

Preparation of polyethylene-graft-clay nanocomposites using Friedel–Crafts alkylation reaction as a new method

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Abstract The main objective of this study was chemical grafting of polyethylene (PE) chains onto clay surfaces in PE/clay nanocomposites. Clay (Cloisite 30B) particles were successfully modified using a laboratory-synthesized carboxylic acid end-functionalized polystyrene (F-PS) and a commercial styrene–maleic anhydride copolymer (SMA). SMA showed higher grafting efficiency than F-PS. It is related to lower molecular weight and higher compatibility of SMA with Cloisite 30B particles. Both modified Cloisite 30B particles were used in preparation of PE nanocomposites where AlCl_3 catalyst was used for chemical grafting of PE chains onto polystyrene (PS) or SMA chains, pendant from the clay particles surfaces. Using AlCl_3 increased the storage modulus and decreased the damping factor, particularly at low-frequency ranges. It was related to the chemical grafting of the PE chains onto the PS segments of the SMA copolymer and the PS chains of F-PS on the clay particle surfaces via Friedel–Crafts alkylation reaction. Catalyzed nanocomposites showed better clay dispersion than those of the plain nanocomposites. It is believed that chemical grafting of PE chains onto clay particles surfaces provided effective stress transfer from PE matrix to clay tactoids resulting in delamination and higher degree of clay exfoliation.

Keywords Polyethylene · Clay · Nanocomposite · Grafting · Surface modification

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Introduction

Preparation of polymer–clay nanocomposites has been investigated for the past two decades [1, 2]. It has well been shown that addition of small amounts of nano-sized clay particles into a polymer matrix remarkably enhances its mechanical, thermal and barrier properties, compared with conventional microcomposites [3, 4]. Polymer–clay nanocomposites, prepared using different polymers such as PE and PS, have been reported to exhibit dramatically enhanced properties such as modulus, tensile strength as well as gas barrier properties [5].

Numerous methods such as solution intercalation, in situ polymerization and melt blending are used for processing of polymer–clay nanocomposites [3]. Depending on the state of clay particles dispersion in polymer matrix, three different types of composites, i.e., microcomposites, intercalated and exfoliated nanocomposites can be achieved. The latter is more favorable, because in exfoliated nanocomposites, the completely delaminated clay layers are individually and randomly dispersed in the polymer matrix, leading to better chemical and physical properties of nanocomposites in comparison with microcomposites and intercalated nanocomposites. However, most polymers are not compatible with pristine clay particles due to the hydrophilic and hydrophobic natures of pristine clay particles and most of polymers, respectively [6]. Hence, to form proper polymer clay nanocomposites, the immiscibility between the polymer and clay particles must be overcome by modifying either polymer structure or clay layers surfaces. The latter is the most frequent and favorable method used in investigations [7–9].

PE is widely used in different industrial applications such as packaging, cable coating and insulations, due to its different suitable properties, including high chemical