Scientific Report on COST TD1003 thematic workshop

“Integrated approaches for biomolecular detection: nanostructures, biosensors and lab-on-chip devices”.

28 - 30 April 2014, Scuola Superiore di Catania, Catania, Italy

In agreement with the MC approval, the thematic workshop, entitled “Integrated approaches for biomolecular detection: nanostructures, biosensors and Lab on chip devices”, has been organized in Catania, Italy, from the 28 to 30 of May, by Giuseppe Spoto and Maria Minuni, Italian members of the Managment Commitee of the COST Action TD1003.

The workshop had three major topics and has last for one and two half days. Experts made presentations under different sessions, and time for discussion was allocated for each presentation. Sessions comprised four invited lectures given by well recognized experts in the field. In particular, Prof. Fabio Beltram, reported about “Nanotechnology and New Paradigms for Nanomedicine: Molecular Sensing and Delivery”. Prof. Luisa De Cola illustrated “Interactions of Cells with Soft and Hard Materials”; the manufacturing of porous systems and nanoparticles has an important impact towards the development of powerful tools for nanomedicine and in particular for regenerative medicine imaging and drug delivery, and this talk focused on nanoparticles designed for simultaneous drug and oligonucleotides delivery and well as the combination of such porous nanoparticles and hydrogel to create surfaces on which the hydrogel can be deposited and/or sandwiched in order to follow cells growth or proliferation. Prof. Andrew J. deMello explored ideas about microfluidic structures and their application to key areas, such as using droplets in chemistry and biology; the title of his talk was “Splendid Isolation: Using Picoliter Droplets in Chemistry and Biology”. Dr. Luigi Occhipinti provided a wide overview on the “Heterogeneous Integration Technologies for Smart Systems in Healthcare”. Furthermore, 33 oral and 12 poster presentations, respectively, were accepted related to the three different mentioned topics of the workshop. The scientific program was divided in three different sessions, respectively: Integrated devices and microfluidics, Nanostructures and molecular assemblies and Biosensing.
On the first day DNA analysis was explored by electrochemical and optical based sensing methods, as well as the use of spherical silicon nanoparticles for sensing applications, obtained by novel laser printing technique for their controlled fabrication and precise deposition. Hyphenated approaches based on surface plasmon resonance imaging with MALDI mass spectrometry were eventually presented opening new applicability in the characterization of biological fluids for clinical diagnostics based on proteomics which plays an important role in biomarker discovery.

On the second day, molecular imprinted polymers (MIP) for lectins were presented with applicability to pathogens (viruses and bacteria) detection in combination with electroanalytical techniques (square wave voltammetry, SWV). Wetting processes on biomolecular nanostructures investigated by environmental electron microscopy were also discussed as well as the development of supramolecular bacterial structure by generating self-assembled monolayers (SAMs) of a miniprotein (Cucurbit[8]uril, CB8) where bacterial cells could adhere and still exhibit a high rate of motility. The system has the potential to exploit bacterial cells as surface immobilized nano-motors.

On the same day, a special new emerging category of aptamer, named aptakiss were presented based on Kissing complexes resulting from the interaction between two nucleic acid hairpins displaying complementary loops. The aptaswich-aptakiss sensing complex allowed the specific detection of adenosine or GTP by surface plasmon resonance. The variety of analyte could be enlarged to allow multiplex detection of analytes. Staying with aptamers, interesting application of this class of molecules, are also in environmental analytics and technology. DNA aptamers selected for protein A integrated in a colorimetric assay based on ELONA was reported together with drug specific aptamers for fluoroquinolones for the development of aptasensors or as catcher molecules in filter systems for rapid and efficient treatment of polluted water.

In the second part of the second day, computational approaches applied to the recognition and binding affinity of amyloidogenic Josephin Domains based on molecular dynamics (MD) to investigate the related Machado Joseph Disease neurodegenerative diseases were presented.

Instrumental approaches were further illustrated related on one hand on the improved sensitivity of optical sensing. Improvement by plasmonic amplification for fluorescence base sensing was eventually reported based on new plasmon-enhanced fluorescence (PEF) that holds potential to enhance the fluorescence signal intensity associated with target molecule binding by a factor by up to $10^3$ opening new perspective in ultrasensitive analyte detection. Electrochemical sensing coupled to carbon nanotubes and ionic liquids based on imidazolium cation has been also shown to be very promising for electrochemical applications. Improved electrochemical hydrogen peroxide detection
with a single carbon nanotube terminated by platinized platinum was also reported. On the other hand single DNA molecule biochip was described, by applying the Tethered Particle Motion (TPM) technique to monitor the conformational dynamics of single DNA molecules in a multi array format allowing simultaneous analysis of hundreds of single DNA molecules. Behind this, an interesting critical evaluation of data of kinetic interaction using commercial instrumentation between RNA-RNA interactions at the 3’-end of the hepatitis C virus as paradigmatic example was reported.

