Short communication

Advances in Thermal Energy Storage Fluids for CSP Systems: Emerging Trends and Challenges

A.S. Sabastine & J.N. Alikaya

Department of Mechanical Engineering, Mohamed Premier University, Oujda

Abstract: The development of advanced thermal energy storage (TES) systems is essential for the efficient operation of Concentrated Solar Power (CSP) plants. This communication highlights the latest progress in TES fluid development, emphasizing the use of novel quaternary nitrate mixtures and their enhancements for improved heat transfer and energy storage. Key challenges and future research directions are also discussed.

Keywords: Thermal storage, csp, trends & challenges

1. Introduction
The quest for sustainable energy solutions has spotlighted CSP plants, which offer a promising pathway for reducing carbon emissions and stabilizing the energy grid. Central to their efficiency is the development of advanced TES systems that enable high thermal conductivity and energy density.

2. TES Fluids and Their Properties
Quaternary nitrate-based molten salts have emerged as significant advancements in TES fluids. Kwasi-Effah et al. (2023) highlighted the development of such mixtures, which are characterized by their favorable thermophysical properties, including enhanced thermal stability and heat transfer capabilities.

3. Enhancements Through Nanoparticle Doping
Further improvements have been reported through nanoparticle doping. The incorporation of materials such as Al_2O_3 into molten salts has shown promising results in augmenting thermal conductivity and energy efficiency.

4. Economic and Environmental Considerations
While the performance benefits of new TES materials are clear, their economic viability remains a subject of extensive analysis. The UN Sustainable Development Goals (SDGs) framework emphasizes the importance of aligning such advancements with sustainability.

5. Future Directions and Challenges
Despite progress, challenges remain, including high costs and long-term stability concerns. Research should focus on balancing material costs with performance benefits, as well as exploring more eco-friendly compositions.

6. Conclusion
The evolution of TES fluids, particularly with quaternary nanoparticle enhancements, holds significant potential for improving CSP efficiency. Continued interdisciplinary research is necessary to overcome existing challenges and align these innovations with global sustainability goals.

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