

Editorial

Special Issue on New Carbon Materials from Biomass and Their Applications

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1. Introduction

Carbon-based materials, such as chars, activated carbons, one-dimensional carbon nanotubes, and two-dimensional graphene nanosheets, have shown great potential for a wide variety of applications. These materials can be synthesized from any precursor with a high proportion of carbon in its composition. Although fossil fuels have been extensively used as precursors, their unstable cost and supply have led to the synthesis of carbon materials from biomass [1]. More importantly, pollution and CO₂ emissions and their impact on climate change are real issues that should concern the scientific community now and lead to the replacement of fossil resources with more environmentally friendly sources. Biomass covers all forms of organic material, including plants, both living and in waste form, and animal waste products. To take full advantage of the renewable characteristics of biomass waste, it should be processed through sustainable processes following the green chemistry principles, such as low energy consumption, high atom efficiency, or use of less hazardous chemicals, among others. The applications of these biomass-derived carbon materials include electronic, electromagnetic, electrochemical, environmental, and biomedical applications. Thus, novel carbon materials from biomass are a subject of intense research, with strong relevance to both science and technology.

2. New Carbon Materials from Biomass and Their Applications

This special issue includes relevant works about the synthesis of carbon-based materials from biomass waste and their use in different applications, with special attention to biochar. In this sense, Ferrentino et al. [2] synthesized several hydrochars from municipal sewage sludge that showed high adsorption capacities of methylene blue dye. A subsequent KOH treatment enhanced adsorption capacity, which seems to be controlled by a complex result of various phenomena, including physisorption and chemisorption and acid–base and redox equilibria. The adsorption of this same dye was analyzed by Li et al. [3], who used *Artemisia selengensis* to produce biochar by microwave pyrolysis. The results indicated that the increase of the pyrolysis temperature results in a decrease of the yield but an increase of the dye adsorption. The use of biochars as adsorbents for water purification was also analyzed by Siipola et al. [4]. In this case, the biochars from pine and spruce bark were subsequently activated with steam at 800 °C and studied in the removal of phenol, and microplastics retention and cation exchange capacity were employed as key test parameters. The work concluded that ultra-high porosities are not necessary for satisfactory water purification, supporting the economic feasibility of bio-based adsorbent production. Similarly, Diaz et al. [5] reported the preparation of low-cost activated grape seed-derived hydrochar through hydrothermal carbonization and chemical activation with different chemical activating agents (KOH, FeCl₃, and H₃PO₄) for sulfamethoxazole adsorption. The hydrochars showed low porosity, however their activation with KOH resulted in highly porous activated carbons (2200 m²·g⁻¹). The adsorption capacity was determined by the porous texture, achieving a high saturation capacity of 650 mg·g⁻¹. Tuomikoski et al. [6] detailed the zinc adsorption using activated carbon prepared from sawdust waste.



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Carbonization and activation were performed in a single stage using steam as a physical activation agent at 800 °C. The adsorption capacity towards zinc was tested and compared favorably to those of the materials reported in the literature. Not only liquid-phase but also gas-phase adsorption applications are included in this special issue. Manyà et al. [7] analyzed the dynamic CO₂ capture on physically activated biochars. Those were obtained from vine shoots and wheat straw pellets through an initial slow pyrolysis and further activation with CO₂ up to different degrees of burn-off. The adsorbent prepared from the vine shoots-derived biochar with the most hierarchical pore size distribution exhibited a good and stable performance under dry conditions. However, the presence of relatively high concentrations of water vapor in the feeding gas clearly interfered with the CO₂ adsorption mechanism, leading to significantly shorter breakthrough times.

