A THERMODYNAMIC JOURNEY:
Unlocking Cold Thermal Energy Storage with Phase Equilibrium Studies

Sequeira, Maria C.M.[A*]; Nikitin, Timur[B]; Caetano, Fernando J.P.[C,D]; Diogo, Hermínio P.[A]; Fareleira, João M.N.A.[A]; Fausto, Rui[B,E]

A – Centro de Química Estrutural - Institute of Molecular Sciences, Departamento de Engenharia Química, Instituto Superior Técnico, Universidade de Lisboa.
B – CQC-IMS, Departamento de Química, Universidade de Coimbra.
C – Departamento de Ciências e Tecnologia, Universidade Aberta.
D – Centro de Química Estrutural - Institute of Molecular Sciences, Instituto Superior Técnico, Universidade de Lisboa.
E - Faculty of Sciences and Letters, Dept. of Physics, Istanbul Kultur Univ., Turkey.
* E-mail: maria.sequeira@tecnico.ulisboa.pt

Overview

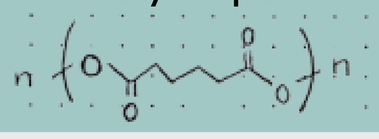
As the urgent demand for sustainable energy solutions increase, thermal energy storage (TES) systems have become crucial in improving energy efficiency and ensuring supply-demand balance [1]. For low-temperature areas such as refrigeration, cold-chain logistics, and specific medical applications, phase change materials (PCM) are particularly valuable due to their high latent heat capacity and reversible phase transitions [1,2].
However, finding PCM that are not only efficient and reliable, but also environmentally safe, remains a challenge.

Our Research

Our research work has focused on phase equilibrium studies of potential binary organic systems, providing valuable experimental data and thermodynamic insights for designing low-temperature TES systems. The work focused on two types of materials:

***n*-Alkanes**

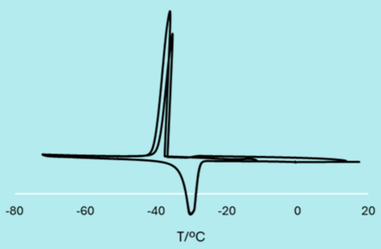
***n*-Alkyl Adipates**



Experimental Methodology

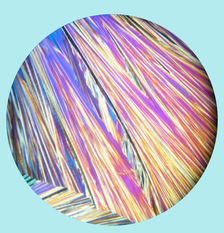
01

Differential Scanning Calorimetry (DSC) to obtain the melting temperatures and enthalpies of fusion.



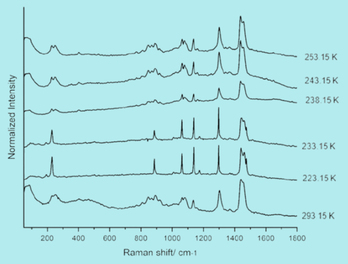
02

Hot Stage Microscopy (HSM) to visually corroborate the DSC results, mainly for polymorphism events.



03

Raman Spectroscopy to corroborate the DSC results both visually and qualitatively.



