

# Preparation and characterization of form-stabilized paraffin/polycaprolactone (PCL) composites as phase change materials

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**ABSTRACT** – Paraffinic Phase Change Materials (PCM) possess desirable properties to make it suitable for thermal energy storage applications. However, paraffin has been reported to leak out during the melting process. In this study, composites were prepared by dissolving paraffin and polycaprolactone (PCL) at varied mass compositions in chloroform and then purified through precipitation techniques. The leakage test was conducted by placing the composite samples on a set of four-layer filter papers and left in a furnace at 90°C for 1 hour. By incorporating PCL into paraffin phase, the leakage percentage was drastically reduced. The PCL polymer matrix in the composites may have trapped the paraffin molecules during melting process thus prevent it from leaking.

## 1. INTRODUCTION

Thermal energy storage (TES) functions as temporary storage of thermal energy in the forms of cold or heat energy. Latent thermal energy storage (LTES) is the most preferred forms of energy storage because it can provide high energy storage density and nearly isothermal heat storage or retrieval processes. Phase change materials (PCM) are materials that can absorb, store and release latent heat of fusion to the environment during melting and freezing processes. Solid-liquid phase change process is shown in Figure 1.

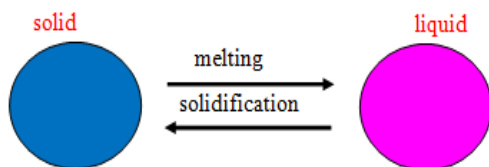


Figure 1 Solid-liquid phase change process.

One of most known PCM is paraffin which possesses desirable properties such as high thermal energy storage and thermal stability to make it the most suitable PCM in thermal energy storage applications. However, the major problem of using paraffin PCMs is leakage during melting process as reported in previous studies [1]. Shape-stabilized PCM, in which the PCM is dispersed in another phase to form a stable composite material, are

attracting attention many researchers due their large specific heat, suitable thermal conductivity and the ability to stabilize the shape of PCM during the phase change process [2].

In this study, paraffin/polycaprolactone (PCL) composites were prepared at varied mass compositions in order to obtain form-stabilized PCM composites thus possibly eliminates the leakage problem.

## 2. METHODOLOGY

### 2.1 Preparation of paraffin/polycaprolactone composites

The composites were prepared by dissolving paraffin and PCL at varied mass compositions in chloroform and then purified through precipitation techniques by using ethanol solution. The composites were then dried in a fume hood.

### 2.2 Leakage test

The leakage test was conducted by placing composite samples on a set of four-layer filter papers and left in a furnace at 90°C for 1 hour. Leakage test set-up in a furnace is shown in Figure 2.

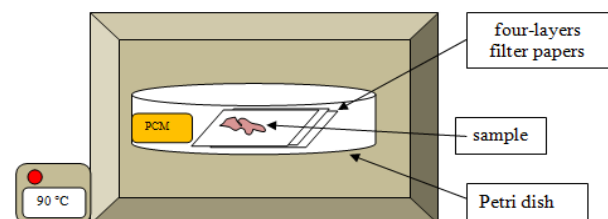


Figure 2 Leakage test set-up.

The leakage percentage was calculated based on the change of sample mass before and after the leakage test.

### 2.3 Thermal properties of paraffin/PCL composites

The melting temperature and the latent heat of fusion of the composites were measured by Differential Scanning Calorimeter (DSC). The heating rate was set to 10°C per minute.

### 3. RESULTS AND DISCUSSIONS

The leakage percentage of the composites is significantly lower than that of pure paraffin (leakage percentage 78.4%). Table 1 shows the leakage test results.

Table 1 Leakage test results.

Sample No.	Paraffin/PCL (wt.%)	Leakage Mass	
		(g)	(%)
PCM1	100/0	0.784	78.4
PCM2	80/20	0.251	35.1
PCM3	60/40	0.197	29.7
PCM4	50/50	0.305	30.5
PCM5	40/60	0.001	0.10
PCM6	20/80	0.182	88.2
PCL	0/100	0.000	0.00

The differential scanning calorimeter (DSC) result shows that the melting temperature of the composites did not change much as compared to that of the pure paraffin. Figures 3 shows the DSC curve that indicates the melting temperature and latent heat of fusion of PCM4 (50 mass % paraffin, 50 mass % PCL).

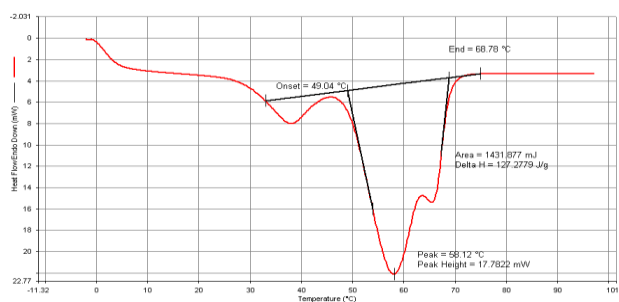


Figure 3 DSC curve of PCM 4.

The melting temperature and latent heat of fusion of the composites that were measured by DSC are shown in Table 2. The heat of fusion of the composites decreased significantly at PCL mass composition 40% to 60%. The composites at these compositions also show the lowest leakage percentage. The composite with 60% PCL shows almost no leakage during the leakage test. This result indicates that the leakage characteristic of the composites is strongly depends on the heat of fusion of the composites. The lower heat of fusion, the more homogeneous the paraffin phase and the PCL polymer matrix which in turn results in the more stable composite structures.

The PCL polymer matrix in the composites may have trapped the paraffin molecules during melting process thus prevent it from leaking, as illustrated in Figure 4.

Table 2 DSC results of Paraffin/PCL composites.

Sample No.	Paraffin/PCL (wt.%)	Melting temp. (°C)	Latent heat of fusion (J/g)
PCM1	100/0	58.97	139.21
PCM2	80/20	59.63	129.06
PCM3	60/40	67.44	85.16
PCM4	50/50	68.78	84.28
PCM5	40/60	67.69	81.44
PCM6	20/80	66.93	102.65
PCL	0/100	64.13	72.13

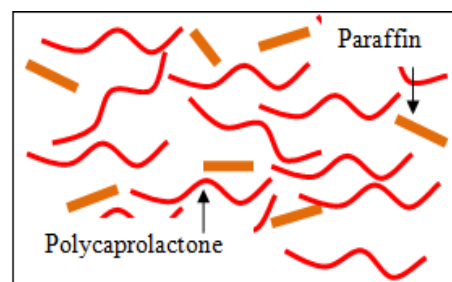


Figure 4 Paraffin molecules in PCL matrix.

### 4. CONCLUSIONS

The leakage test results indicated that by incorporating polycaprolactone (PCL) into paraffin phase, the leakage problem that associated to the pure paraffin can be prevented. The leakage characteristic of the composites is strongly depends on the heat of fusion of the composites. These form-stabilized PCMs would potentially become novel candidates of PCM for thermal energy storage applications.

### REFERENCES

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