MATERIALS SCIENCE AND TECHNOLOGY

Ateneo - 3D micro and nanostructures obtained through sustainable processes and additive techniques for the biomedical, energy & environmental sectors

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Context of the research activity	This research activity aims to develop processes based on 3D printing and electrospinning of sustainable formulations to manufacture 3D (micro- and nano) structures for innovative applications in the biomedical, energy and environmental sectors. In the biomedical field, 3D biomimetic structures find wide application in tissue regeneration (e.g. bone, cardiac, dermis). The potential offered by 3D manufacturing technologies can be also exploited for producing composite fibrous polymeric membranes to be used as more efficient separators in batteries. Finally, a new emerging application involves the use of 3D structures for the immobilisation of microorganisms to be used in innovative agricultural practices and for bioremediation.
Objectives	The main objective of this research is the development of processes based on the use of 3D printing and electrospinning technologies to develop innovative and multifunctional solutions for different applications (biomedical, energy and environmental fields). The sustainability of the developed processes will be central and will be constantly guaranteed by the selection of materials of natural origin, including natural polymers such as alginate, chitosan, and cellulose, and by the optimization of water-based formulations or using solvents with low toxicity to health and the environment. In particular, the processes will be aimed at the development of multifunctional biomimetic scaffolds for the regeneration of hard (bone) and soft (cardiac, dermis) tissues, capable of ensuring high cell colonization and proliferation and the release of biological agents and drugs to stimulate the healing and the functional recovery of the target tissue. The ability to stimulate regeneration will be characterized through in vitro and in vivo experiments, taking advantage of consolidated collaborations with clinical partners in the relevant field. The printing and electrospinning processes will also be engineered to develop new polymeric separators for batteries, optimizing the chemical, structural and mechanical properties of the produced membranes. To increase the overall ionic conductivity of the membrane the incorporation of

	inorganic phases will be also explored and the sustainability of the process will be attained by sourcing natural polymers (e.g. cellulose, lignin) dissolved in aqueous or non-toxic solvents. Finally, the research activities will be also aimed at an emerging topic, which focuses on the design of innovative soil bioinoculants to improve the plant assimilation of nutrients and water. To this aim, 3D degradable structures will be exploited to incorporate viable plant growth-promoting microorganisms (i.e. bacteria, fungi) and used to coat the crop seeds. The viability of the incorporated microorganisms will be assessed through in pot experiments and the degradation kinetics of the seed coating will be optimised to support the overall plant cycle.

Skills and competencies for the development of the activity	The candidate skills and competencies required are the following: • Experience in the synthesis and characterization of materials • Know-how relating to additive manufacturing and electrospinning techniques • Know-how relating to the biological assessment of developed systems • Ability to work within a research team and to collaborate with scientists from other research fields. • Availability to conduct part of the research abroad (at least six months). As an indication, some possible centres are the following: Universidad Complutense de Madrid, New Castle upon Tyne, Dublin City University.