Advanced functional polymers for pharmaceutic and cosmetic applications by targeted enzymatic synthesis and derivatization.

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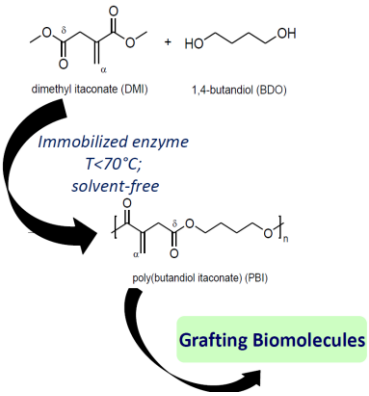
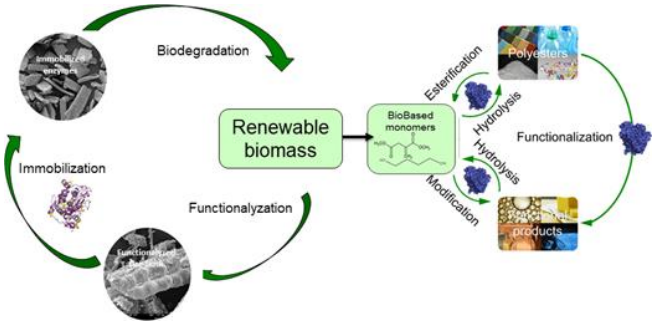
Aim: The project will aim at the synthesis of renewable and biodegradable polymers (polyesters and polyamides) made from bio-based resources. UN has estimated that the yearly environmental cost of plastic use amounts to US$75 billions. Most of this cost is due to extraction and processing of petrol based raw materials. Therefore, the recycling of plastics is not sufficient for mitigating the problem. The project intends to close the cycle, by synthetizing advanced polymers that can be bio-degraded but that are also made from renewable raw-materials.



Background: In the last years, the group of Applied and Computational Biocatalysis has developed the first examples of fully-renewable and biodegradable polyesters starting from bio-based monomers. The application of enzymes in polyester synthesis not only overcomes the use of toxic metal catalysts: they are also able to control the polymer architecture maintaining functional groups on polyester sequence without causing cross reactivity. By operating under very mild conditions (50-80°C), polycondensation can be carried out also starting from sensitive and functionalized monomers that would degrade under classical conditions (>150°C). Finally, enzymes were immobilized on renewable carriers from rice biomass, characterized in collaboration with ELETTRA Synchrotron. The work led to the publication of 19 papers (2014-2019) and a patent, which demonstrates the feasibility of enzymatic polycondensation in turbo reactors at pilot scale [EP 2 620 462 A1.].



Expected progress beyond the state of the art: Bio-based polymers will be synthetized enzymatically from renewable resources, e.g. oils, sugars, to produce precursors to polyesters. The oligoesters will be subjected to post-polymerization functionalization to facilitate covalent anchorage of pro-drugs or biomolecules.. Optimisation of the extraction of the primary raw-materials with supercritical CO_2 will also be addressed and re-utilization of the process waste will also be investigated. Computational studies will guide "substrate engineering" approaches, for selecting monomer structures favorable to chain elongation and enzymatic attack to enhance biodegradability. The work will be part of MIUR funded project and it will be carried out in collaboration with University of Naples, CNR-Pozzuoli, ELETTRA-Synchrotron and leading Italian companies in the field of bio-based plastics.

Impact: Global bio-based plastics production capacity is set to increase from around 4.2 million tonnes in 2016 to approximately 6.1 million tonnes in 2021. The Italian bio-plastic sector is world leader in the field.

References: Guarneri A., et al. "Functionalization of enzymatically-synthesized rigid poly(itaconates) *via* post-polymerization aza-Michael addition of primary amines". 2019, *Adv. Synth. Cat.*, DOI: 10.1002/adsc.201900055.

More at: https://www.units.it/data/curricula/5281.pdf