Materials and Design 32 (2011) 1806–1813

Contents lists available at ScienceDirect

Materials and Design

journal homepage: www.elsevier.com/locate/matdes

Studies on the oxygen barrier and mechanical properties of low density polyethylene/organoclay nanocomposite films in the presence of ethylene vinyl acetate copolymer as a new type of compatibilizer

S.M. Ali Dadfar, I. Alemzadeh *, S.M. Reza Dadfar, M. Vosoughi

Department of Chemical and Petroleum Engineering, Sharif University of Technology, Tehran, Iran

ARTICLE INFO

Article history:
Received 29 September 2009
Accepted 13 December 2010
Available online 23 December 2010

Keywords:
A. Nanoclay
B. Film
A. Nanocomposite

ABSTRACT

Nanocomposite films based on low density polyethylene (LDPE), containing of 2, 3, and 4 wt.% organoclay (OC) and ethylene vinyl acetate (EVA) copolymer as a new compatibilizer were prepared and characterized using rheological tests, X-ray diffraction, differential scanning calorimetry, oxygen permeation measurements, and tensile tests. There was no exfoliation or intercalation of the clay layers in the absence of EVA, while an obvious increase in *d*-spacing was observed when the samples were prepared with EVA present. This issue was reflected in the properties of nanocomposites. The oxygen barrier properties of the LDPE/EVA/OC film were significantly better than those of the LDPE/OC film. The average aspect ratio of clay platelets in nanocomposites was determined from permeability measurements and using Lape–Cussler model. In addition to barrier properties, the LDPE/EVA/OC film also had better elastic modulus than their counterparts without EVA. The modulus reinforcement of nanocomposites was studied using Halpin–Tsai equations, which are universally used for composites reinforced by flake-like or rod-like fillers.

© 2010 Elsevier Ltd. All rights reserved.

1. Introduction

In recent years, there is an increased demand in the polymer industry for producing packaging films that are more barrier and stronger than those already on the market [1]. Recent researches on the properties of a novel class of composite materials known as polymer/clay nanocomposites (PCNs) indicate that they could be employed for this purpose [2–4]. As their name suggests, PCNs are a group of hybrid materials made from layered silicates of clay, for example montmorillonite, dispersed in the polymer matrix with layer thickness in nanometer dimensions [5–7]. Properties such as super mechanical strength [8–10], high modulus [8–10], reduction in weight, as well as improved barrier properties against liquids [11,12], gases [13–15] and vapors [9] are achievable with this novel composite. The enhanced properties are due to the interaction between polymer and clay at the nanoscale level.

Film is the largest market segment for polyethylene (PE). PE films are used for food, good, and farming packaging [3]. Thus, improvements in both the mechanical and barrier properties of the PE films will promote current applications as well as lead to more advanced applications like pharmaceutical packaging. Incorporation of a small amount of organoclay (OC) into PE is expected to enhance the mechanical and barrier properties concurrently [16–18]. Nevertheless, PEs are highly inefficient at exfoliating the OC because they lack a favorable interaction with the polar surface of the clay. While complete exfoliation of the OC in PE seems impossible, it is possible to improve the level of clay dispersion by introducing some modified polymer having polar group in the nanocomposite formulation [17,19–21]. In fact, this modified polymer, called as compatibilizer, enhances interfacial interactions between the clay layers and PE chains. Maleic anhydride grafted polyethylene (PE-g-MA) is the most widely used compatibilizer in the polyethylene/clay nanocomposite (PECN) compositions [16,19,20,22,23].

Many papers have been published on the development of PECNs [16–26]. Zhong et al. [16] prepared high density polyethylene (HDPE) and low density polyethylene (LDPE) nanocomposites via melt blending using PE-g-MA compatibilizer. They reported that incorporation 5 wt.% clay improved the oxygen barrier by 30% and the tensile modulus by 37% for the LDPE/PE-g-MA system while incorporation of clay did not enhance the properties of the HDPE/PE-g-MA system. Morawiec et al. [19] prepared nanocomposites based on LDPE, containing of 3 or 6 wt.% of OC and maleic anhydride grafted low density polyethylene (LDPE-g-MA) as a compatibilizer. They concluded that LDPE-g-MA not only promoted the exfoliation of the clay and its good adhesion to LDPE but it also toughened the polymer matrix. Lee et al. [20] synthesized PECNs by melt blending using either maleic anhydride grafted polypropylene (PP-g-MA) or PE-g-MA as a compatibilizer.

* Corresponding author. Tel.: +98 21 66165486; fax: +98 21 66012983.
E-mail address: alemzadeh@sharif.edu (I. Alemzadeh).

0261-3069/$ - see front matter © 2010 Elsevier Ltd. All rights reserved.
doi:10.1016/j.matdes.2010.12.028