Comparative Study Of The Thermal Properties Of Nanoparticle-Enhanced Phase Change Materials For Building Envelope Applications

CONECT

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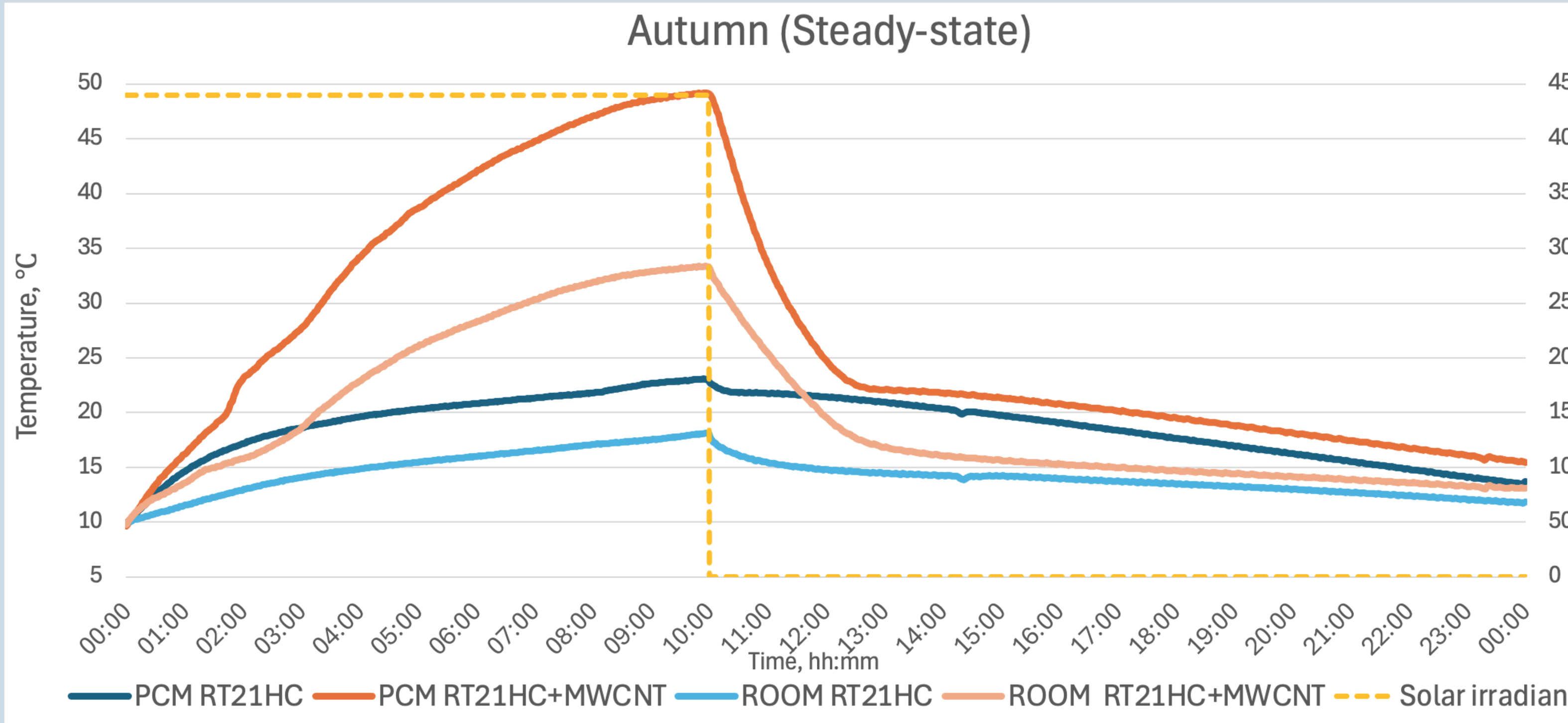
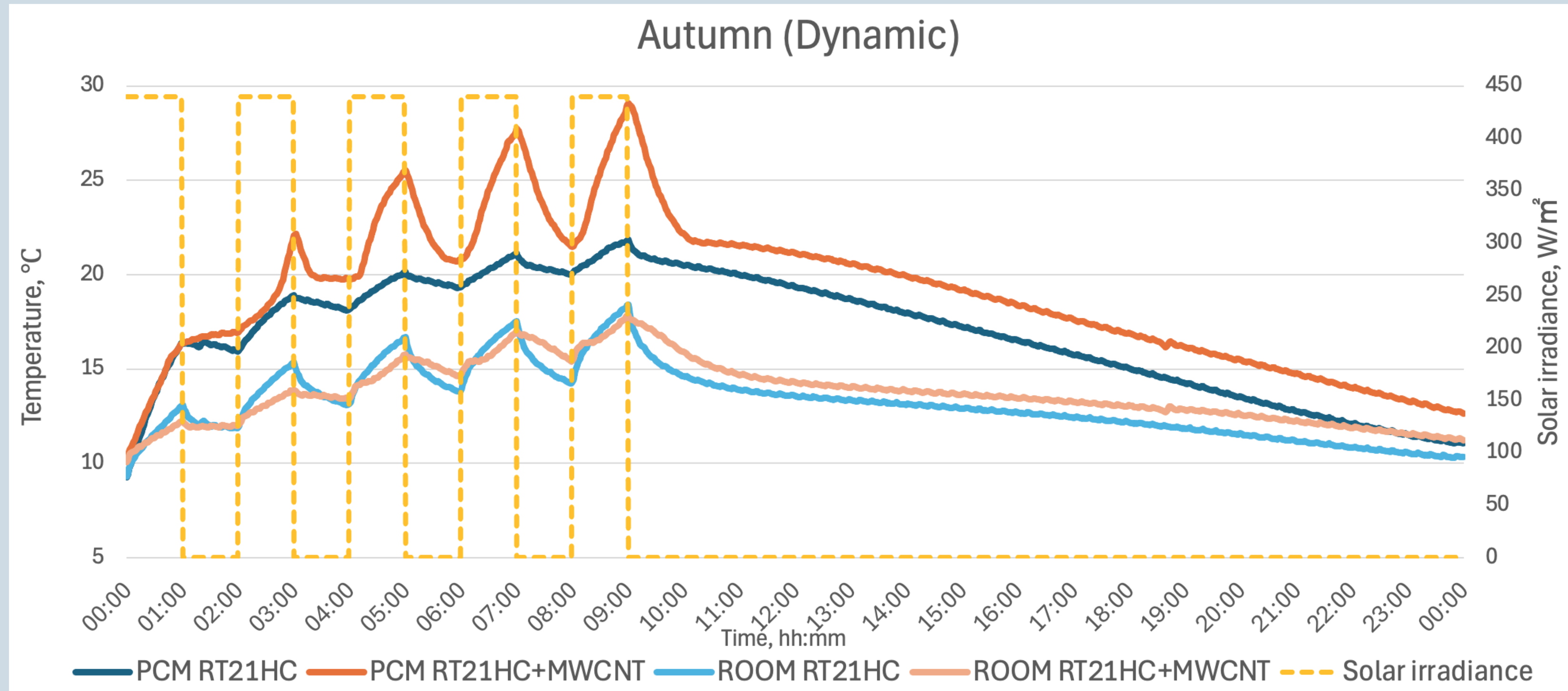
Inclusion of nano particles significantly increases the thermal conductivity of paraffin wax.

