ECLIPS
Enhancing Concrete Life in Infrastructure through Phase Change Systems

Quarterly Report: 1st Quarter (Sept 1 2015 – Dec 31 2015)

1	**Deviations from plan**
	It was decided to develop a project handbook to serve as a guideline for how the partners will collaborate on the project and how decisions will be made. However, the partners developed a comprehensive consortium agreement which covers all the aspects supposed to be covered in the project handbook, and hence to avoid repetition, the consortium agreement will serve as the project handbook. Any changes will be discussed among all the partners during the quarterly meetings and consensus arrived at.
2	**Progress made since last reporting**
	This is the first quarterly report for this project. The progress made during this time are listed below. The team has successfully accomplished all the deliverables set for this reporting period. Details are provided below. The deliverable numbers are 9.1, 8.1, and 1.1 as listed in the work plan. a) Deliverable 9.1: Project handbook: As described above, the consortium agreement was comprehensive and covers all the aspects that were supposed to be covered in the handbook, thus resulting in the project handbook becoming redundant. b) Deliverable 8.1: Project website as part of FEHRL's website: The initial project website was created under FEHRL's website. Please see http://www.infravation.net/projects/ECLIPS. Efforts are underway to develop this website as well as provide more visibility to the project through other websites of collaborators in different institutions. c) Deliverable 1.1: Database of PCMs: An exhaustive database of PCMs have been compiled by the research team. Over 300 different PCMs have been compiled. This database, sorted by manufacturers all over the world and the chemical composition of the PCMs will help potential users of the material to identify the chemical type and the local source for this material so that they can implement their own cost and life cycle analyses. The investigators have come to the close of the process of identifying and selecting desirable PCMs from this group in order to carry out the extensive experiments that form the core of the proposed work.
3	**Published deliverables and achieved milestones**
	a) PCM Database and material selection: The major deliverable is a list of PCMs that can be used in the further stages of this work. The compilation has been carefully examined by the partners.
4	**Any problems that occurred and solutions found**
	No problems have occurred in the first quarter of this project.
5	**Financial Progress**
	The partner universities and organizations have been provided the respective share of the pre-financing amount, and the coordinator is monitoring the progress carefully. A project manager, Lisa Schulze has been assigned to this project by the office of knowledge enterprise development (OKED) at Arizona State University and she will oversee the managerial aspects of the project and coordination with partners.

Activities in Progress or Completed

The following activities have been started at the coordinating and participating institutions to ensure that the project is on track. The investigators are closely monitoring the progress of the several tasks. The following are the tasks that overlap between the first and second quarters and the progress in those tasks.

PCM selection (1000% complete): From the database of the PCMs compiled, the investigators have selected one specific group of microencapsulated PCM and another specific set of liquid PCMs that can be used to impregnate porous solids such as lightweight aggregates. The microencapsulated PCM chosen was the Micronal series of PCMs, manufactured by Encapsys Inc., who has been providing the research group with the microencapsulated PCM and Entropy solutions, who manufactures the PureTemp series of liquid PCMs. For both the PCMs, initial studies have employed a PCM with a phase change temperature of 25°C, while other temperatures (higher and lower) are under consideration. We have also used Micronal series of PCMs from BASF for comparative purposes, especially the efficiency of microencapsulation. The microstructure of the Encapsys and Micronal PCMs are shown in Fig. 1.