The role of nanoparticles in magnetic solid-phase extraction and in the generation of new magnetogel for MNR imaging as contrast agent was finally reported.

Finally, a special session devoted to “BioInspired and Open Resources Approaches: Are there links between them?” was inserted in the program and interesting discussion followed after the speaker talks regarding the use of platforms for sharing the samples among scientists, eventually after a fee payment. Intriguing were also ideas coming from the use of biotechnology for creativity in science to promote knowledge on up to date scientific problems utilizing art as vector for science spreading among non scientists.

On the third day application to clinical diagnostic and theranostic were also presented.

A novel class of fluorescent molecular sensors that can sense dynamic changes on protein surfaces was presented. This novel approach will allow one to track changes in the conformations of various proteins including changes that result from binding interactions.

Targeted protein surface sensors as a tool for analyzing small populations of proteins in biological mixtures were also discussed. In particular, designed and synthesized cross-reactive sensor arrays that can discriminate among glutathione S-Transferases (GSTs) in biological mixtures. The expression profile of GSTs family has been associated with the progression of various diseases. Also DNA-gold nanoparticles conjugated with application to theranostics, together with gold nanorods for nanoimmunosensor with autoswitchable functions were presented. Studies on mucins in solution and at surfaces were illustrated, eventually supported by electron microscopies (AFM and SEM) and imunoassays. Polymethylmethacrylate-nanoparticles as carriers of molecular beacon for theranostic applications. In particular, the target analyte was surviving protein mRNA, belonging to a family of inhibitors of apoptosis proteins, over-expressed in different tumors. On the same last day, some examples of innovative approaches for environmental analysis and cultural heritage diagnostic were presented. Localized surface plasmon resonance on optical fiber with nanostructured surface using nanostars for 2,3,6-trinitrotoluene (TNT) analysis using MIP as synthetic receptor was shown. Behind this a portable biosensors for on site detection of proteins in artworks by chemiluminescent
immunochemical contact imaging, with the perspective of developing in the future simple strips to be used by non-skilled personnel on site (i.e. restorers).

The poster session was also rich and focused on one hand on nucleic acid detection i.e. microRNA and DNA using microfluidics and optical based approaches, with improved sensitivities by building molecular architecture with nanostructures. Protein detection was also addressed by quantum dot coupled to electrochemical sensing using paper-based electrodes.

AFM microscopy was eventually applied to mechanically characterize and distinguish scar tissue versus healthy tissue of diabetic rat skin and for the detection of biomolecular interactions. Recent advances in ultra-fast lasers were shown and some examples of ultra-compact, air-cooled femtosecond oscillators and ultra-fast lasers with high average power, as well as output energy that can be used for three-dimensional nanofabrication by two photon polymerization (2PP) technique were presented.

Some considerations aiming to explore energy potential supply utilising the human body as an energy source to replace batteries for medical devices were also presented.

Nanostructures with different application targets were presented. Some obtained from an amphiphilic carboxy-calix[4]arene derivative to serve as reservoir and co-delivery of hydrophobic and hydrophilic drugs useful for synergistic effects in the treatment of diseases. Detection of intracellular copper distribution and the tracking of metal dynamic changes upon cell ‘perturbation’ conditions was interestingly, presented showing enhanced imaging capability of the nanoparticle-based sensor compared with the traditional free small molecule chemosensor, as well as highlight the potential use of the new system as multifunctional nanoplatform for both imaging and drug delivery applications.

Covalent immobilization on silicon surfaces of different lectins, was also presented, capable of providing specific cellular recognition of specific carbohydrates expressed on the cell membrane useful for identification of individual cells.

The abstracts of all contributions were collected in a book. 100 participants attended the workshop. 41 participants were supported by COST TD1003 Action. The gender balance was almost perfect, with 44 women and 56 men. An important percentage of participants was young researchers and PhD students.
The presentations were of very high scientific level. The discussion of the presented paper was also very interesting. The opening and the plenary lectures were livestreamed via the internet and are available at both the livestream link:

https://new.livestream.com/accounts/5791652/events/2944820

as well as from Scuola Superiore website:


At the third day (30 May), at the 14,30 of the Management Committee meeting of the COST Action TD1003 took place.

Organizers:

Giuseppe Spoto, University of Catania, Maria Minunni, University of Florence