n-Alkanes

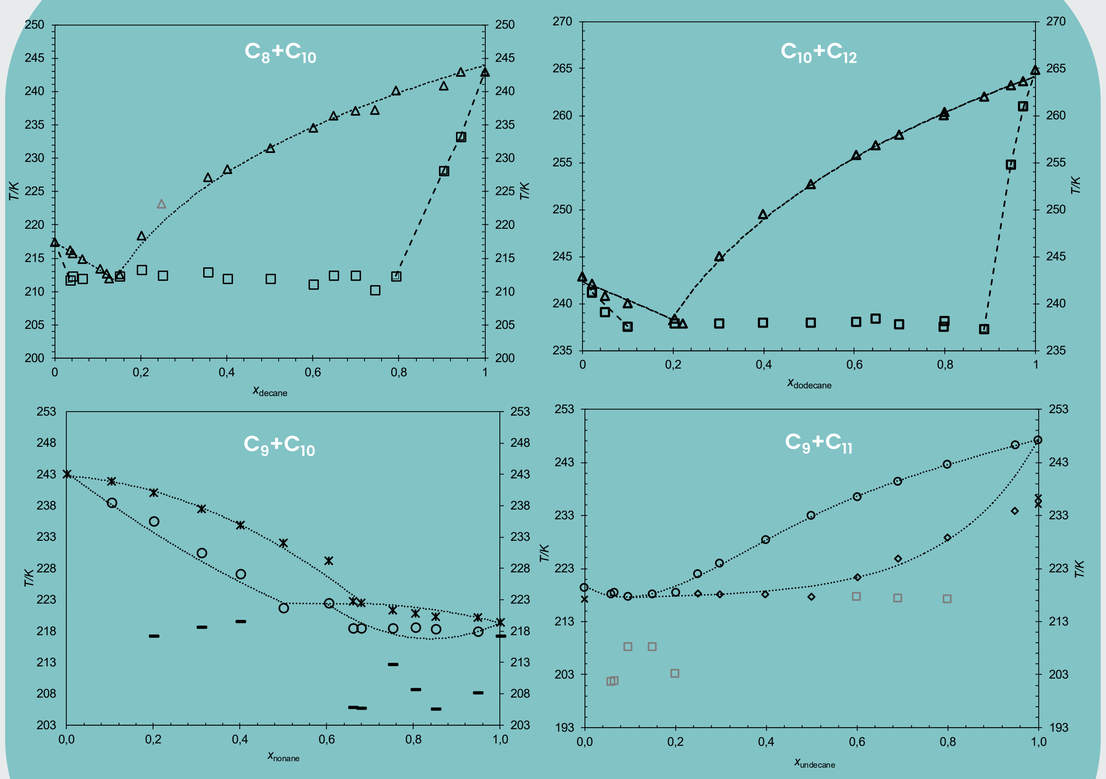


Fig. 1 Binary solid-liquid phase diagrams of: (a) *n*-C_8 + *n*-C_{10} (doi: 10.1007/s10765-023-03317-9); (b) *n*-C_{10} + *n*-C_{12} (doi: 10.1007/s10765-023-03317-9); (c) *n*-C_9 + *n*-C_{10} (doi: 10.1007/s10765-025-03531-7); (d) *n*-C_9 + *n*-C_{11} (doi: 10.1007/s10765-024-03411-6).

