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ORIGINAL PAPER

Low molecular weight paraffin, as phase change material, in physical and micro-structural changes of novel LLDPE/LDPE/paraffin composite pellets and films

Sepideh Bahrami[1] · **Maryam Mizani**[1] · **Masoud Honarvar**[1] · **Mohammad Abdollahian Noghabi**[2,3]

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Abstract Latent heat storage system by phase change materials is an effective method to achieve high density energy storage. A novel composite pellet consisted of a blend of linear low density polyethylene and low density polyethylene (LLDPE/LDPE) with low molecular weight paraffin (a phase change material, at 25 and 50 wt%) has been developed and coated by calcium silicate to prevent paraffin leakage. Three-layer coextruded films containing the paraffin composites as the middle layer have been prepared from each group for application as plastic film cover to control undesirable temperature variations during the storage of agricultural crops. The Melt Flow Index and thermal properties of the pellets as well as the quantity of paraffin leakage were studied. Thermal/morphological and permeation properties of the coextruded films have been investigated. The results showed that the LLDPE/LDPE polymer matrix provided an appropriate structural morphology for low molecular weight paraffin ($n < 18$) entrapment with good miscibility and low paraffin leakage (< 5%). Based on differential scanning calorimetry (DSC) thermographs, this type of paraffin may promote the compatibility between linear and low-density polyethylene. A dispersion-type morphology was observed in the micrograph of LLDPE/LDPE film, where the sizes of the spherical micro-domains were reduced as evident in the microscopic images of the paraffin-containing composite films. At storage temperatures below the phase change temperature ($T < 25$ °C), the oxygen permeability was substantially decreased because of the combined effects of paraffin crystallites and calcium silicate.

Keywords Phase change material · LLDPE/LDPE/paraffin composite film · Calcium silicate · Paraffin leakage · Polymer compatibility

Introduction

Latent heat storage systems comprising phase change materials (PCMs) represent an effective means of achieving a high density of energy storage with a moderate temperature variation [1]. PCMs absorb energy and/or release it to the environment during the heating and reverse cooling processes, respectively [2]. The global PCM market was valued at $675.67 million in 2015 and is expected to reach $1674.29 million by 2020, showing a compound annual growth rate of 19.9% [3]. Up to now, several applications of these groups of materials have been practiced; free cooling with PCMs has been used as an alternative method to cool buildings, which takes advantage of night ventilation to reduce the effects of rising air temperatures during the day time [4]. The storage of passive solar energy for deployment in the walls and floors of the buildings is another example of the potential applications of PCM [5]. In textile industry, these materials could be incorporated in textile structures to absorb surplus body heat and show thermo-regulating properties that are able to maintain a nearly constant body temperature [6]. PCMs also have been used by food industry in temperature-controlled packaging, shipping and transporting of different types of food products to delay undesirable color changes, control respiratory rates, prevent microbial spoilage and

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✉ Maryam Mizani
m.mizani@srbiau.ac.ir

[1] Department of Food Science and Technology, Tehran Science and Research Branch, Islamic Azad University, Tehran, Iran

[2] Sugar Beet Seed Institute, Karaj, Iran

[3] Agricultural Research, Education and Extension Organization, Tehran, Iran