참깨 바이오차의 열분해 온도가 열에너지 저장 성능에 미치는 영향 평가

Effect of pyrolysis temperature on the thermal energy storage performance of sesame plant biochar

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Abstract : This study is aimed to understand the effect of pyrolysis temperature on the biochar synthesis for shape stabilizing the Lauric acid (LA). Three different temperatures (350, 500, and 650 °C) have been chosen with a soaking time of 1h for synthesizing biochars form sesame plants (SP). The structural characterizations indicate the formation of amorphous biochar at 350 °C whereas, a stain of graphene formation has been observed for the biochar synthesized at 500 °C. Formation of a substantial amount of graphene has been found for the sample, synthesized at 650 °C. Energy storage performances of the PCMs which are shape stabilized by these three biochars have been discussed in this paper.

키워드 : 바이오차, 열분해, 열저장성능
Keywords : biochar, pyrolysis temperature, thermal energy storage

1. Introduction

The quest for sustainable and renewable energy solutions has driven extensive research into innovative technologies for thermal energy storage (TES) [1]. A key factor influencing the performance of biochar as a TES medium is the pyrolysis temperature during its production [1]. This study investigates the profound effect of pyrolysis temperature on the thermal energy storage performance of SP biochar. Pyrolysis, the controlled heating of organic materials in the absence of oxygen, is the primary process by which biochar is derived from biomass. The temperature at which this pyrolysis occurs has a substantial impact on the resulting biochar's physicochemical properties, such as surface area, pore size distribution, and chemical composition. These properties, in turn, significantly influence the biochar's capacity to store and release thermal energy effectively.

Understanding how variations in pyrolysis temperature affect sesame biochar's thermal energy storage characteristics is crucial for optimizing its performance in TES applications. A comprehensive analysis of this relationship can provide valuable insights into tailoring sesame biochar production to meet specific TES requirements, ultimately contributing to the development of more efficient and sustainable energy storage solutions. This research aims to bridge the gap in knowledge regarding the influence of pyrolysis temperature on SP biochar's thermal energy storage capabilities, thereby advancing the field of renewable energy technology and promoting a greener and more sustainable energy future.

2. Materials and method

Dried sesame plants (SP) were collected from India and washed with water vigorously before keeping in the oven for overnight at 100 °C. The dried plant stems were pulverized to powder by mortar pastel. The powder was then treated with 10% KOH aqueous solution and pyrolyzed at three different temperatures viz. 350, 500, and 650 °C with thermal soaking times of 1h. The pyrolyzed biochars were cleaned with 3% aqueous HCl solution followed by hot distilled water. Further, by vacuum impregnation, Lauric acid (LA) was impregnated into the biochars to achieve LASP biochar PCMs.

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3. Results and discussion

The SEM micrographs reveal the porous and channel like morphologies of the SP biochars (Figure 1(a)-(c)). The sizes of the pores are found to be increasing with elevating the pyrolysis temperatures. The structural analysis by XRD shows that SP biochar pyrolyzed at 350 °C is fully amorphous (Figure 2(a)). However, the other two SP biochars pyrolyzed at 500 and 650 °C show strong diffraction peak of graphene at $2\theta = 26.5°$ [2]. Besides, the Raman spectroscopy data (Figure 2(b)) is well corroborated with the XRD results.

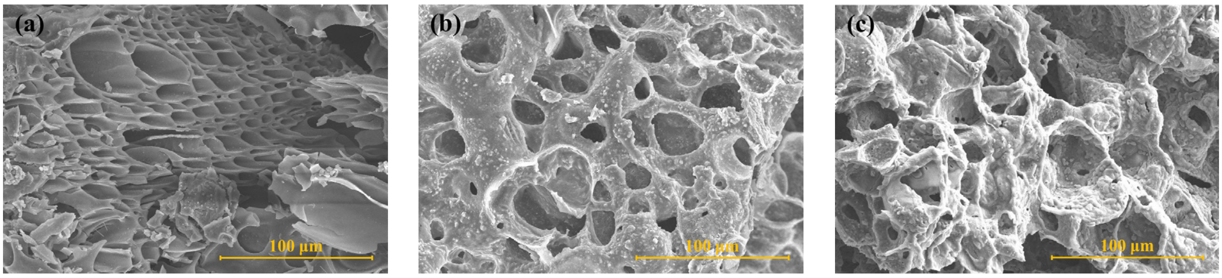

Figure 1. SEM micrographs of SP biochars pyrolyzed at (a) 350, (b) 500, and (c) 650 °C

The TES capacities of the LASP biochars are examined by DSC scans (Figure 2(c)) at a heating rate of 10 °C/min from 20 to 70 °C. The melting and solidification enthalpies (△Hm, △Hs) of LA are found to be 179.7 and 181.7 J/g. For the LASP composite PCMs, LASP-650 has the highest △Hm, △Hs whereas the same are found lowest in LASP-350.

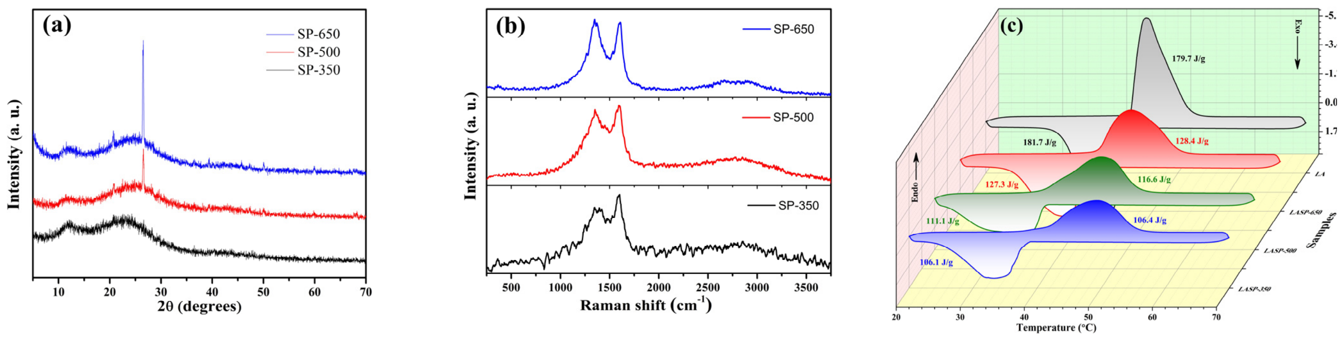

Figure 2. (a) XRD, (b) Raman spectroscopy of SP biochars, (c) DSC thermograms of different LASP composite PCMs

4. Conclusion

From the results of this work, it is evidenced that the pyrolysis temperature plays an important role on the accommodability of PCMs into biochar as well as the phase transformation behavior. At the higher temperature the possibility of graphitic structure is more in the biochars which ease the heat transfer for TES applications. The study also demonstrates that a suitable temperature with optimized soaking time can produce controlled amount of graphene structures in the biochars. Besides, the biochars synthesized at higher temperature can accommodate more fatty acids for higher TES application and that results into the higher thermal energy storage capacities.

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