Microstructure, Barrier Properties, and Mechanical Properties of Nylon-12 Nanocomposite Films

by

Dr. Cecilia L. Stevens, Polymer Engineering Company
Dr. Marek J. Gnatowski, Polymer Engineering Company
Dr. Scott Duncan, Defence Research and Development Canada
Samples

• Extruded films
• 1.0 mil thick
• 10% treated montmorillonite clay in nylon-12
• Various blending methods
Batch blending for 1 minute (B)

REE 67 prep mixer with high-shear roller blades (W.C. Brabender)
Single-screw extrusion (C)

25mm extruder with mixing screw, L/D = 25 (W.C. Brabender)
Twin-screw extrusion with compounding screws (D)

D6-2 counter-rotating twin-screw extruder, L/D = 6 (W.C. Brabender)
Twin-screw extrusion with standard screws (E)

TSE 20mm co-rotating twin-screw extruder, L/D = 40 (W.C. Brabender)
Methods of Assessment

• Physical
  – Mechanical properties
    • Stress
    • Strain
    • Young’s modulus
  – Barrier properties
    • Breakthrough time

• Structural
  – TEM imaging
    • Platelet size
    • Platelet exfoliation
  – FTIR spectroscopy
## Observed Platelet sizes (nm)

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<table>
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<tbody>
<tr>
<td>A (100% nylon-12)</td>
<td>N/A</td>
</tr>
<tr>
<td>B (batch blended)</td>
<td>202</td>
</tr>
<tr>
<td>C (single-screw extrusion)</td>
<td>171</td>
</tr>
<tr>
<td>D (compounding twin-screw)</td>
<td>144</td>
</tr>
<tr>
<td>E (standard twin-screw)</td>
<td>111</td>
</tr>
</tbody>
</table>
Platelet exfoliation
Batch blending (B)
Platelet exfoliation
Single-screw extrusion (C)
Platelet exfoliation
Compounding twin-screw (D)
Platelet exfoliation
Standard twin-screw (E)
Mechanical properties
Strain (%)
Mechanical properties
Ultimate tensile stress

![Graph showing the relationship between platelet size (nm) and ultimate tensile stress (MPa).](image-url)
Mechanical properties
Young’s modulus

![Graph showing Young's modulus vs. platelet size (nm). The x-axis represents platelet size in nanometers ranging from 100 to 220, and the y-axis represents Young's modulus in MPa ranging from 0 to 2000. The graph indicates a decrease in Young's modulus as platelet size increases.]
Breakthrough time

![Graph showing the relationship between platelet size (nm) and breakthrough time (h). The graph indicates a decreasing trend as platelet size increases.]
FTIR spectroscopy

![Graph showing FTIR peak height vs. platelet size (nm)]
FTIR example spectrum

Nylon-12 peak used for normalisation of FTIR spectra

Silicate peak
Conclusions

• Platelet size starts to decrease prior to full exfoliation.
• Prior to full exfoliation, mechanical properties are not highly responsive to platelet size (completeness of exfoliation).
• After exfoliation, elongation at break is directly dependent on platelet size.
• After exfoliation, stress and Young’s modulus are not highly responsive to platelet size, although improved over non-exfoliated samples.
• Barrier properties are inversely related to platelet size both before and after exfoliation.
• FTIR may be responsive to nanoclay dispersion.
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pecltd@telus.net
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Dr. Scott Duncan
Scott.Duncan@drdc-rddc.gc.ca
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