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ELECTRET CHARGE STABILITY OF POLYOLEFIN BLENDS WITH POLAR POLYMERS

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Absrtact. In this paper, a comprehensive view is given on the effect of morphology, crystallinity and composition of polyolefin blends with polar polymers. Polypropylene homopolymer based blends were investigated on electret charge stability by TSSPD and phase transitions of these blends by DSC. Depending on the chemical structure of the polar polymer, already small concentrations could significantly change the charge stability. Low melting fluoropolymers had a significant higher impact than polar polymers such as ethylene methyl acrylate EMAC or polyethylene terephthalate (PET) at low additive percentages in the polypropylene matrix.

Keywords: polypropylene, blends, charge stability.

Introduction

Recent years, several papers from various groups have been published where the effect of polar chemical functional groups on the electret stability have been investigated [1,2,3]. The incorporation of additives, either organic or inorganic can have a substantial effect on the electret charge stability. For many purposes, the aim of these composite investigations was towards higher charge stability, however for some applications such as cable insulation, the situation can be much more nuanced and trap dept on itself does not give the full picture on the material performances. This study therefore focused on the electret stability of model blends in polyolefin blends where the charge trap distribution is strongly dominated by the abundance of trapping sites provided by the polar chemical functional groups.

Materials and methods

Polymer granules were made in different compositions by extrusion in a Scamia single screw extruder with L/D 26 at 190°C to avoid degradation. Granules were thereafter pressed in a hot press at 230°C for 5 minutes at 200bar and immediately afterwards pressed in a water-cooled press at 200 bar until they reached room temperature after 3 minutes gaining 100µm thick films. Differential Scanning calorimetry (DSC) was used to determine the phase transitions of the thin films. Thermally stimulated surface potential decay was used to assess the electret charge stability. Thin films were charged during 30 seconds at 2000V under a classic corona triode at 12kV and a control grid at 2000V placed 5mm above the thin films. Heating rate was set at 3K/min. Polypropylene samples were acquired from Polychim Industrie, France. Poly(ethylene-methyl acrylate) copolymer SP2220 (EMAC) was used from Westlake (USA) and PET5530 (PET) was supplied from Indorama. Fluoropolymer FX5911 from 3M was used in this study as processing aid.

Results

Although many fluoropolymers are used for their well characterized charge stability, see the many PTFE publications in the field [4], the addition of fluoropolymers is not always a benefit for the charge stability. In Fig. 1, two PP homopolymers with a classical phenolic anti-oxidant packages are shown. One polymer however was blend with trace amounts (~300ppm) of a low melting fluoropolymer processing aid. As is clearly seen from the graph, the addition of a small trace amount of this processing aid has strongly detrimental effects on the charge stability.

