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Adhesion properties of atactic polypropylene/acrylate blend copolymer and its adhesion mechanism for untreated polypropylene materials

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Abstract

The adhesion and coating of polypropylene (PP) materials usually requires pre-processing, or the use of modified chlorinated polypropylene (CPP) as an adhesive, which is often synthesized in a benzene solution. Here a feasible method was achieved to modify atactic polypropylene (APP) to obtain an adhesive for polypropylene. Through "grafting from", acrylate monomers were successfully grafted onto atactic polypropylene to obtain a blend copolymer in a butyl acetate solution. The adhesive presented excellent adhesion to polypropylene. A maximum peel strength of 12.9 N/m was achieved. A mechanism to account for this enhanced adhesion between the blend copolymer and PP was proposed. In addition to a van der Waals force contribution, it was concluded that the promotion of adhesion included the contributions from diffusion and entanglement together with crystallization.

Abbreviation list

PP, polypropylene; APP, Atactic polypropylene; CPP, Chlorinated polypropylene; EVA, Ethylene-vinyl acetate; BOPP, Biaxially oriented polypropylene; AA, Acrylic acid; MMA, Methyl methacrylate; AM, Acrylamide; BA, Butyl acrylate; IBOA, Isobornyl acrylate; THF, Tetrahydrofuran; DCP, Dicumyl peroxide; DSC, Differential scanning calorimetry; AFM, Atomic force microscopy; XPS, X-ray photoelectron spectroscopy; SEM, Scanning electron microscope; POM, Polarizing microscopy; GPC, Gel permeation chromatography

Key words: atactic polypropylene, grafted APP, isobornyl acrylate, peel strength

1. Introduction

Polypropylene materials, due to their low surface energy, non-polarity and high crystallinity, are difficult to bond or coat In the fields of adhesives and coatings, the application of polypropylene materials usually requires corona [1, 2], plasma [3-6] and other pre-processing, which can improve the polarity of the PP surface so as to increase the surface energy and adhesion properties. However, polymer surfaces modified by corona discharge often undergoes severe degeneracy, especially in a damp environment [7, 8].

It has been reported that some kinds of adhesives can be used directly to bond polypropylene materials, such as modified chlorinated polypropylene (CPP) [9-12] or ethylene-vinyl acetate copolymer (EVA) [13-15]. However, these types of adhesive are either synthesized or applied in toluene or xylene solution, which are organic pollutants which can be severely harmful to human health. Besides, the presence of chlorine limits its application. Adhesives modified with dopamine/DOPA [16, 17] or organoborane [18-20] are able to produce excellent adhesion to low surface energy materials. Unfortunately, due to exorbitant expense, they have been restricted to employment in medical and other top grade fields.

Atactic polypropylene (APP) is widely used as a hot melt adhesive, showing good adhesion strength for polypropylene materials [21-24]. However, the hot melt adhesive is inconvenient to the coating process. In contrast to isotactic polypropylene (IPP), APP is easily dissolved, which is conducive to modifying the APP in a weak solvent to obtain a solvent hot melt pressure sensitive adhesive. Therefore, we have accomplished a practicable method to prepare atactic polypropylene/acrylate copolymer blend adhesive through graft polymerization in butyl acetate solution. The structure and thermal properties of grafted APP were characterized via FTIR and DSC. In this work, the adhesion mechanism of a grafted APP copolymer blend for PP materials was firstly proposed. Meanwhile, the effects of various formulas