열 에너지 저장용 카프르산을 이용한 아몬드 껍질 바이오차 기반의 안정화 형태 상변이 물질의 성능

Synthesis of Almond Shell Biochar-Based Shape-Stable Composite Phase Change Material Using Capric Acid for Thermal Energy Storage

잔낫[1] · 소우멘 만달[2] · 이한승[3*]
Adnin Raihana Jannat[1] · Soumen, Mandal[2] · Lee, Han Seung[3*]

Abstract : A new shape-stable composite phase change material (PCM) have been produced via an easy and simple vacuum impregnation method. The composite PCM have been derived from almond shell biochar (ASB) as supporting material and capric acid (CA) as phase change material. Cost effective waste almond shells (AS) are renewable, eco-friendly, and rich in pores which enhance the possibility of CA impregnation. Therefore, in this study, three different ratios of CA (1:1, 1:2 and 1:3) have been incorporated in ASB to produce shape-stabilized phase change composites (ASCAs). Different techniques such as scanning electron microscopy (SEM), Fourier transform-infrared spectroscope (FT-IR), differential scanning calorimetry (DSC), and thermogravimetric analysis (TGA) have been applied to evaluate the characteristics of ASCAs. The attained composite PCMs have exhibited shape stability with high latent heat storage, that makes it suitable for thermal energy storage applications.

키워드 : 아몬드 껍질, 바이오차, 상변화 물질, 열 에너지 저장, 카프르산
Keywords : almond shell, biochar, phase change material, thermal energy storage, capric acid

1. Introduction

Non-renewable energy resources have come to the attention of researchers and scientists due to their expeditious diminution. Extensive utilization of non-renewable energy sources causes negative consequences viz. climate change, greenhouse gas emission, global warming, acid rain etc. which demand the exploration of alternate energy sources[1]. Therefore, sustainable and renewable energy sources are endeavoring to replace conventional energy sources. Hence, maximizing the utilization of eco-friendly biochar from waste materials has drawn significant attention of the researchers to extenuate the energy crisis[2]. Implementing phase change materials (PCMs) in biochar has expedited the revolution of energy-efficient technology. In this study, we have attempted to prepare shape stabilized composite PCM from sustainable almond shell biochar (ASB) material by implementing capric acid (CA) for thermal energy storage applications.

2. Materials and Method

KOH activated almond shell biochar (ASB) was kept inside an oven at 100°C for 15 hours before the day of PCM impregnation to remove the intercepted moisture completely. Subsequently, to remove adsorbed gases from surface, AS biochar was kept inside a desiccator for 6 hours.

In order to produce AS biochar based composite PCM, CA was loaded in three different contents, at 1:1,1:2 and 1:3 ratios. CA and ASB were kept in beaker and the beaker were kept on a hotplate magnetic stirring at 40°C and 1200 rpm for 30 minutes to get the mixture. Consequently, the mixture was kept in desiccator at a pressure of -0.1 MPa to remove the adsorbed gases from the mixture and the samples were continued stirring at 40°C. To get our desired shape stabilized composite PCM, this process was repeated 7 times. The excess PCMs was removed from the mixture by using filter paper. The fabrication of shape-stabilized phase change composite ASCA is schematically illustrated in Figure 1.

1) 한양대학교 스마트시티공학과, 박사과정
2) 대구경북대학교 연구교수
3) 한양대학교 ERICA 건축학부, 교수, 교신저자(ercleehs@hanyang.ac.kr)

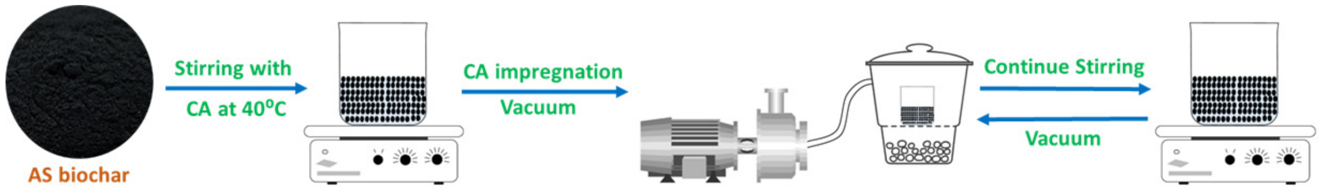

Figure 1. Scheme of synthesis of ASCA composite PCM

3. Result and Discussion

The representative surface morphology of AS biochar, examined by SEM, showed the porous structure of AS biochar which indicates a helpful pathway for CA impregnation (Figure 2-a). The morphology of CA impregnated composite PCMs is shown in Figure 2(b-d) respectively with impregnation ratio. The impregnation of PCM into biochar at 1:2 ratio led to the nearly complete filling of its mesopores, leaving only a small quantity visible. However, the 1:1 and 1:3 ratios show large pores unfilled. This suggests that the surface characteristics and structure of AS biochar are effective in encapsulating the CA PCM at 1:2 ratio. The exceptional properties exhibited by the ASB-based composite PCM sample can be attributed to the porous structures and surface functionalities of the biochar, which provide capillary action, strong surface tension, and space confinement effects. FTIR results revealed the presence of several functional groups such as (-C = O) bonds, (-C = C) bonds, hydroxyl (-O-H), (-C-H) bonds, and (-C-OH) groups (Figure 2-e).

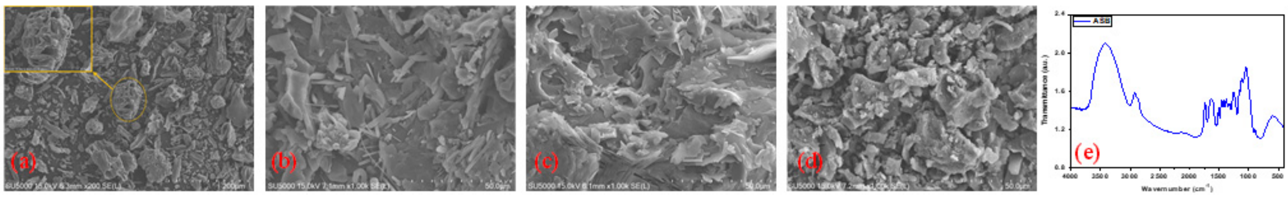

Figure 2. SEM of (a) AS biochar (b) 1–1 CAB (c) 1–2 CAB (d) 1–3 CAB and (e) FTIR of AS biochar

4. Conclusion

In summary, this work indicates the suitability of AS biochar matrix for CA impregnation where biochar has enhanced the shape stability of PCM. This work will help the efficient synthesis of composite PCM by greater use of biochar resources.

감사의 글

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