Multifunctional Nanodevices for Detection, Elimination and Killing of Pathogens from Living Enviroments

K. Zuzek Rozman, D. Pecko N. Kostevsek, S. Kobe, S. Trafela
Odsek za nanostrukturne materiale
Institut Jozef Stefan
Jamova 39, 1000 Ljubljana
tina.zuzek@ijs.si, darja.pecko@ijs.si, nina.kostevsek@ijs.si, spomenka.kobe@ijs.si, spela.trafela@ijs.si

ABSTRACT: *For the purpose of detecting and eliminating pathogenic organisms from air and water, we offer the production of bioreceptor elements for sensors. We will upgrade the sensor systems in cooperation with Institute of Environment and Sensors.*

Keywords: Bioreceptor Elements, Sensors, Water Purifiers

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1. Introduction

One-dimensional magnetic nanostructures, i.e. magnetic nanoparticles or nanowires, can be activated and manipulated to remotely using low external magnetic fields, where possibly their size and shape precisely experimental determine and control in the range of several nm to several hundred nm. V this size class also includes biological entities such as: cells, bacteria, viruses, enzymes, genes or cellular receptors, therefore, magnetic nanowires are suitable for use in sensor technologies and pathogen elimination (bacteria, viruses) from different environments useful for both households as further education and infrastructure, schools, kindergartens, retirement homes, hospitals, etc. Here we also see the advantage of using hybrid magnetoplasmnons nanostructured materials that we develop at Nano for Nanostructured Materials for use in aspect smart cities and smart communities with a vision of sensitive development sensor devices that will simultaneously detect as well as eliminate possible pathogens from living environments: water, air. The advantage the use of nanomaterials is in their specific structure from which specific physical and chemical properties are derived which further allow to improve the performance of devices in sensitivitydetection and elimination efficiency.

The topic is placed in the PAMETSKUP Strategy, in Technology areas.

Supportive open technologies and activities: T.1 New sensor materials and in Public spaces and participatory: J.4 Monitoring quality of living parameters.

The following references are very important for this task.

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2. Proposed Project Idea

The interest in functional materials of the order 1-100 nm is associated with their novel physical and chemical properties and their potential for introducing highly innovative and marketable technologies with major applications in health, diagnostics and therapies, environmental, information and communication, engineering, energy, electronics, chemical and living environment industries among others.

By exhibiting large aspect ratios and quasi-one-dimensional features nanowires and nanotubes can be built into light weight and portable but still high-density devices, with optical, optoelectronic, electric and magnetic properties diverging from bulk counterparts, due to quantum confinement and thermal effects. While optical properties were found to be particle size and shape dependent, the superparamagnetic limit has been recognized to depend on the systems crystal anisotropy, which can be overcame by induced anisotropy coming from nanomaterial's shape. This translates that the optical and magnetic properties of nanowires/nanotubes can be customized by controlling their morphology and size. The optical part finds applications in bio sensing since it is known that so called hotspots, which are represented by localized regions formed within the interstitial cavities in metallic nanostructures, provide extraordinary enhancements (of up to 1015) of signals due to surface enhanced Raman scattering (SERS) [2] which results in very small detection limits; and furthermore in phototherapies where pathogens' killing is triggered with light-to-heat energy conversion at visible or near infrared wavelength.

Proposed bottom up synthesis approach via electrochemical or chemical reduction offers broad flexibility regarding the nanowires' or/and nanotubes' material and surface functionalization; before assembly on the chip surface. However, the ability to magneti-cally manipulate and extract such structures makes them appealing and well suited for controlled assemblies of multifunctional nanostructures for complex networks for sensor devices. The length of each nanotube/nanowire segment can be controlled the synthesis parameters, with further functionalization being dependant on the chemical affinity between the metallic parts and the targets/pathogens used. For instance, Au, Ag, Cu, Hg and Fe are known to have strong affinity with the thiol groups, Pt and Pd on the other hand have strong affinity with the cyanides and metal oxides bonds with the carboxylic group as well as oligonucle-otides or antibodies therefore they are well suited as sensors for multicomplexed assays. By combining two entities in a single nanosystem composed of optically active Ag and Au segments aiming at hot spots, which will be realized via selective etching for enhanced sensitivity and photoinduced therapy; with Fe-based alloys enabling the magnetic manipulation, we are going to construct a multifunctional detection-, extraction- and killingbased nanodevice founded on the model system of a pathogenic bacteria E. coli in collaboration with Seoul National University, Mechanical and Aero space engineering, Department Member, Seoul, South Korea. The bacterial detection and capture experiments will be performed by multifunctional nanotubes/nanowires functionalized with carboxylic groups on which NH2 modified anti- E.coli aptamer will be bound which will be proved by using SERS and extracted from the system using the means of external magnetic fields which will be followed by a subsequent bacteria killing triggered via light induced heating in the visible or near infrared spectra.

References

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