n-Adipates

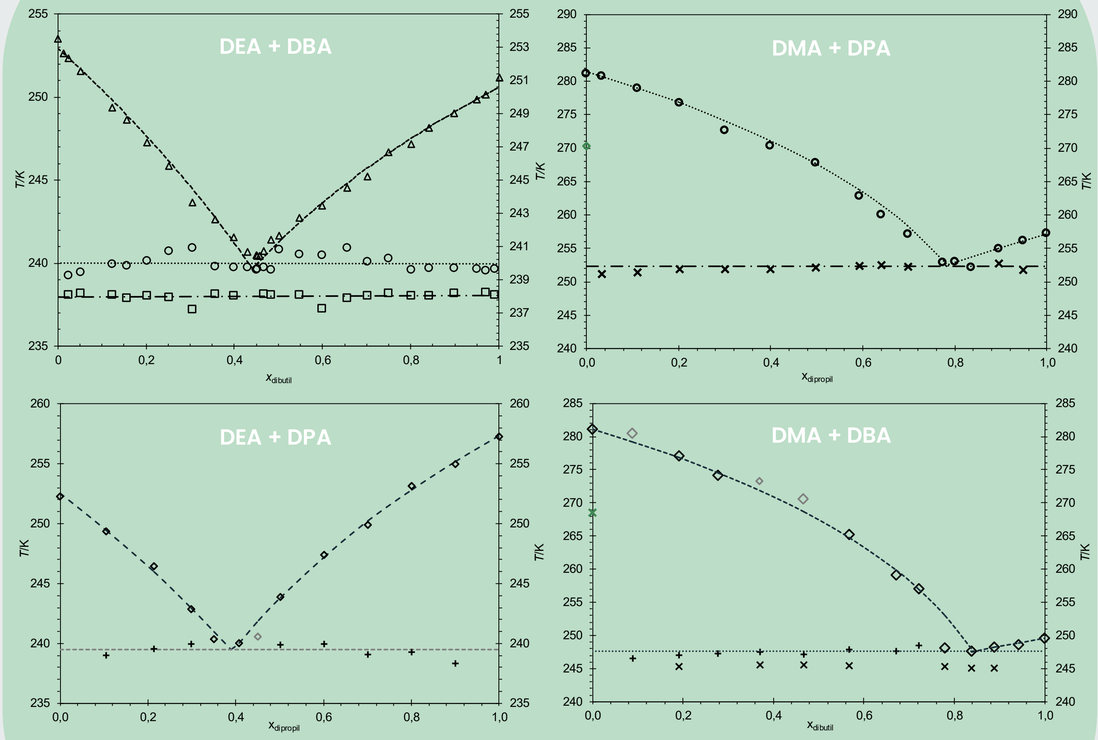


Fig. 2 Binary solid-liquid phase diagrams of: (a) Dietil (DEA)+ Dibutil (DBA) adipates (doi: 10.1007/s10765-023-03274-3); (b) Dimethyl (DMA) + Dipropil (DPA) adipates (doi: 10.1007/s10765-025-03598-2); (c) *DEA + DPA* (doi: 10.1007/s10765-025-03598-2); (d) preliminary results for DMA + DBA.

Unlocking Cold Thermal Energy Storage

01

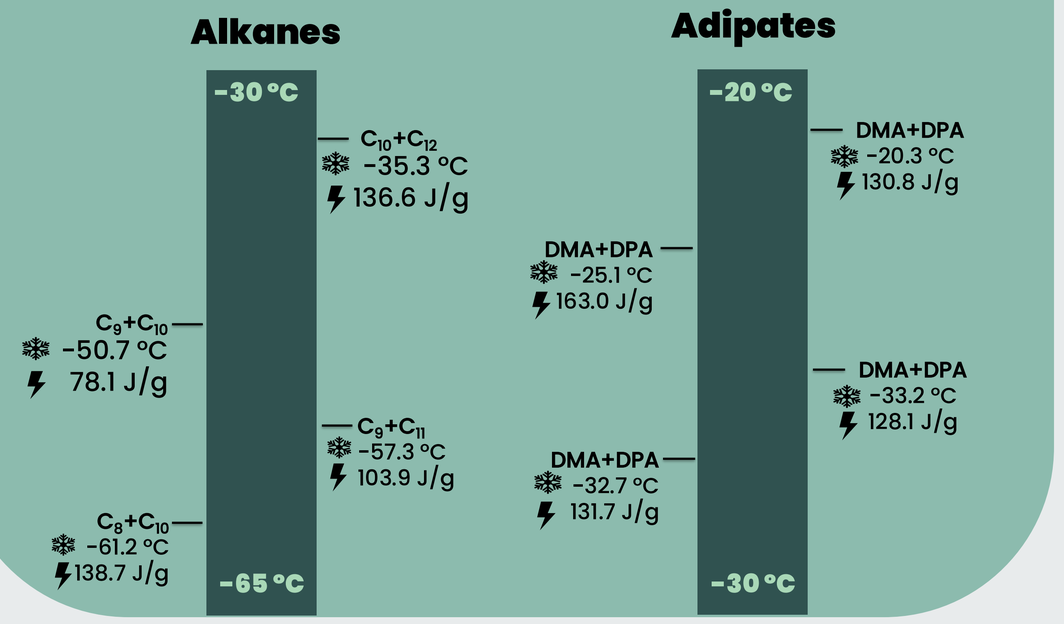
8 different PCM candidates:
4 binary alkane + 4 binary adipate systems

02

Different applications, similar performance:
Different melting temperatures, similar enthalpy of fusion

03

Design of low-T TES systems:
New phase equilibrium data to fulfil the lack of available data on low T PCM systems



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