POLYURETHANE/POLYETHYL ACRYLATE INTERPENETRATING POLYMER NETWORKS
Thermal decomposition kinetics

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Abstract

The thermal decomposition kinetics of polyurethane/polyethyl acrylate interpenetrating polymer networks (PU/PEA IPN) were studied by means of thermogravimetry and derivative thermogravimetry (TG-DTG), and compared with those of polyurethane (PU) and polyethyl acrylate (PEA). The decomposition temperature ($T_i$) of PU/PEA IPN was found to be higher than $T_i$ of PEA, but lower than $T_i$ of PU. Thermal decomposition kinetic parameters, $n$ and $E$, estimated using Coats-Redfern method, are found for PU/PEA IPN, PU and PEA to be 1.6, 1.9 and 1.1, and 196.6, 258.6 and 139.2 kJ mol$^{-1}$, respectively. The results show that PU/PEA IPN is neither a simple mixture of PU and PEA nor a copolymer of them. The mechanism of thermal decomposition of PU/PEA IPN is different from those of PU and PEA. The special network in PU/PEA IPN effectually protects weak bonds in the molecular chain of PU and PEA.

Keywords: polyurethane/polyethyl acrylate interpenetrating polymer networks (PU/PEA IPN), TG-DTG, thermal decomposition kinetics

Introduction

‘Interpenetrating polymer networks (IPN)’ was first reported by Millar in 1960 [1]. Sperling made systematic studies on this material in 1969–1971 [2, 3]. Since then, new IPN materials have been found and applied in various fields [4, 5]. Polyurethane/polyethyl acrylate interpenetrating polymer network (PU/PEA IPN) is a new material with a potential application in paint. The film of it is as bright as that of polyethyl acrylate (PEA) and as pliable and tough as that of polyurethane (PU). In order to study thermal stability and thermal decomposition mechanism of PU/PEA IPN, the thermal decomposition kinetics were studied by means of TG-DTG and compared with those of PU and PEA alone.

Experimental

The sample of PU/PEA IPN

The linear polyurethane (The soft and hard segment were polyethylene glycol adipate and polyethylene dis(4-phenylene iso-cyanate) ethylene glycol) and the linear polyethyl acrylate were dissolved in a suitable solvent. The crosslinking agent
(1,2,3-hydroxy-methyl-propane) was added to the above solution to form PU/PEA IPN. The fraction of PU and PEA in IPN is 1/1 (w/w).

**TG-DTG experimental equipment and conditions**

TG-DTG experiments were carried out on a Perkin-Elmer TGA-7 Thermo-gravimetric Analyzer, in a nitrogen atmosphere (80 ml min⁻¹) and a heating rate of 10°C min⁻¹. The sample sizes were 8–10 mg.

**Results and discussion**

**TG data and thermal decomposition behaviour in the first stage**

The TG-DTG curves of PU/PEA IPN, PU and PEA are shown in Fig. 1.

It can be observed from Fig. 1 that the TG-DTG curve of PU/PEA IPN is different than those of PU and PEA, and also is not a simple ‘sum’ of them. On the TG curve of PU/PEA IPN, there is a longer ‘terrace’ from 350 to 450°C.

![TG-DTG curves](image)

**Table 1** Thermal decomposition data of PU/PEA IPN, PU and PEA

<table>
<thead>
<tr>
<th>Sample</th>
<th>$T_i$ /°C</th>
<th>$T_f$ /°C</th>
<th>$T_p$ /°C</th>
<th>Mass loss / %</th>
</tr>
</thead>
<tbody>
<tr>
<td>PU/PEA IPN</td>
<td>281.6</td>
<td>392.2</td>
<td>331.7</td>
<td>61.6</td>
</tr>
<tr>
<td>PU</td>
<td>296.8</td>
<td>462.1</td>
<td>412.9</td>
<td>70.2</td>
</tr>
<tr>
<td>PEA</td>
<td>172.3</td>
<td>278.5</td>
<td>206.4</td>
<td>11.8</td>
</tr>
</tbody>
</table>

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