Results from steady-state experiments indicate that the phase change material temperatures can reach values more than twice as high with the addition of nanoparticles. Additionally, the incorporation of multi-walled carbon nanotubes reduces the phase transition time by up to 28% in dynamic experiments. Overall, the nanoparticles enhance the response to temperature fluctuations and achieve higher room temperatures in all cases.





Introduction

Phase change materials (PCMs) are gaining attention for their potential to improve the thermal energy performance of building envelopes. However, PCMs generally have low thermal conductivity, which means they absorb and release heat at a slower rate. This can limit their effectiveness in applications where fast heat transfer is essential for maintaining desired temperatures. Additionally, the performance of PCMs depends heavily on their phase transition temperature. If the temperature in the building fluctuates significantly, PCMs may not operate effectively or activate at the right moments.

Methodology

This study investigates the enhancement of paraffin wax through the incorporation of various nanoparticles to address the limitations commonly associated with PCMs.

Paraffin waxes Rubitherm RT21HC and RT28HC have been used as the base PCM medium for the nanoparticle mixtures in different concentrations.

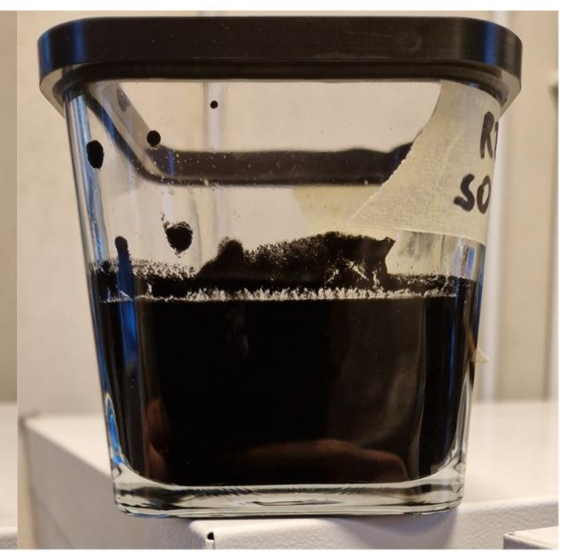
A series of steady-state and dynamic experiments were conducted to assess the impact of carbon nanotubes (CNTs) and zinc oxide (ZnO) nanoparticles on the thermal characteristics and phase transition time of paraffin wax.

