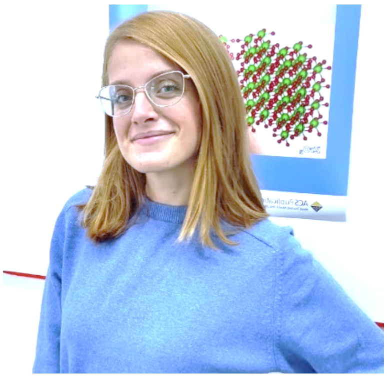
MULTIFUNCTIONAL HYBRID MATERIALS FROM BIOWASTE VALORIZATION



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Curriculum: Ingegneria dei Materiali

The waste-to-wealth concept is a challenging research field encouraging a future sustainable lifestyle, where biowastes (BWs) valorization can bring huge benefits to the environment as well as promote economic and technological advances. In fact, BWs represent a largely available and cheap source of chemical and biological richness and can be transformed into a wide plethora of end-use products and functional novel materials. For this reason, industry and academic researchers aim at enhancing the economic and environmental value of BWs and to develop strategies for their conversion into added-value compounds and material, through their recycling or conversion.

Among BWs, humic acids (HA) are the alkali-soluble fraction of natural organic matter, consisting in a multitude of heterogeneous organic molecules surviving the biological and chemical degradation of both vegetal and animal biomasses.

These moieties are rich in functional groups including carboxylic acids, phenols and quinones and that are direct responsible of regenerable red-ox properties that make them able to generate or scavenge Reactive Oxygen Species (ROS). These features finally result in different useful properties including the adsorbing capacity towards metals and organic pollutants and antibacterial/antioxidant activity.

However, their fast conformational dynamics, poor stability and prompt reactivity in water environment strongly limit technological application of HA which are largely managed as wastes. Moreover, HA are available as poor soluble, incoherent powders, making more difficult their use in the environmental field.

A suitable solution may rely on the combination of HA with an organic or inorganic component, providing for mechanical and physico-chemical stability, preserving their multifunctional properties.

Actually, wet-chemistry approaches can be a powerful tool to develop robust bio-hybrid materials with a wide range of shapes and morphology as well as enhanced chemical stability and tunable properties.

Following this strategy, a new synthetic approach to hybrid nanomaterials was recently proposed, wherein inorganic oxides acted as catalysts and structure directing agents in biopolymers building up. In particular, the inorganic nanostructured phase tuned bio-polymers supramolecular structure, ultimately improving their properties.

In this context, my PhD project aims at defining the most appropriate valorization strategies that could address current stability issues of HAs and convert them into high value materials. To this purpose, we will explore new synthetic approaches based on ceramic templated strategy to obtain hybrid nanomaterials where the inorganic oxides (i.e., TiO_2, SiO_2 or ZnO) act as biocompatible matrix to control and tune the chemical and colloidal stability as well as the reactivity of HA in acqueous solution (Figure 1).

At same time, HA-based 3D porous architectures (hydrogel, aerogel) will be obtained by developing ecofriendly gelification strategies based on physical or chemical reticulation, exploiting on the use of aldehydes or bioavailable organic polymers (chitosan or gelatin) acting as reticulating agents. Obtained samples exhibit promising antimicrobial and antioxidant properties as well as intriguing adsorbent features for a huge number of applications including catalysis and water and soil remediation (Figure 1).

The project is developed in cooperation with Verde Vita S.r.l. (Sassari), where the composting plant is located, since this company produces quality compost certified by Italian Consortium Compostatori. This PhD project is inserted in the Program POC R&I 2014-2020 - Dottorati Innovativi a caratterizzazione industriale, Ciclo XXXV.

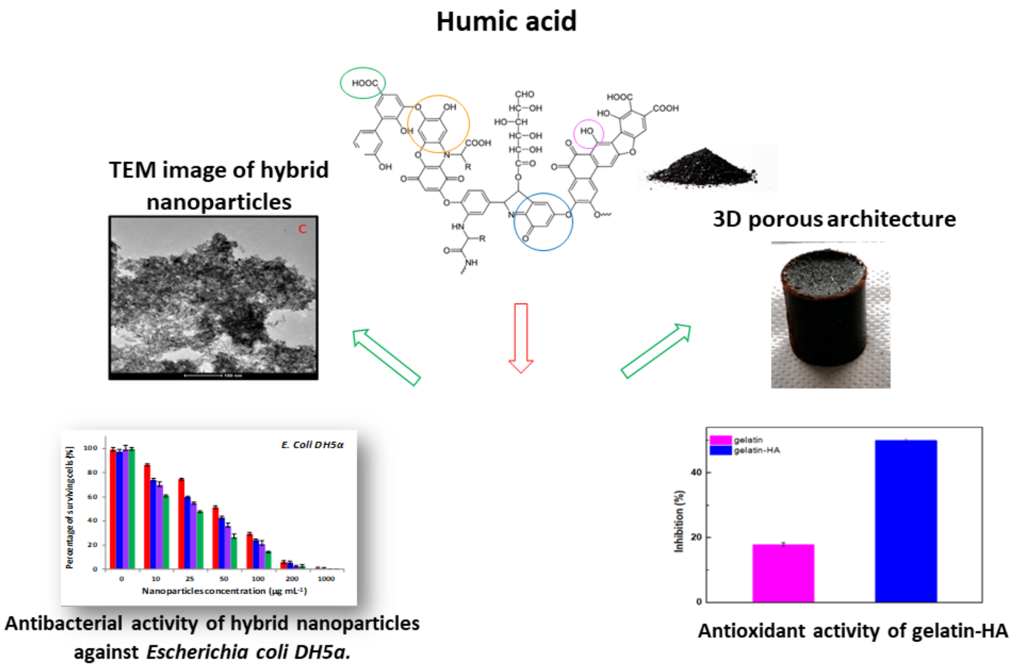

Figure 1. Hybrid Nanoparticles and hydrogels based on HA.

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