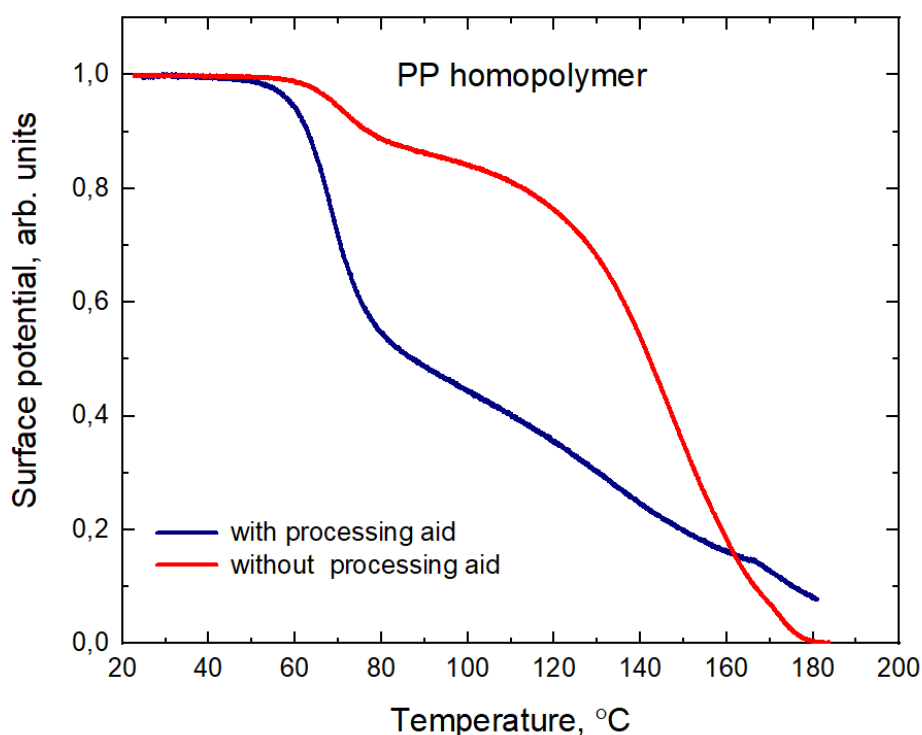


Fig. 1. Comparison of the effect of a low melting fluoropolymer processing aid

In order to determine the effect of several other polar polymers, additional blends were prepared with a polar polyethylene acrylate copolymer at high concentration and compared with previous blends from the earlier studies and a polyester based blend (Fig. 2) [5].

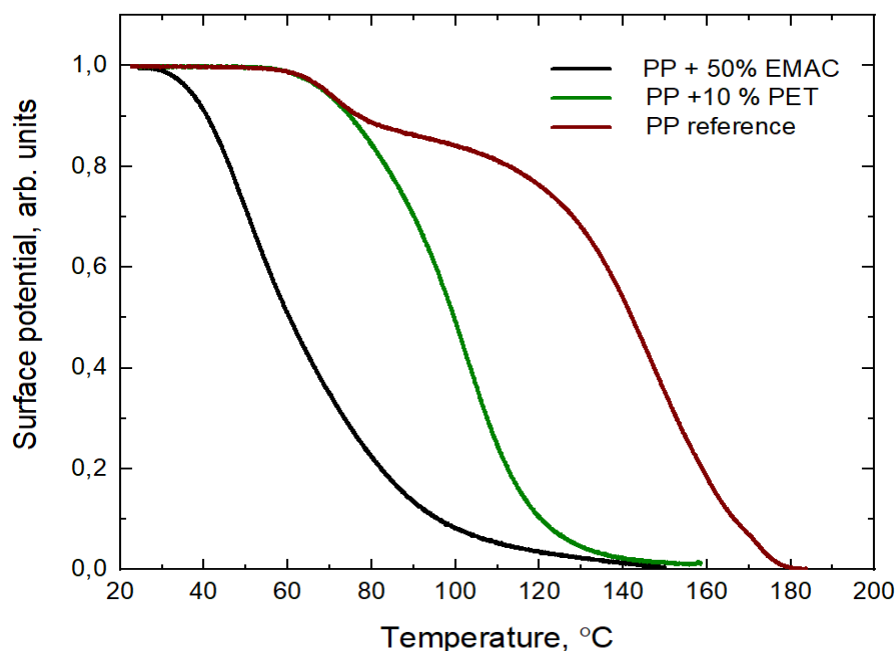


Fig. 2. Comparison of charge decay of different PP based blends with polar polymers.

The melting curves of the used polymers are shown in Fig. 3. The polypropylene homopolymer has a melting peak around 165°C as is common for Ziegler-Natta catalyzed polypropylene homopolymers. The polyethylene random copolymer with polar methyl acrylate copolymer has a significantly reduced melting peak. Even in high concentrations in the blends, the low melting PE copolymer doesn't show a major calorimetric signal in the DSC curves. In similar way, the melting peak if the PET in the PP+10%PET blend is not strongly noticeable due to the relatively small endotherms of this polyester material. For the PET reference, the glass transition temperature around 80°C is visible, which is not detectable in the blends.

