황마 바이오차를 사용한 에너지 저장용 상변화 물질의 제조 및 성능평가에 관한 연구

A promising form-stable phase change material prepared using cost effective Jute stick Biochar as the matrix of stearic acid for thermal energy storage

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Abstract : Due to the higher use of nonrenewable fossil fuel energy, environment friendly sustainable energy from waste materials is attracting attention of the researchers. Considering that, jute stick (JS) biochar has been considered for this study for ecofriendly and sustainable thermal energy storage application. Waste jute sticks (JS), which are being mainly used as a fuel for cooking purpose, have been pyrolyzed to produce porous biochar and have been used for shape stabilization of stearic acid (SA) as phase change material (PCM). SA at 1:1 ratio has been incorporated into the activated JS biochar to concoct shape-stabilized phase change composite (SAJS). The SAJS has been evaluated by different techniques such as Fourier transform-infrared spectroscope (FT-IR), scanning electron microscopy (SEM), differential scanning calorimetry (DSC), and thermogravimetric analysis (TGA). The obtained composite PCM has shown excellent shape stability with a high latent heat storage, suggesting its suitability for thermal energy storage applications.

키워드 : 황마 막대기, 상변화 물질, 열 에너지 저장, 스테아르 산
Keywords : jute stick, phase change material,thermal energy storage, stearic acid

1. Introduction

The rapid depletion and exploitation of non-renewable energy resources has become a great concern worldwide. Due to the excessive usage of natural resources, our environment is facing several problems viz. greenhouse gas emission, climate change, depletion of the ozone layer, acid rain, global warming, glacier melting and ecological disturbance, and many more[1]. Therefore, it is essential to find alternatives to minimize the depletion of non-renewable energy sources and energy crisis. Consequently, to alleviate the energy crisis, the maximum utilization of waste materials into biochar has gained a tremendous research focus. The implementation of phase change materials (PCMs) in biochar can enhance the energy utilization efficiencies which have been proven as an economical technology[2]. Hence, in this study, an effort has been made to prepare PCM from stearic acid (SA) and sustainable, cheap jute stick (JS) biochar material, for thermal energy storage applications.

2. Materials and Methodology

Jute sticks (JS) were collected, washed, and dried at 100 °C for 24 h. Dried jute sticks were ground mechanically and sieved. The JS powder was then soaked into 1:1 KOH aqueous solution for 12 h. Then the sample was pyrolyzed in restricted air environment at 400 °C, in a furnace. The pyrolyzed sample was neutralized using 3 (N) HCl and after that the sample was vigorously rinsed with distilled water. Further, the sample was dried at 100 °C in an oven for 24 h and the final JS biochar sample was collected.

The vacuum impregnation method was used to produce JS biochar based composite PCM where 1:1 ratio SA was loaded with JS biochar. At 70 ○C, mixture of SA and JS were kept in vacuum furnace at a pressure of -0.1 MPa. Hereafter, for removing the excess SA, the sample was filtered and washed with boiling water. The synthesis procedure of JS biochar and the fabrication of shape-stabilized phase change composite SAJS is schematically illustrated in Figure 1.

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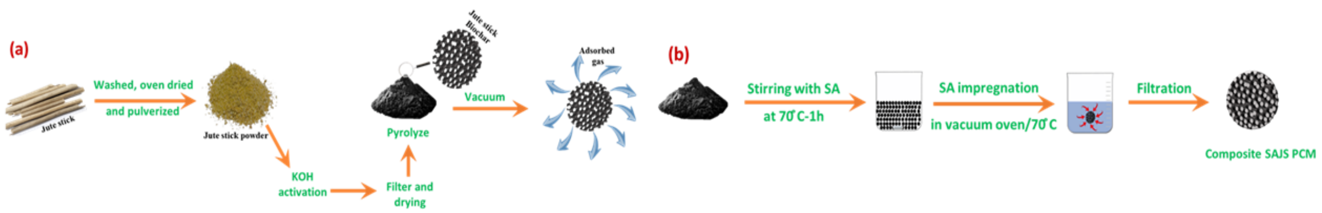

Figure 1. (a) Preparation of JS biocha (b) impregnation processes of SAJS composite PCM

3. Results and Discussion

The morphology of biochar sample was examined by SEM which exhibited porous structure, suitable for PCMs impregnation (Figure 2-a). The morphological investigation of the SAJS composite PCM showed the pores were filled up with SA (Figure 2-b). The chemical characterization of the JS biochar by FTIR revealed the presence of several functional groups such as hydroxyl (-O-H), (-C-H) bonds, (-C = O) bonds, (-C = C) bonds and (-C-OH) groups (Figure 2-c), for SA (black) and JS (red) (Figure 2-d). DSC scan of SAJS showed the melting and solidification temperatures at 69.95 and 63.5 °C as well as the respective enthalpy values were found to be 44.5 and 43.8 J/g. TGA plot demonstrated that the weight loss of SAJS started at 166 °C and till 500 °C it showed only 58% weight loss which indicated about the good thermal stability of SAJS (Figure 2-e).

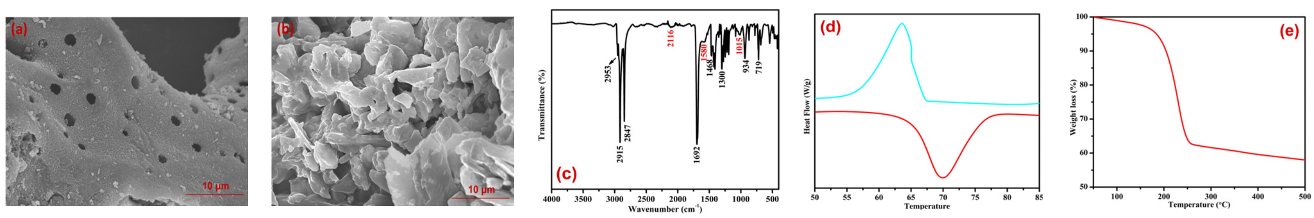

Figure. 2. (a) SEM of JS biochar (b) SEM of SAJS (c) FTIR of SAJS (d) DSC of SAJS (e) TGA of SAJS

4. Conclusion

In conclusion, the JS biochar is a suitable matrix and can be used for the stabilization of SA for thermal energy storage applications. With the stabilizing matrix, the biochar has also enhanced the stability and thermal degradation of the PCM. This study will help to utilize more biochar resources for efficient composite PCM synthesis.

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