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A comprehensive assessment of thermophysical properties of MXene doped Polyethylene glycol 400 for cold chain logistics

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ABSTRACT

Organic Phase change materials (PCMs) are commonly utilized in cold-chain logistics applications. Numerous logistics firms have successfully demonstrated the commercial viability of PCM-integrated shipping containers. Enhancing the thermal characteristics of PCMs could contribute to increased viability and sustainability. This research evaluates the thermophysical viability of a novel phase change composite, which could be used for a cold chain logistics system. Specifically, this research aims to shed light on energy storage systems that employ nanocomposites operating in lower (5–10 °C) temperature ranges. Polyethylene Glycol is a commonly used organic PCM as the molecular weight can be tuned according to necessities. MXene is a 2-dimensional nanomaterial with excellent properties. Initially, MXene nanoflakes were produced using a wet chemical process. The purity of the synthesized MXene flakes was verified by XRD analysis. The (PEG400/MXene) nanocomposite was synthesized using a facile two-step synthesis. From the viewpoint of MXene flake addition, the thermophysical properties of the nanocomposite PCM were analyzed in this article. A series of nanocomposites were methodically formulated by doping MXene flakes in varying concentrations (0-1 wt%) in PEG 400 to optimize their thermal properties. A boost of 17.98 % in thermal conductivity was noted for a maximum (1 wt%) loading of MXene nanoparticles. The phase change enthalpy of the nanocomposite was 100.68 kJ/kg. The thermo gravimetric analysis showed that all nanocomposites had decomposed above 350 °C, well above the permitted working temperature range. The solar transmittance value is as low as 0.127 %, showing that the NEPCCs can absorb the entire inherent solar spectrum. The comprehensive thermophysical characterization results indicate that the developed nanocomposite holds tremendous potential for integration in cold chain logistics systems.

1. Introduction

An estimated 820 million people around the world are vulnerable to malnutrition, which has a global impact. The United Nations formulated the seventeen Sustainable Development Goals (SDGs) for 2030 in September 2015. The “Zero Hunger” program of the United Nations ranks second among the various objectives. It is evident that to achieve Goal #2, it is necessary to prevent food waste and food losses. An estimated 1.3 billion tons of food is lost or wasted every year, representing one-third of the total food produced, as reported by the Food and Agriculture Organization (FAO). Notably, 630 million tons are lost, and 670 million tons go to trash [1]. Furthermore, inadequate cold chain protection in China results in an annual food loss rate exceeding 20 % [2]. Research findings indicate that inadequate temperature storage and transportation contribute to the wastage of one-third of the perishable foods consumed globally. Maximizing the usage of Cold Chain Logistic Systems (CCLS), particularly when transporting heat-sensitive perishables such as food and vaccines, can resolve this issue to a great extent [3]. CCLS is known for maintaining the freshness and usefulness of packaged commodities while preserving their quality and extending their shelf life. Improved CCLS infrastructure has become a global priority following the COVID-19 pandemic [4]. Research on CCLS is gaining significant interest from scientists focussing on thermal management applications. The primary factors contributing to this include a growing

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