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Editorial

New Insights on Environmentally Friendly Materials

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In recent years, the world has been confronting a growing planet-wide crisis due to uncontrolled population growth and rapid industrialization. The growing energy demand for development and the non-renewable feature of fossil-based fuels have raised concerns about energy sources [1]. The corresponding industrial and municipal waste has contributed significantly to the deterioration of the environment and is intertwined with the deterioration of public health [2]. Consequently, environmentally friendly materials have been consciously developed to improve the efficiency of resources and energy utilization and to reduce pollutants.

Abundant biological resources (e.g., woods, leaves, grasses, vines, etc.) and biological derivatives can be processed to produce bio-based materials (e.g., fuels, chemicals, and carbon materials) [3]. As the fourth largest energy source, biofuel is expected to play an important role in the transition period from fossil fuel-dominated energy to renewable clean energy [4]. Keller et al. [5] proved the economic feasibility and environmental significance of using forest residual materials to generate electricity, i.e., reducing the cost of electricity generation while significantly reducing the concentration of nitrogen and sulfur oxides in combustion products. With excellent biosorption and biodegradation properties, bio-based materials can be used for the adsorption treatment of wastewater, the preparation of biodegradable bio-based plastics, and the biofiltration of exhaust gases. Moreover, biomaterials can produce environmentally friendly membranes for oil–water separation and thus deal with oily wastewater from industries and oil spills [3]. The promotion of renewable bio-based materials contributes to environmental protection and the green transformation of economic structures.

In addition to the development of new sources, some scholars focus on the recovery of waste heat from the metallurgy, chemical, petrochemical, paper making, and many other industries. Waste heat recovery and storage can be achieved with phase-change energy storage materials (PCMs), which absorb, store, and release large amounts of heat energy through phase changes. The ideal PCMs should have high thermal conductivity and large amounts of latent heat so that the waste heat can be effectively recycled. The most commonly used PCMs can be simply divided into inorganic, organic, and composite PCMs. Inorganic PCMs are usually economical and have high thermal conductivity and energy storage capacity, but the defects of phase separation, supercooling, and corrosion limit their performance and durability. Organic PCMs are more stable without corrosion or supercooling, but they suffer from poor thermal properties and leakage risk during phase changes. Composite PCMs, in which PCMs are combined with other materials, are supposed to overcome the above shortcomings and achieve good thermal conductivity together with promising energy storage properties. For example, Chen et al. [6] prepared a shape-stabilized silicon carbide/paraffin using the vacuum impregnation method, and the thermal conductivity of the porous SiC70/paraffin CPCM was 4.28 times higher than that of pure paraffin. The thermodynamic and thermophysical properties of PCMs can be predicted and controlled via advanced computational methods, such as molecular dynamics simulations and first-principle calculations, which help the understanding and optimization of the thermal behavior of PCMs.

The utilization of solid wastes is another important part of producing environmentally friendly materials, such as large volumes of industrial and municipal wastes. The traditional treatments of simple stacking and landfills not only had low value added but also wasted valuable space resources. At the same time, in the manufacturing process of buildings, people are increasingly interested in reducing energy consumption and minimizing negative effects on the environment. Therefore, many researchers are working hard to employ these solid wastes as sustainable building materials for green buildings and components. Spherical fly ash is a typical industrial solid waste from coal combustion. The excellent pozzolanic activity of fly ash enables it to partially substitute Portland cement and to produce low-carbon concrete [7,8]. Moreover, fly ash can also be an alternative to non-renewable laterite soil in the manufacture of unfired bricks [9]. Tong et al. proved the feasibility of preparing new road base material via iron tailing (mixing solid residues left after valuable minerals have been extracted from the ores) with natural soil and adding a certain amount of cement and soil agent [10]. It is worth noting that municipal waste usually contain high levels of organic substances, which is different from industrial waste. An effective and popular pre-treatment is incineration before use as a building material. Tang and Brouwers [11] used the bottom ash of municipal solid waste in combination with other types of industrial waste to produce artificial aggregates with a cold-bonding pelletizing technique. Tian et al. [12] used the incinerator bottom ash of municipal waste and waste glass to produce foaming ceramics with impressive thermal properties and mechanical properties. The above studies have shown that both industrial and municipal waste have great potential as building materials, and the promotion of solid waste is key to achieving sustainable construction.

For wastewater and exhaust gas, which contain heavy metal ions and other harmful substances, the key to treatment is the removal of harmful pollutants and contaminants before they are discharged into nature. Compared to traditional treatment materials such as metal oxides, clays, mesoporous silicas, and zeolites, byproducts derived from agricultural waste have dual environmental significance: the effective removal of pollutants and the high-value utilization of agricultural wastes. Miri Kafi Abad et al. [13] synthesized a green, efficient, and stable Pd@biochar nanocatalyst from corn husk wastes, which electrochemically reduces hazardous Cr (VI) in industrial wastewater to less toxic Cr (III). Landin-Sandoval et al. [14] compared the performance of carbon-based adsorbents prepared via carbonization and pyrolysis for removing metal cations and found that the adsorbents obtained via pyrolysis exhibited the highest adsorption capacity. Zhu et al. [15] used modified rice husk char to remove gaseous mercury, SO_2, and NO of exhaust gas, and they found that the rice husk char adsorbent impregnated with ammonium bromide has excellent mercury removal performance. In addition to agricultural waste, protein nanofibers, carbon nanotubes, graphene, and other materials can also purify wastewater and exhaust gas. The challenges involved in developing materials for the removal of hazardous components include the need to reduce manufacturing costs, simplify the synthesis pathway, and introduce appropriate manufacturing and modification strategies to tailor absorption properties.

Waste is usually composed of several complex components that vary in composition and proportions from batch to batch. Improper treatment may cause great regional ecological environment risks and jeopardize human life and health. Traditional solid waste source identification methods (i.e., manual identification and X-ray diffraction) can quantitatively or qualitatively accurately determine the chemical composition of solid waste materials but typically requires skilled technicians or expensive equipment [16]. Therefore, effective waste collection, identification, and treatment are crucial for effective waste management. Researchers are working on developing machine learning algorithms to predict the volume of waste generation, forecast waste composition, and optimize waste classification and treatment [17].

Although many relevant achievements have been attained in the field of environment protection and related environmentally friendly material development. There are still many critical scientific questions to be resolved in this regard. Further studies are needed to provide new insights into developing environmentally friendly materials with excellent performance using clean and green preparation technologies, including advanced technological innovations and optimized application fields.

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