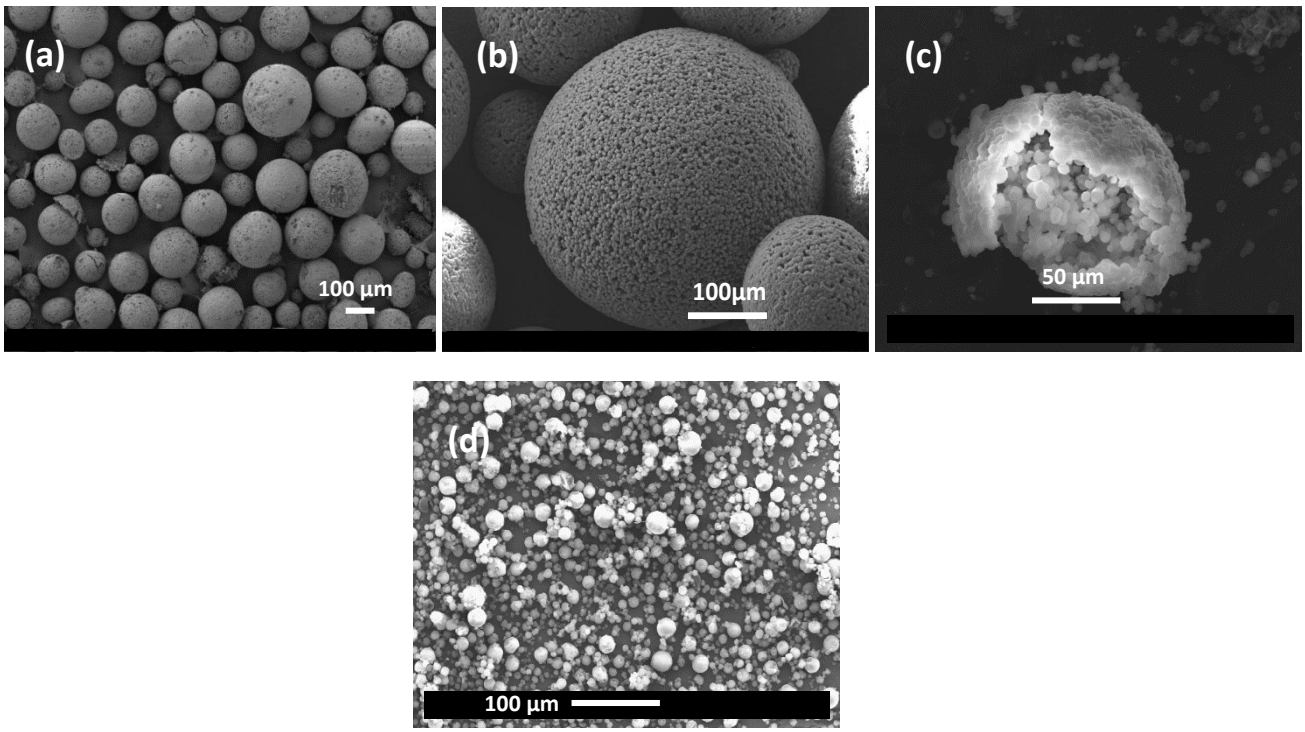

Figure 1: Micrographs of: (a) Micronal PCM, (b) and (c) Micronal PCM showing smaller capsules that are agglomerated to form the larger capsule, and (d) Encapsys PCM, which is composed of discrete particles.

PCM thermophysical characterization (80% complete): The thermophysical properties of the microencapsulated PCMs were determined in detail. Figure 2 shows the thermal analysis spectra of the Micronal (PCM-M) and Encapsys (PCM-E) PCMs. The derivative (DTG) curve shows two distinct peaks: a first (dominant) peak associated with the decomposition of the paraffin that is encapsulated within the shell, and a second peak associated with the decomposition of the polymer encapsulation. For PCM-M the thermal degradation of the paraffin occurs in the temperature range of 175 to 275°C whereas the paraffin in PCM-E decomposes in the temperature range of 200 to 350°C; most likely a result of their differing molecular weights. The chemical composition of theses PCMs as extracted from the thermal analysis data are shown in Table 1.

Table 1: Chemical composition PCM-M and PCM-E as extracted from TG data

Chemical Composition	PCM-M	PCM-E
Paraffin wax (%)	69.50	90.22
Polymeric capsule (%)	20.70	7.67
Residue (%)	9.80	2.10
Core-to-shell ratio (mass-based)	3.4	11.8

