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Mechanical Properties of Polymer / Clay Nanocomposites

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Introduction
Hybrid inorganic/organic nanocomposites based on polymers reinforced with silicate minerals (clay) can exhibit marked improvement in properties like stiffness, barrier, thermal stability, flame retardance at low filler content of approximately 5wt%. The goal of this project is to investigate the micro mechanical behaviour of these materials and link it with their macroscopic properties.

Materials and Methods
Clays are naturally occurring highly crystalline hydrophilic minerals. Two types of clays were used as a reinforcing elements for the PE and PP matrix.

- Layered silicates

  - High aspect ratio platelets
  - Surface area ~ 800m²/gr.
  - Negatively charged layers balanced by alkali cations

- Fibrous clay minerals

  - High aspect ratio
  - Hollow structure

Nanocomposite preparation

Clays are rendered organophilic through ion exchange reactions with organic cations and subsequently dispersed into polymer matrix via extrusion melt mixing. In the case clay platelets three types of structures are obtainable depending on the thermodynamic interactions between the matrix and clay layers:

- Phase separation
- Intercalation
- Exfoliation

Using surface modifying agents for the clay to promote more favourable clay-polymer interactions.

For the PP matrix clay was modified using PEO-EBE block copolymer, for the PE based nanocomposite PE-MAS was used as a modifier.

Results

- Layered clay minerals

  PE / Somasif 5%

Clay platelets are homogeneously dispersed

<table>
<thead>
<tr>
<th>Material</th>
<th>E-modulus, MPa</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pure PE</td>
<td>4.20</td>
</tr>
<tr>
<td>PE/clay 5%</td>
<td>7.10</td>
</tr>
</tbody>
</table>

- PP / Montmorillonie 5%

In-situ tensile testing under ESEM shows formation of crazes around clay tactoids

<table>
<thead>
<tr>
<th>Material</th>
<th>Impact Energy, kJ/m²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pure PP</td>
<td>4.9</td>
</tr>
<tr>
<td>PP/clay 5%</td>
<td>7.0</td>
</tr>
</tbody>
</table>

Future work

- Further investigation of the morphology, crystallisation and structure development of polymer / clay nanocomposites
- Investigation of the deformation behaviour of polymer/clay nanocomposites by means of in-situ SAXS, WAXS, ESEM, AFM

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