Engineering advanced polymeric surfaces for smart systems in biomedicine, biology, material science and nanotecnology: A cross-disciplinary approach of Biology, Chemistry and Physics

Reporting

Project Information

BIOPOLYSURF

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Final Activity Report Summary - BIOPOLYSURF (Engineering advanced polymeric surfaces for smart systems ...: A cross-disciplinary approach of Biology, Chemistry and Physics)

Over the four years of life of the BIOPOLYSURF Marie Curie Research Training Network, the proposed scientific goals were successfully fulfilled because of the integration of multidisciplinary researching carried out by biologists, chemists, physicists and material engineers. These focussed on use of nanostructured polymeric surfaces designed for cutting-edge applications in biomedicine, materials' science and nanotechnology. Developments were brought together under two principal targets:

1. the fabrication of multifunctional, nano-patterned and micro-patterned surfaces; and
2. the development of smart nanodevices based on these patterns.

The career opportunities of the young researchers were highly increased after their participation within the network. The achieved level of networking interactions was really extensive, either in number of international meetings organised or in exchange of young researchers between the 12 groups in order to improve their knowledge in additional fields. A significant number of publications in some of the most important journals in the area were a highlight among the network results.

Several teams developed advanced techniques for the synthesis and biosynthesis of new polymers showing acute smart behaviour. Recombinant protein-based polymers, i.e Elastin-like (ELPs), were synthesised by genetic engineering techniques containing bioactive sequences for tissue engineering in order to induce biomineralisation and bone regeneration or polymers with sequences for neuronal cells adhesion and spreading improvement. Different versions of di-blocks and tri-blocks with polar and apolar blocks suitable to tune their structure by external stimuli such as pH or temperature changes were also obtained.
% Further controlled and living polymerisation methods were implemented to obtain complex and well-defined topologies. In addition, polymer modification of nucleotide sequences enabled the preparation of model surfaces so as to study bacterial response towards the topography of the substrate. The continuous addition polymerisation technique was employed to synthesise a great variety of fluorinated polymers containing active sites for further functionalisation.

While working on the engineering of nano-patterned and micro-patterned surfaces, different state of the art technologies were used to design surfaces for tissue engineering, such as multilayer films of ELPs obtained by the layer-by-layer technique for biocompatible coatings for cells and tissues (immunoisolation). Moreover, poly(N-isopropyl acrylamide) (PNIPAM-RGD) stimulus-responsive brushes were grafted following multiple steps synthesis and bio-functionalisation in order to obtain vertically structured platforms for the study of cell adhesion phenomena in tissue regeneration.

Modified surface polymeric topographies were created to study cell-material interactions showing an unprecedented reorganisation of internal cellular structure in response to surface properties of the material on which they were grown, such as cell morphology, proliferation, adhesion and apoptosis, i.e. programmed cell death, induction. By photolithography or micro-contact printing methods patterned surfaces were created, including features as grooves and ridges or micropillars and channels.

Other surfaces, consisting of arrays of correlated polymer crystals or by attaching of different molecules to obtain intelligent surfaces or systems were also developed. From functionalised ELPs further three-dimensional structures on hydrogels or fibres were obtained and the behaviour of several cell-lines was tested for their use as scaffolds in both nerve and tissue regeneration. Patterned surfaces to induce biomimicked mineralisation and bone regeneration were obtained by covalent attaching of ELPs to titanium in order to improve biomaterial-tissue interaction and integration of titanium implants into the surrounding bone.

Focussing on the fabrication of smart nano-devices, responsive nanoparticles tuned by the temperature of the surrounding medium were synthesised as releasing drug systems. The creation of temperature the surrounding medium were synthesised as releasing drug systems. The creation of temperature responsive membranes with monodisperse pores for drug delivery or filtering applications by polymer-protein conconjugates was achieved, as well as functionalised nano-vesicles with tunable diameter via temperature or pH stimuli with binding possibilities to specific targets.

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