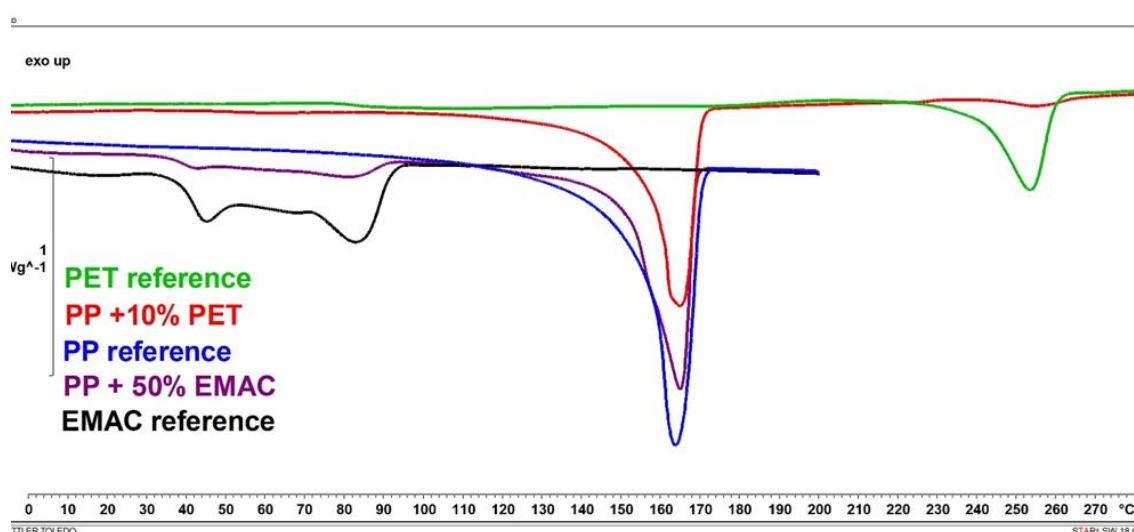


Fig. 3. DSC melting graphs of PP homopolymer, PET and a polar ethylene methyl acrylate copolymer.

Discussion

In this study, it was shown that polypropylene homopolymer can serve as a decent material for good, thermally stable electret films when it is pressed as a pure material. However, the incorporation of low melting polar materials, such as fluoropolymer processing aids, in trace amounts can already substantially decrease the electret stability. This is in major part due to the high affinity of fluoropolymers to capture the injected charge. Although the additive is present in low amounts, the melting of the already low crystalline fluoropolymer induced the fast release of the trapped charge which results into a decreasing surface potential. The addition of polar polyethylene copolymers reduces the electret properties in a similar manner, but in case of these polyolefin blends, a similar reduction in charge stability is obtained with high blend ratios. It was noticed that despite the high melting point of the used PET type polyester, surface potential decay drops very fast after roughly 75°C. This can be linked to the combination of a relaxation process occurring on the PP crystals together with the glass transition of PET which in the same way induced a discharging of the trapped charges.

Conclusions

In conclusion, the polarity and phase transitions of polymer are strongly connected with the electret charge stability in thin films. Depending on the type and concentration of polar polymer additive, already strong changes in stability can be obtained. In order to keep polypropylene based electrets as stable as possible, it is crucial to avoid any contamination with polymer additives which can strongly affect the charge storage mechanism. However, when both (di)electric properties are needed to be tuned, the addition of for example, flexible polyethylene copolymers with polar comonomers can be used for applications where a balance between for example flexibility and charge stability should be balanced.

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Conflict of interests. The authors declare no conflict of interest.

Statement of Informed Consent. Informed consent was obtained from all study participants.

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СТАБИЛЬНОСТЬ ЭЛЕКТРЕТНОГО ЗАРЯДА В СМЕСЯХ ПОЛИОЛЕФИНОВ С ПОЛЯРНЫМИ ПОЛИМЕРАМИ

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Аннотация. В этой статье дается всестороннее представление о влиянии морфологии, кристалличности и состава смесей полиолефинов с полярными полимерами. Смеси на основе гомополимера полипропилена были исследованы на стабильность электретного заряда методом TSSPD и фазовые переходы в этих смесях методом DSC. В зависимости от химической структуры полярного полимера, даже небольшие концентрации могут существенно изменить стабильность заряда. При низком содержании добавок в полипропиленовой матрице эффективность низкоплавких фторполимеров значительно выше, чем у полярных полимеров, таких как этиленметилакрилат ЕМАС или полиэтилентерефталат (PET).

Ключевые слова: полипропилен, смеси, стабильность загрузки.

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