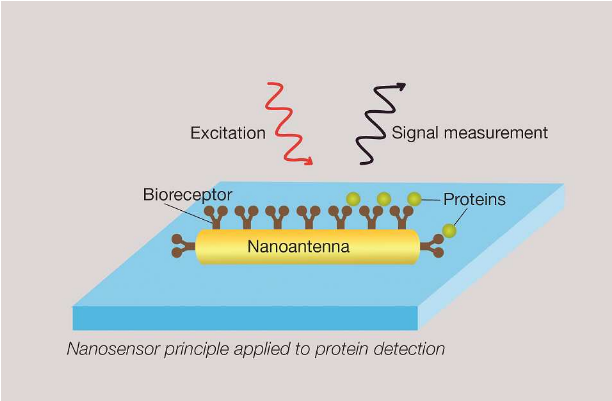

Figure 1: Nanosensor principle applied to protein detection

Work performed and main results so far

The first step of the project is dedicated to the determination of the spectral signature of the proteins to be detected by the nanobiosensor. For the purposes of the project, four different proteins with relevant applications in the medical field had been chosen: MnSOD and MMP2 (both involved in liver cancer development or in atherosclerosis), GIPC-1 (upregulated in breast and ovarian cancers) and Ebna-1 (actual biomarker of the Epstein-Barr related malignancies leading to viral infections diseases). At the beginning of the project a careful analyzis of these proteins started with the aim of acquiring a database of their related vibrational fingerprints. Some experiments are still being conducted in order to obtain a complete record of the proteins' spectra, so that in a few months, only two out of the four proteins with the most reliable signal will be chosen.

The second step of the project is dedicated to the transducer optimisation and thus on the optical properties of the metallic nanoantenna devices. Up to now, many results have been obtained concerning the nanoantennas optical properties. Modelling results have also been obtained showing the feasibility of the nanoantenna concept. Optimization results regarding the size of the nanoantennas in order to reach the maximum enhancement will soon permit to estimate the optimum geometric parameters of the nanoantennas for specific enhancement wavelengths.

The bioreceptor optimisation leading to the specific functionalisation of the nanoantennas constitutes the third step of the project. Fab functionalisation has started and experiments are still being conducted with different molecules.

A fourth step aims at combining all the results obtained during the first three steps by integrating them to develop a nanobiosensor prototype. Several tests have already been conducted to determine the prototype characteristics. Based on further results the prototype characterisation will be completed.

In terms of communication and dissemination, in the project framework a complete range of dissemination tools have been put in place: a website presenting the project, a restricted area for project members serving as an exchange platform, a leaflet promoting the project, a Wikipedia page has been open, workshops were organised (one Summer School, two Symposia with external invited speakers). Project members regularly attend meetings, national and international conferences to talk about scientific aspects of the project and present their results. Several articles have already been published in international journals. In the near future it is planned to write a newsletter to disseminate information about the first results obtained.

At mid-term of the project, many significant results have already been obtained. In less than one year, decisions will be taken to determine the exact characteristics of the prototype which will be then validated by experiments. Up to now, thanks to the project a strong dynamic has been developed between the involved researchers giving them the possibility to communicate, exchange and disseminate their results with other researchers having different backgrounds. It has allowed so far for instance students, PhD, post-docs, to extend their knowledge by visiting other laboratories working with different techniques.

The expected final results and their potential impact and use (including the socio-economic impact and the wider societal implications of the project so far)

The final results of the project (the developed nanobiosensor) will constitute a real advance in terms of early medical diagnosis and will therefore open a way to its potential commercialization. With the involvement of industrial partners in the consortium, the project will contribute to strengthen the European competitiveness in the biotechnology sector. In the end, it will contribute to improve European citizens' quality of life.