ILSES Report Summary

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Periodic Report Summary 1 - ILSES (Metal nanoparticle interactions with bioorganic molecules and their applications in biosensing)

Present project "Metal nanoparticle interactions with bioorganic molecules and their applications in biosensing" includes 4 workpackages. They implied such style of work when host groups act together with visiting experienced and young scientists from the institutes of Project Consortium.
Such stuff exchange allows better realization of scientific and organizational tasks, exchange by scientific experience and good practice between several scientific groups engaged in the project work. By the time of half-period project report 20 scientific secondments were realized. They are described relatively to the project objectives, work packages and their specific tasks.

Workpackage 1 aimed development of the Surface Enhanced Spectroscopy (SES) laboratory. SES laboratory was organized as a community of scientists working with Surface Enhanced Raman Scattering (SERS) and Surface Enhanced Infrared Absorption effects (SEIRA). Thus mutual exchange of stuff between these groups was realized for the transfer of good scientific experience in work with infrared and Raman equipment and training of young scientists. In frame of this work package visits of young scientist V. Boiko to Tartu University and visit of Prof. G. Dovbeshko to Turin University were realized from Ukraine. In the course of visit to Tartu University it was discovered (DOI:10.1186/s11671-015-0781-y) that photonic crystal formed from close-packed nanoparticles can selectively enhance both intrinsic fluorescence of crystal and signal from organic analytes such as deoxyribonucleic acid loaded in cavities between nanoparticles. The series of experiments proving pronounced SEIRA effect for bovine serum albumine (BSA) adsorbed on the nanostructured gold were realized during the vist of Prof. G. Dovbeshko to Turin University. At the same time infrared signal from BSA adsorbed on the nanoparticles of hydroxyapatite was moderate. These results were represented at the international scientific conference NANO-2015, August 26 - 29, 2015, Lviv, Ukraine.

The objective of workpackage 2 is functionalization of nanoparticles by organic molecules and obtaining novel data about interactions of nanostructures with biomolecules. To achieve this aim 7 exchange visits took place in directions from Ukrainian and Russian partners to EU Partners and vice versa. Particularly, during the visit of young Ukrainian researcher A. Rynder to French Partner, it was demonstrated that gold nanoparticle modified by organic shell can be driven by electric voltage from the sharp tip of scanning tunneling microscop in regime in which the electric current is controlled electron by electron (Coulomb blockade). The prospects of this result for the using in sensing devices and molecular switches were represented at the international scientific conference NANO-2014, August 23-30, 2014, Yaremche-Lviv, Ukraine and published in scientific papers (DOI: 10.1021/la5029806, DOI: 10.1021/la5030058). Saying about collective electronic oscillations, it was shown and reported at the SPP7 conference, May 31-June 5, Jerusalem, Israel (https://events.eventact.com/programview/ViewAbstract.aspx?Abst=90529&Code=1615680) that decrease in size of metal nanoparticles from hundreds to tens nanometers causes transformation of surface plasmon-polariton waves to localized surface plasmons. Using of localized plasmons for control of fluorescence (DOI: 10.1186/1556-276X-9-143) and light absorption in solar cells (DOI:10.1007/s00339-014-8681-z, DOI:10.1016/j.surfcoat.2015.01.036) was investigated and reported in collaboration with Estonian scientific groups of Tartu and Tallinn Universities.
Moscow researchers from General Physics Institute D. Pominova and R. Pishchalnikov experimentally and theoretically investigated fluorescent behaviour of phtalocyanine and pheophorbide photosentisizers capped on the gold nanoparticles. These photosensitizers are prospective for the medical treatment of cancer. Experiments were done during the visits of D. Pominova and R. Pishchalnikov to the Applied Physics Institute, Johannes Kepler University, Austria.
Curing of cancer cells is strongly dependent on the permeability of their membranes for the drugs. The search of optimal geometry of noble metal nanoparticles for the sensing of switchable membrane proteins was carried by Austrian researcher Dr. C. Hrelescu during his visit to the Houston Medical School at the University of Texas, USA. During the visit of young Italian researcher P. Ivanchenko to the same Medical school it was revealed that not only noble metal, but also hydroxyapatite nanoparticles can improve spectral signal from the protein, particularly bovine serum albumin molecules.

The aims of workpackage 3 are oriented on the applications effects revealed in workpackage 2 for optical sensing. So the tasks of workpackage 3 logically follows from the results of workpackage 2. In this sense the results of secondments of Estonian Prof. Yu. Orlovskiy and young researcher E. Samsonova to General Physics Institute are

important. Because they were devoted to the application of fluorescent nanoparticles to practical visualization of cancer diseases by means of laser fluorescent diagnostics. In collaboration with Moscow scientists they prepared rare earth doped nanoparticles and revealed that for their effective using quenching of fluorescence by OH groups adsorbed on their surface should be avoided (DOI: 10.1039/c4cp03774j). The reciprocal visits of Moscow scientists Prof. V. Loschenov and Dr. A. Ryabova to Estonian colleagues aimed the selection of the most optimal stoichiometric ratio of components in the host material of nanoparticles providing the most effective fluorescent properties. The further work in this direction is in process.
Spectral sensing of bacteriochlorin photosentisizer and protein molecules on the nanostructured noble metal surfaces by SERS and SEIRA methods was realized during the scientific secondment of Moscow young researches I. Romanishkin and A. Borodkin to the Free University of Berlin, Germany. They obtained nice training and important experience in time-resolved UV/Vis spectroscopy, measurement of absorption kinetics after laser excitation (bacteriochlorin in solution and nanoparticle forms), time-resolved IR absorption spectroscopy of biological molecules using quantum-cascade laser. During the reciprocal visit of early stage researcher Cynthia Vidal to Moscow the Au nanoparticles shaped as nanostars and covered by fluorescent dye were examined for the visualization and treatment of organic cells.

Finally the objective of workpackage 4 is exchange of experience and practice in implementation of scientific achievements to the technologies and their commercialization. Technology transfer (TT) experts from TT Department of the Institute of Physics of NAS of Ukraine (IOP) Yevhen Kifiuk and Roman Nyshchyk visited the University Pierre et Marie Curie (UPMC) for 18-27 June 2014 within the frame of ILSES Project, Work Package 4, task 4.1. This task 4.1 provide staff exchange of R&D managers experienced in technology transfer and commercialization of developments for exchange of good practices and analysis of organization of management system of R&D projects, intellectual property protection and technology transfer. Therefore the secondment was devoted to the visit of the innovation and business relations departments at UPMC, where TT experts of UPMC shared their knowledge on tracking patents, managing licenses, creation of innovative start-ups etc. The following meetings at UPMC took place: meeting with specialists from TT office of Research and Technology Transfer Department (DGRTT) - Arnaud Boissiere and Anais Desclos, expert from Technology Transfer and Partnerships Office of UPMC - Julie Zittel, Intellectual Property Engineer - Rose-Marie Volmant. Also TT experts of IOP visited the laboratory of Professor Nicolas Treps who shared his experience on successful creation of start-up based on its promising inventions. The last meeting was appointed at the company SATT Lutech where Mr. Damien Bretegnier explained the concept of SATT Lutech activities which are working on selection of promising technologies in UPMC and other research institutions and their commercialization, protection of intellectual property, start-up creation etc. During these meetings the possibilities for joint submission of international collaborative projects were discussed and fruitful contacts were established.

It is expected that further implementation of the project will result in the development of novel nanostructured substrates for the sensing of biological molecules, particularly proteins and DNA, optimization of properties of prepared functionalized nanoparticles for their using in diagnostics and treatment of diseases, particularly malignant tumor.

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