Polypropylene Reactive Nanocomposites with Functional Nanoclays

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Introduction

The most interesting polymer nanocomposite is the one that made of a polymer and nanofiller called nanoclay or organoclay. Here in this work, the nanoclay was prepared from Tham beaverite and common sodium montmorillonite (Na-MMT) with CEC of 115 meq/100 g, respectively. Polypropylene (Moplen HP900N, 120 MFI) was from HMC Polymer Co., Ltd. Sodium-activated ethylene-co-methacrylic acid (Strylin® PE250, 45 MFI) was purchased from DuraFlex, Inc. Two alkylammonium agents with same carbon length (C12), dihydrogenated tall oil dimethylammonium chloride (DTDM) and Methyl 1-Decylcarboxylate-2-hydroxyethyl ammonium methylammonium (DCEM) with ester linkage and hydroxy group were selected for the preparation of organo-modified clay by ion exchange.

Two types of clay minerals with different CEC were used: local sodium bentonite (Na-BN) with 25.55 meq/100 g and common montmorillonite (Na-MMT) with CEC of 115 meq/100 g, respectively. Polypropylene (Moplen HP900N, 120 MFI) was from HMC Polymer Co., Ltd. Sodium-activated ethylene-co-methacrylic acid (Strylin® PE250, 45 MFI) was purchased from DuraFlex, Inc. Two alkylammonium agents with same carbon length (C12), dihydrogenated tall oil dimethylammonium chloride (DTDM) and Methyl 1-Decylcarboxylate-2-hydroxyethyl ammonium methylammonium (DCEM) with ester linkage and hydroxy group were selected for the preparation of organo-modified clay by ion exchange.

The 3 wt% of organoclays were blended with PP and 5 wt% of Strylin in the twins screw extruder (80, 160, 180, 190, and 200°C from hopper to die, 50 rpm) and the pellets were added to injection molding (barrel temperature of 200°C, mold temperature of 45°C, injection pressure of 1000 bar) to get specimens for tensile test (ASTM D638).

Experimental

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Table 1. Melting and crystallization behavior of PP and nanocomposites (using Perkin Elmer DSC-7, 20-250°C at 10°C/min).

<table>
<thead>
<tr>
<th>Material</th>
<th>T_m (°C)</th>
<th>T_c (°C)</th>
<th>∆Hm (J/g)</th>
<th>Crystallinity %</th>
</tr>
</thead>
<tbody>
<tr>
<td>PP</td>
<td>170.8</td>
<td>161.7</td>
<td>66.45</td>
<td>31.80</td>
</tr>
<tr>
<td>PP + Strylin + DTDM-B</td>
<td>108.9</td>
<td>106.7</td>
<td>65.05</td>
<td>32.33</td>
</tr>
<tr>
<td>PP + Strylin + DCEM-B</td>
<td>109.6</td>
<td>107.7</td>
<td>65.56</td>
<td>34.17</td>
</tr>
<tr>
<td>PP + Strylin + DTDM-M</td>
<td>108.1</td>
<td>108.3</td>
<td>63.34</td>
<td>33.01</td>
</tr>
<tr>
<td>PP + Strylin + DCEM-M</td>
<td>109.1</td>
<td>108.0</td>
<td>65.22</td>
<td>33.77</td>
</tr>
</tbody>
</table>

Results and discussion

The results show in Figure 1 confirm the intercalation of two alkylammonium agents in both Na-BN and Na-MMT. The functional nanoclays (DCEM) show peaks at lower angle region suggesting that the silicate layers were expanded largely [1]. Moreover in Figure 2, the PP-sodium nanoclay nanocomposites show no peaks at lower angle region indicating the good exfoliation of silicate layers while those with DTDM (linear ammonium ammonium) show some shoulders. Thermal properties of the nanocomposites reveal that the nanoclay can initiate early crystallization but do not change crystal structure [2] and thus resulting in higher crystallinity (Table 1).

Figure 1. XRD results for the modified nanoclays

Figure 2. XRD results for PP/nanoclay nanocomposites

Figure 3. Tensile properties of PP/nanoclay nanocomposites

Conclusion

PP nanoclay nanocomposites were successfully obtained by both simple and reactive melt mixing (with an inorganic compatibilizer and functional alkylammonium agents). The reactive nanocomposites show slightly higher crystallinity and better mechanical properties. However, the interaction between components and clay imparties affects obviously on mechanical properties rather than thermal properties.

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References