Nanotechnology applied to construction: Experimental and Numerical Study of Building Solutions with Phase change materials

Cláudia Amaral[1], Romeu Vicente[1], Paula Maques[2], Ana Barros-Timmons[3]

The incorporation of phase change materials (PCM) into building solutions and components is a growing trend that has proven, in many applications, to enhance thermal comfort in buildings and energy efficiency for new and existing building. This is because PCM can storage more energy, in latent form, than the typical sensible energy stored by common construction materials. However, the low thermal conductivity of PCM is an acknowledged drawback that constrains the use of their full potential since it slows down the heat transfer response associated to the charging and discharging processes.

The work developed addressed this drawback, and solutions incorporating two types of shape stabilized PCM, one based on paraffin and calcium carbonate (PCM@CaCO3) and other on paraffin, silica and graphene oxide (PCM@SiGO) to enhance their thermal conductivity were developed (see Figure 1a). The results achieved for the two types of shape stabilized PCM in comparison to those obtained using commercially available PCM (PCM@BASF) and their incorporation method in different polymeric matrices brought forward potential latent heat thermal energy storage (LHTES) applications (see Figure 1b). The PCM@CaCO3 was integrated in different polyurethane foams (PUFs) assembled in rigid PUFs panel and in composite PUFs panels (rigid /soft/rigid) and fully characterized. The thermal performance was evaluated using the Hotbox setup (see Figure 2), Hotplate and Hotdisk methods. Complementary, these PCM@CaCO3 and the PCM@SiGO were also incorporated in a poly(vinyl chloride) (PVC) structural layer.

The results obtained for three rigid PUFs panels, one without PCM (RPU) and the other two containing 5 wt% of each PCM (RPU_5PCM@CaCO3 and RPU_5PCM@BASF) are shown in Figure 2. These results reveal the thermal regulation effect of incorporating PCM, which could improve thermal comfort, reducing the temperature swing of the indoor spaces as well as the associated energy consumption to keep the temperature within the comfort range.

Additionally, a numerical model was developed and calibrated resourcing to experimental data to then carry out a parametric study to further assess the thermal performance, varying different parameters such as loading content of PCM and latent heat capacity

1 — Department of Civil Engineering & RISCO, University of Aveiro
2 — Department of Mechanical Engineering & TEMA, University of Aveiro
3 — Department of Chemistry & CICECO, University of Aveiro

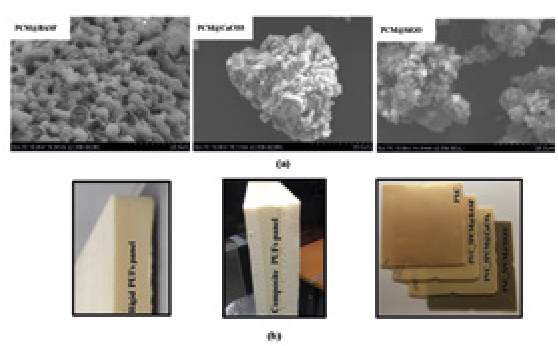

FIGURE 1
Incorporation of PCM into support polymeric matrices: (a) SEM images of different types of PCM (b) PUF panels and PVC films

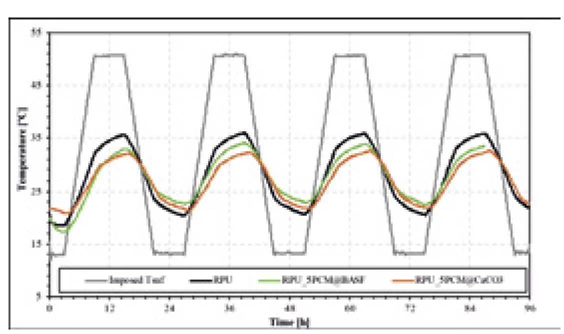

FIGURE 2
Temperature profiles of rigid PUFs panels (RPU) for a 4 day cycle