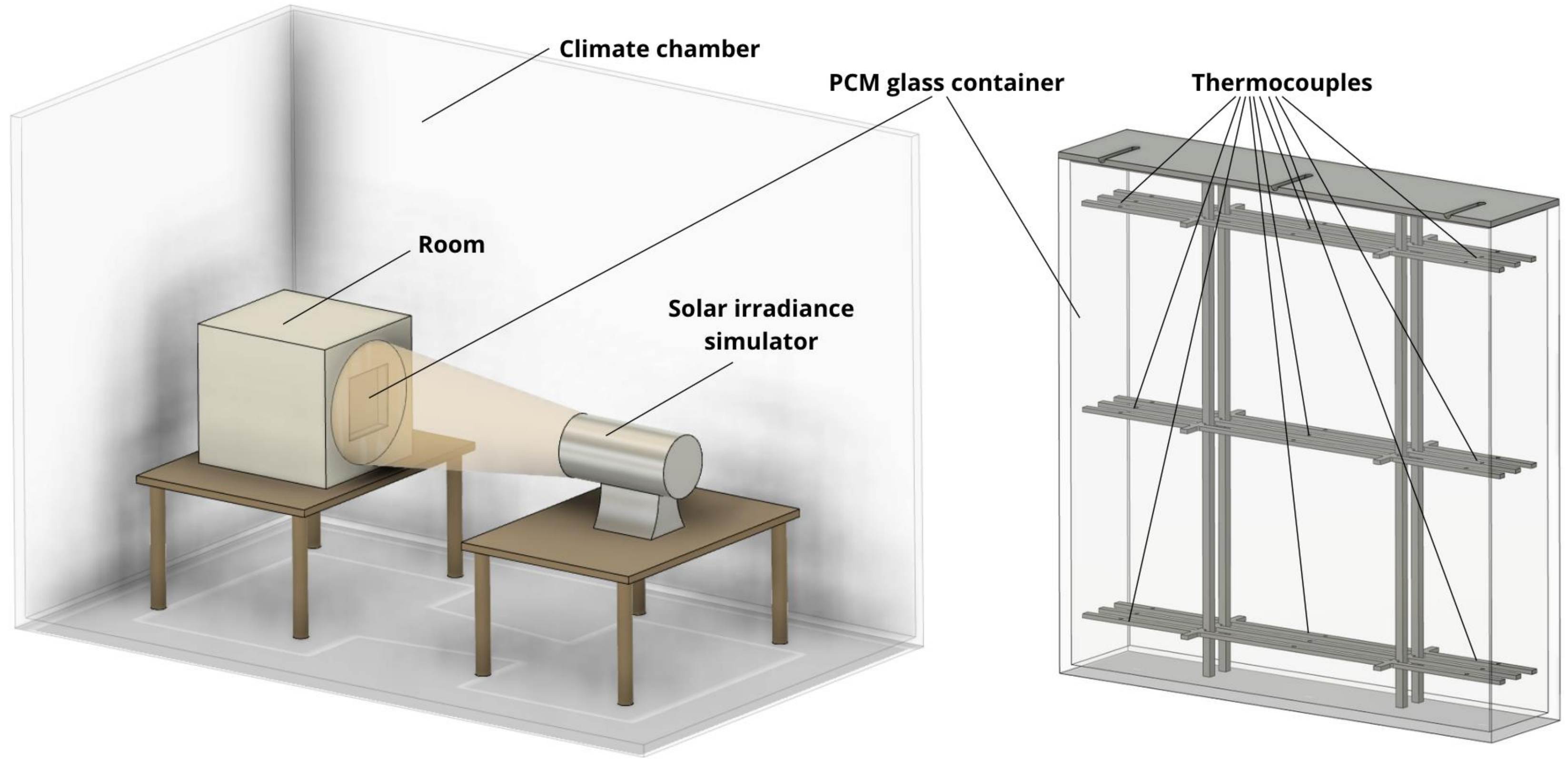
During the laboratory testing, four different climate seasons of the year were simulated using a climate chamber and halogen lamp. To obtain the average values of parameters such as daylight duration, solar irradiance, and outdoor temperature for a typical day in each season, data from the local meteorological station was analysed.

Experimental setup


Paraffin wax


ZnO-Paraffin wax


CNT-Paraffin wax



Condition settings

Season	Condition	Value
Spring	Daylight (solar simulation) duration Irradiance intensity Outdoor temperature	12 h 690 W/m² 7 ˚C
Summer	Daylight (solar simulation) duration Irradiance intensity Outdoor temperature	12 h 750 W/m² 19 ˚C
Autumn	Daylight (solar simulation) duration Irradiance intensity Outdoor temperature	10 h 440 W/m² 10 ˚C
Winter	Daylight (solar simulation) duration Irradiance intensity Outdoor temperature	9 h 230 W/m² 0 ˚C