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Fabrication and stability of Hexadecane/pigment composite for construction sector based on ultramarine blue

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Abstract

A standard ultramarine pigment was used to produce phase change material composites. These type of pigments are conventionally used in construction sector once have been dispersed in different building components (paint, concrete, plastic). The main advantage of the use of n-hexadecane/pigment composite is that processes for building components manufacturing as the thermal storage capability is provided by the modified pigment.

Vacuum impregnation method was employed optimizing the process variables to maximize the latent heat of the hexadecane/pigment composite. In addition to the process optimization, the stability of the composite having the maximum latent heat was investigated.

The hexadecane/pigment composite providing the highest latent heat has a 20%wt. hexadecane adsorbed in the pigment. Durability of the material was tested by thermodiffractometic measurements showing a reduction of the area intensity up to 6.5% after the 100 cycles.

Introduction

Phase Change Materials (PCMs) are ideal products for thermal management solutions as they store and release thermal energy within the temperature of the melting & freezing processes and can be integrated in different building components with the aim of reducing energy consumption for space conditioning [1-3].

The incorporation of paraffin PCMs in construction materials requires a previous encapsulation as the thermal energy of paraffin is stored and released when the material changes from solid to liquid and from liquid to solid, respectively, and this fact can lead to leakages.

Support of PCMs into porous materials is a promising alternative method for the encapsulation of PCMs but there is still a real need of development

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concerning PCM containment method to be economically available. Also, long term stability of encapsulated materials subjected to thermal cycling must be assessed [4-6].

The standard ultramarine pigment is a potential material for the production of phase change material composite by using different impregnation methods.

The main advantage of the use of this hexadecane/pigment composite is that as ultramarine pigments are commonly used in construction sector, processes of building components would not be altered as the thermal storage capability is provided by the modified pigment.

In this paper, vaccum impregnation process was studied optimizing the process variables to maximize the latent heat of the hexadecane/pigment composite. In addition to the process optimization, the stability of the composite having the maximum latent heat was investigated.

Fabrication of the pigment with thermal storage capability

Hexadecane/pigment composite was fabricated by using vacuum impregnation method. Different experiments were planned to optimize five different process variables with the aim of obtaining a composite with the maximum latent heat:

a) ratio pigment:hexadecane,

b) cleaning strategies,

c) the time having the pigment under vacuum,

d) the time having the mixture pigment-hexadecane under vacuum,

e) the time having the pigment-hexadecane mixture at atmospheric pressure.

After optimizing all the process variables, the maximum latent heat obtained for the composites is 44.40 J/g using petroleum ether as the best cleaning strategy. Table 1 summarizes the prepared samples and the thermal properties obtained.

Table 1.- Thermal properties of hexadecane/pigment composites.

Ratio pig.: PCM	Pigment under vacuum: Time (min)	Mixture under vacuum: Time (min)	Mixture at atomospheric pressure: Time (min)	Cleaning strategy	Latent heat (fusion) (J/g)
1:0.8	15	15	15	Petroleum ether	44,62
1:0.8	30	30	30	Petroleum ether	23,75
1:0.8	60	60	60	Petroleum ether	25,96

1:1	15	15	15	Petroleum ether	24,33
1:1.5	15	15	15	Petroleum ether	22,11
1:0.8	15	15	15	Deionized water	30,34

Composite characterization

The particle size distribution of the hexadecane/pigment composite was analyzed using a Malvern Mastersizer 2000 and a stable and mono-modal distribution was obtained for this system being the mean particle size a 25% larger than the raw pigment (being the original size 1.1µ).

The X-ray diffraction (XRD) patterns for the hexadecane/pigment composite were measured using a Bruker D8 Advance X-ray diffractometer.

The semi quantitative calculations using the FULLPROF program for the main phases show the 20/80 relation for hexadecane/pigment composite.

The composite was subjected to 30ºC during 1000 hours with the aim of monitoring the latent heat of fusion and crystallization at different times, indicating that the reduction of the thermal storage capability of the composite is around 3%, after long time treatment.

In order to simulate the heating and cooling processes associated with day and night conditions cyclic experiments were used using X ray diffraction. Thermodiffractometic measurements were done in a Bruker D8 Advance and an Anton Parr MRI low-temperature camera.

The X ray diffraction signals were evaluated by using the Diffrac Plus Evaluation EVA software. After extracting the background the raw area and half-width parameter of the (111) maxima of the PCM was calculated. The reduction of the thermal storage capability was small enough (around 5%) after 100 cycles to assume real live time of more than 10 years for this composite materials.

Conclusions

In this study, a pigment having thermal storage capacity of 44J/g has been fabricated by using vacuum impregnation technique. The obtained size distribution ensures the further dispersability of the pigments in desired matrix (paint, concrete, polymers).

The durability of the material has been tested during 1000 hours at 30ºC showing an slight reduction of its thermal storage of about 3%. Concerning the material durability against temperature cycles the results showed a slow reduction of the area intensity (and thus on thermal storage capacity) of 6.5% after 100 cooling/heating cycles.

The main advantage of the hexadecane/pigment composite is that as ultramarine pigments are commonly used in construction sector, processes of building components would not be altered as the thermal storage capability is provided by the modified pigment.

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