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Editorial

Recent Trends in Biomass Materials

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1. Introduction

In recent years, biomass materials have garnered increasing amounts of attention due to their excellent biocompatibility, high biodegradability, easy modification, low cost, and high sustainability [1,2]. With the development of nanotechnology and biotechnology, these naturally abundant and easily regenerated materials, which include cellulose, hemicellulose, polysaccharides, proteins, peptides, and other kinds of biopolymers, have exhibited many advantages for a diverse range of applications [3–5].

In modern biomass utilization, biomass materials have come to be considered good candidates for solving problems related to the use of renewable and sustainable energy sources [6,7]. Biomass gasification can effectively convert solid fuels into gases, thereby representing a method for reducing the consumption of global fossil fuels [8]. In addition, biomass can be used as a high-quality carbon source to produce carbon-based nanomaterials, such as graphene, carbon nanotubes, carbon nanofibers, and carbon dots, which can be further utilized for energy storage and electrochemical catalytic applications [9–11] due to the highly specific surface area in biomass material, as well as its abundant active sites and adjustable dimensions from 0D to 3D. Biomass materials can also be processed to create various functional bionanomaterials. Due to their unique biomimetic properties, biomass exhibits high potential for the biomimetic synthesis of various metal and metal oxide nanomaterials [12,13]. Moreover, biomineralization based on biomass materials promotes the application of formed bionanomaterials in bone and dental tissue engineering [14,15].

In addition, it is easy to carry out the structural design and functional regulation of biomass materials for advanced applications. With the help of self-assembly, electrospinning, vacuum filtering, freeze drying, 3D printing, and other techniques, biomass materials can be constructed into structure-tailorable materials from nanofibers to nanofilms, membranes, hydrogels, and aerogels [16–19], in which the porous frameworks constructed provide the space for these materials to be incorporated within other nanomaterials, such as polymers, nanoparticles, quantum dots, nanotubes, and 2D materials, making it possible to achieve functional regulation of biomass materials. It has been reported that the incorporation of biomass materials with natural rubbers or other polymers reinforced the structure and properties of polymer materials [20,21], demonstrating promising application in chemical engineering and industrial fields. Through structural and functional modulation, the biomass–hybrid materials presented improved biological, chemical, and physical properties, facilitating their application in energy storage, adsorption and filtration, antimicrobial surfaces, biomedical engineering, sensors/biosensors, and wearable devices [22,23].

The aim of this Special Issue, therefore, was to compile contributions that focus on (but are not limited to) biomass use in materials science and nanotechnology in order to present recent advances in the synthesis, functionalization, hybridization, and application of biomass materials.

2. Overview of the Articles Published

A total of six articles in all, including one review and five research articles, have been published in this collection.

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In one review article (Contribution 1), the authors presented current processes and challenges in the manufacture of Lyocell man-made cellulosic fibres (L-MMCF) with industrial hemp stalks. The efficient utilization of agriculturally produced hemp stalks can not only mitigate environment-related issues but also address the problem of cellulose shortage for the large-scale synthesis of functional biomass materials. This article provided detailed information of the formation process of L-MMCF and introduced and discussed the main steps of feedstock preparation, chelation, pulping, contaminant removal, and fibre spinning. The authors additionally detailed the challenges posed by the utilization of industrial hemp stalks, including the removal of heavy metals that accumulate in the plants, harvesting and processing techniques, and proper separation methods for hemp stalks.

The development of novel preparation techniques for carbon sources is crucial for the synthesis of functional biomass-based materials, as indicated by the work shown in Contribution 2, which presented a study on enzyme-based bio-synthesis of bacterial cellulose (BC) and other useful carbon sources by using *Komagateibacter xylinus*. In a culture medium, accessible carbon sources were successfully synthesized through oligo- and polysaccharides via specific enzymes. The results obtained indicated that the enzyme-mediated fermentation process had high potential and was highly efficient, with a more than 40% yield of biomass sources. This enzyme-based strategy provided a simple way to synthesize many valuable carbon sources in the process of BC production.

