Biochar: revisiting an availful material for life sustainability

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The enduring agricultural and agro-industrial activities are generating tremendous quantities of agrowastes. The valorization of such inexhaustible natural feedstocks is at the heart of today's challenges for a clean and sustainable development. Within this context, the production of agrowaste-derived biochar for specialty materials, relevant to various areas, is receiving an unprecedented interest within the concept ″ trash to treasure ″ and circular economy. Herein, we suggest a series of strategies for producing biochar-based nanocomposites for environmental and biomedical applications. Different biomasses have been employed with and without pretreatment. It is worth mentioning that the biomass treatment prior its pyrolysis permits to tune the final biochar textural, structural and morphological properties, and to adapt these properties to the target application. The pretreatment we propose is low-cost and far away from conventional, physical and chemical ones requiring chemicals and harsh conditions of pH and temperature. Moreover, the proposed strategies permitted to valorize both the solid and the liquid phases of the agrowaste. The liquid phase, the natural liquid extract which is a complex mixture, highly rich in bio-reducing and bio-capping agents.

The main objective of our studies are i) studying the influence of the biomass initial composition on the quality of the final biochar, ii) studying the effect of the carbonization parameters on the physicochemical properties of the produced biochar, iii) the development of green processes to treat agrowaste and enhance the textural and the structural properties of the derived biochar, iv) getting more insights into the interaction between the biomass structure and the modifying species to understand their effect on the biochar properties and v) the preparation of biochar-based nanocomposites for different kinds of applications.

For example, olive pit-derived biochar decorated with silver nanoparticles has been prepared by wet impregnation and slow pyrolysis to finally obtain biochar@Ag. The latter revealed an exceptional biocidal activity against promastigotes stage of L. donovani, L. amazonensis and epimastigotes of T. cruzi responsible for the neglected tropical diseases (NTDs). A green, zero-waste strategy has been also proposed to fabricate biochar supported silver and copper bimetallic and unsupported bimetallic nanoparticles (NPs) from sugarcane bagasse (SCB). These materials served for addressing water catalyzed decontamination and also NTDs issues. Additionally, we have introduced a versatile pathway for the phytochemical reduction of metal ions on biochar arylated surface. Bio-reducing and bio-capping agents which are contained in the SCB natural extract replaced the highly toxic reducing agents conventionally employed for the metal ions reduction. The SCB-derived biochar has been also prepared and in-situ arylated to offer a double protection forbiosynthezied Fe_3O_4 NPs coated with amine modified silica in highly acidic media. The ternary nanocomposite could serve for the heavy metals scavenging in acidic media or for biomedical applications. To sum up, we have designed exceptional nanometal-coated biochars by slow pyrolysis for water and neglected tropical disease treatments via green and cost-effective pathway.