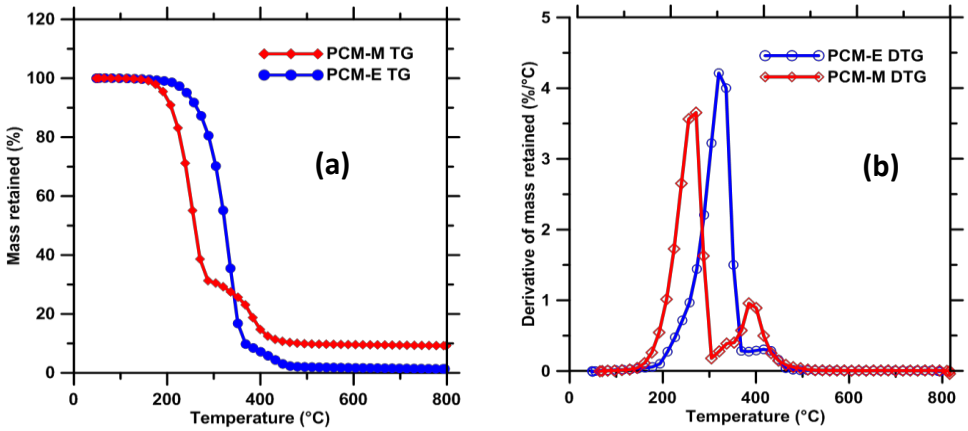

Figure 2: (a) Thermogravimetric (TG), and (b) differential TG curves of PCM-M and PCM-E.

Fourier Transform Infrared (FTIR) spectra of both the PCMs are shown in Figure 3(a). The spectral peaks in the 2950 cm^{-1} to 2850 cm^{-1} range are attributed to the aliphatic C-H stretching vibration, the peak at 1465 cm^{-1} is attributed to C-H bending, and the peak at 717 cm^{-1} corresponds to the in-plane rocking vibration of the CH_2 group. These spectral vibration peaks are related to the paraffins in the PCM-M and PCM-E. The other spectral peaks at 1730 cm^{-1} and the multiple peaks from 1250 cm^{-1} to 1000 cm^{-1} correspond to the carbonyl group of the co-polymer and C-O stretching of the co-polymer respectively.

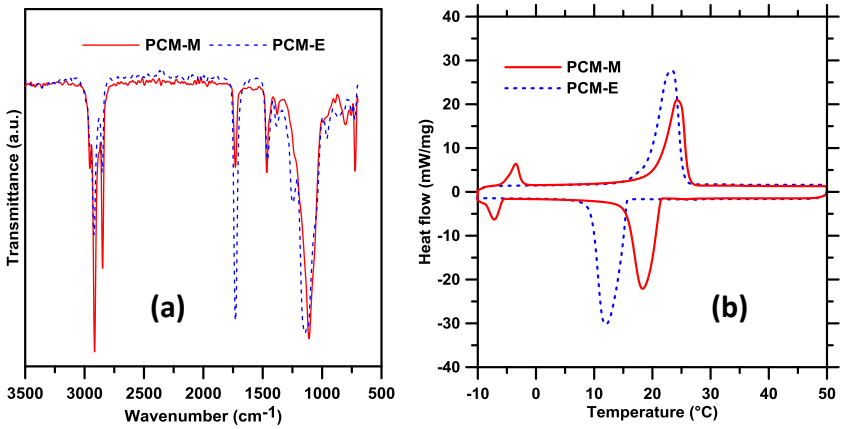

Figure 3: (a) FTIR spectra, and (b) DSC scans, of PCM-M and PCM-E. The DSC scans were carried out in the temperature range of -10°C to 50°C at a heating rate of 5°C/min.

Figure 3(b) shows representative DSC curves of the microencapsulated PCMs (PCM-M and PCM-E). The enthalpy of phase change of the PCMs was determined as the area under the main heat flow curve during the phase transition. The enthalpies of phase change of the PCMs used in this study were found to be 100 and 159 J/g respectively for PCM-M and PCM-E. This is in agreement with published results for similar PCM types. For PCM-M, the onset temperature (T_{onset}) corresponding to melting is 21.1°C and the completion temperature ($T_{completion}$) is 26.0°C, with the endothermic peak (T_{peak}) noted at 24.3°C. The onset, offset and peak temperatures for PCM-E was 19.5, 25.0 and 23.4°C respectively.

Novel microencapsulation strategies (5% complete): Novel microencapsulation strategies where a silica core is used for encapsulation is being studied. This work has just started.

Dissemination strategies (strategies developed): A detailed dissemination plan has been prepared by EUPAVE, our dissemination partner, in coordination with TECNALIA who leads the European dissemination component. The dissemination plan is submitted as an Appendix to this report.