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Conversion of food waste to energy storage materials

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Abstract

Food waste and loss have been recognized as major issues facing humanity because of their environmental, economic, and social implications with global consequences. Waste is generated throughout the food life cycle, starting from agricultural production up to industrial manufacturing, processing, retail and household consumption, resulting in loss of valuable resources and causing management problems. However, many of the waste streams generated during food production, processing, marketing and consumption have the potential for valorization within biorefineries. This presentation focuses development of composite materials from food industry byproducts, specifically shells of edible tree nuts, edible oil wax and animal fat that can be used in energy storage systems and many other applications. The goal of this study is to develop composite materials for solar energy storage. Although solar energy is an abundant resource, its intermittency is a major constraint for continuous supply of energy for domestic and industrial use. Hence, development of efficient energy storage systems is vital for augmenting reliability of energy supply from renewable sources. Thermal energy storage (TES) materials are used to mitigate the intermittence of solar energy directly from the source. Concentrated Solar Power (CSP) systems utilize TES to store solar energy in thermal energy form. This study focuses on the latent heat thermal energy storage, also referred to as Phase Change Materials (PCM) which have an intrinsic capability of absorbing (charging) and releasing (discharging) heat during phase transition cycles. Hazel nut shells are evaluated as a potential feedstock for producing high porosity carbon materials that can be used to encapsulate and shape stabilize PCM to eliminate leakage during operation of CSP systems. Thermal properties of sunflower oil wax, and beef, pork and lamb fat are examined to evaluate their suitability as PCM to be loaded into porous carbon produced from hazel nut shells for shape stabilization. Zinc chloride and potassium hydroxide were separately tested as catalysts to increase pore volume of the carbon produced from nut shells via pyrolysis. Evaluation of the surface area and pore distribution of the produced biochar samples indicated that $ZnCl_2$ was a better catalyst than KOH to generate high surface area and pore volume. A carbon material with over 1200 m^2/g of specific surface area, as measured via Brunauer-Emmett-Teller (BET) analyses, and pore volume of 0.627 cm^3/g was produced from hazel nut shells via pyrolysis at 600 ^oC. Acid treatment of the samples prior to water washing enhanced pore volume and surface area of the material. Pore size distribution analysis showed that average pore diameter and width for the

latter sample was 20.462 Angstrom (2.1 nm) and 21.795 Angstrom (2.2 nm), respectively. XRD analyses of the biochar samples indicate high carbon content and a disordered structure. Thermal analyses of the animal fat and sunflower wax confirmed their suitability as PCM.

Keywords: nut shell, lipids, food processing byproducts, energy storage, porous carbon

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