Modifications of biomass materials are also important for improving the properties of biomass-based functional materials. In the third Contribution, the biomass of 1-indanone was chemically modified with methyl and methoxy groups and then studied with the use of experimental and computational methods to understand the energetic effects of chemical modification. Through the analysis conducted, it is possible to understand the effect of the position of the chemical groups on the properties of the modified biomass materials, which can guide the design and synthesis of biomass materials with specific desired properties and functions. In another study (Contribution 4), a torrefaction process (in a temperature of 250–350 °C and an N_2 environment) was applied to improve the fuel characteristics of lignocellulose and non-lignocellulose. Temperature and time factors were used to evaluate the heating values, mass and energy yields, torrefaction severity indexes, and energy–mass co-benefit indexes of three biomasses. The results presented indicated that the torrefaction process could improve the fuel properties of raw miscanthus and hops but had no effect on the pure sewage sludge biomass.

Above all, the key output of biomass materials is their practical application. In Contribution 5, coconut shells were used as a carbon source to produce chemically modified activated carbons (ACs), which could be used for the removal of 4-ethylphenol (4-EP) and 4-ethylguaiacol (4-EG) from red wine. It was found that in the presence of both 4-EP and 4-EG, ethanol had a cooperative effect and promoted the adsorption of both components in ACs. Therefore, this study provided suggestions to synthesize biomass-material-based ACs with similar properties, which could decrease the contents of 4-EG and 4-EP in red wine. In another study (Contribution 6), coffee oil was loaded into a water-based lubrication fluid with the help of ionic liquid in order to improve the tribological properties of the materials. It was clearly demonstrated that the addition of coffee oil and a protic ionic liquid with suitable content could improve wettability, enhance corrosion protection, and reduce wear and friction.

3. Conclusions and Outlooks

In summary, biomass materials have exhibited great potential for the synthesis of functional nanoscale and microscale materials via structural and functional regulation. Biomass can be used as good additives for the reinforcement of polymer materials, the biomimetic synthesis of various nanoparticles, and hybridization with other nanomaterials—all of which enhance the physical, chemical, and biological properties and functions of biomass materials as well as extend their applications. In addition, with the help of nanotechnology, biomass materials can be constructed into 1D, 2D, and 3D structures by various nanotechnologies, such as self-assembly, electrospinning, 3D printing, and others. With the high energy-saving and sustainability demands of modern society, the use of biomass materials in energy science, environmental science, and human healthcare is sure to attract more scientific attention in the future.

To promote the development of biomass materials, the author would like to demonstrate several potential research topics here in this promising field. Firstly, more efforts should be carried out to produce biomass nanomaterials (such as nanofibers, nanorods, and nanosheets) with high dispersity and solubility through the chemical, physical, and biological modification of biomass molecules. Subsequently, the combination of regulated biomass materials with other nanoscale building blocks, such as polymers, nanoparticles, nanotubes, and 2D materials, can be easily performed. Secondly, it is suggested that biomass-based films and membranes be fabricated using the self-assembly and vacuum filtering techniques. In these cases, the doping of catalytic nanoparticles (such as TiO_2, MnO_2, and others) and 2D graphene/MXene nanosheets into biomass films/membranes could greatly improve the performance of materials and extend their application in dye degradation, desalination, ionic adsorption and removal, and molecule separation. Thirdly, it is beneficial to further the biomimetic synthesis of functional nanomaterials based on biomass material properties, given that biomimetic mineralization is one of the unique abilities of biomass molecules. Biomimetic biomass materials have high bioactivity, good biodegradation, and satisfactory biocompatibility, and they could be widely utilized for the construction of bioactive hydrogels for wound healing, nerve regeneration, bone repair, and antimicrobial devices. Fourthly, producing hierarchical 3D biomass materials via advanced techniques, such as electrospinning and 3D printing, is a compelling area of research. The structural regulation of biomass materials can increase the mechanical properties of hybrid materials, and their hierarchical structures can mimic the complex structure of some organisms in nature, such as seashells, sharkskin, corals, and others, presenting high mechanical strength and other unique abilities as well, such as self-cleaning and antifouling. Finally, it is necessary to perform sustainability analyses of the biomass materials under study, and these can be affected by many factors, such as biomass type, societal factors, policy-related factors, economic factors, and others. However, readers are suggested to refer to two potential methods for the evaluation of the sustainability of biomass materials: ranking efficiency product (REP) [24] and sustainability footprint (SF) analysis [25].

Conflicts of Interest: Author Gang Wei was employed by the company New Dongyue Group Co., Ltd. The author declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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