Besides biochar, many of the publications collected in this special issue were devoted to soil enrichment. Yu et al. [8] reported the use of mixed hardwood and sugarcane bagasse biochar as potting mix components for container tomato and basil seedling production. The study concluded that 70% mixed hardwood biochar could be amended with peat moss for tomato and basil seedling production without negative effects on plant biomass. Similarly, Saletnik et al. [9] investigated the stimulation and conditioning of seeds with biochar and the effects observed in the germination and emergence of Virginia mallow seedlings. The biochars, applied as conditioner added to water in the process of seed hydration, improved the germination capacity. The beneficial effects of biochar application were also reflected in the increased mass of Virginia mallow seedlings. Shin et al. [10] used nutrient uploaded biochar pellets as slow release fertilizers. It was observed that the cumulative ammonium nitrogen in the blended biochar pellets was slow released over the 77 days of precipitation period, but nitrite nitrogen was rapidly released, i.e., within 15 days of precipitation. Accumulated phosphate phosphorus concentrations were not much different, and slowly released until the final precipitation period. These findings indicated that blended biochar pellets can be used as slow-release fertilizers for agricultural practices. The effect of biochar application depth on crop productivity under tropical rainfed conditions was researched by Moiwo et al. [11]. The study determined the effect of biochar application depth on the productivity of NERICA-4 upland rice cultivars under tropical rainfed conditions, concluding that the biochar can enhance crop productivity. Finally, Huang et al. [12] evaluated the use of biochar and compost mixes as substitutes to a commercial propagation mix. High percentages (70% or 80%, by volume) of biochars with vermicompost or chicken manure compost were evaluated to substitute a commercial propagation mix. The combination of biochars with vermicompost improves the results, however the mixture with chicken manure compost was not recommended.

The use of biomass waste as a potential environmentally friendly energy source is also a relevant research field. In this sense, Mousa et al. [13] studied the use of biocarbon briquettes for foundry industry. The foundry industry, like many others, is currently facing challenges to reduce the environmental impacts from application of fossil fuels. Replacing foundry coke with alternative renewable carbon sources can lead to significant decreases in fossil fuel consumption and fossil CO₂ emission. The work was aimed at the design, optimization, and development of briquettes containing biocarbon for an efficient use in cupola furnace.

Biomass-derived carbons are also being extensively analyzed as part of catalysts and/or catalyst's support in different catalytic reactions. Lu et al. [14] synthesized solid acid catalysts by one-step carbonization and sulfonation of *Salix psammophila* in the presence of concentrated sulfuric acid. The catalysts were used in the esterification reaction between oleic acid and methanol to prepare the biodiesel, achieving a conversion of 94.15% in the optimized conditions. Ma et al. [15] reports the process simulation and economic evaluation of a two-stage bio-oil hydrogenation process. An Aspen Plus process simulation model was developed for the two-stage bio-oil hydrogenation demonstration plant, which was used to evaluate the effect of catalyst coking on the bio-oil upgrading process and the

economic performance of the process. The model was also used to investigate the effect of catalyst deactivation caused by coke deposition in the mild stage.

Finally, we would like to mention two review contributions. The first one by Yang et al. [16] reviewed the preparation and modification of biochar materials and their application in soil remediation, which was extensively treated in this special issue. The wide application of biochar is due to its abilities to remove pollutants, remediate contaminated soil, and reduce greenhouse gas emissions. The study analyzed the influence of preparation methods, process parameters, and modification methods on the physicochemical properties of biochar, as well as the mechanisms of biochar in the remediation of soil pollution. The biochar applications in soil remediation in the past years were summarized, such as the removal of heavy metals and persistent organic pollutants (POPs), and the improvement of soil quality. The review also details the potential risks of biochar applications and the future research directions. The second review by Saletnik et al. [17] reported the use of biochar for environmental applications. The article reviews the information related to the broad uses of carbonization products. It also discusses the legal aspects and quality standards applicable to these materials, with special attention to the lack of uniform legal and quality conditions, which would allow for much better use of biochar. The review also aims to highlight the high potential for use of biochar in different environments. The presented text attempts to emphasize the importance of biochar as an alternative to classic products used for energy, for environmental and agricultural purposes.

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