Interfacial tension and coalescence in polymer blends

Citation for published version (APA):

Document status and date:
Published: 01/01/2004

Publisher's PDF, also known as Version of Record (includes final page, issue and volume numbers)

Please check the document version of this publication:
• A submitted manuscript is the version of the article upon submission and before peer-review. There can be important differences between the submitted version and the official published version of record. People interested in the research are advised to contact the author for the final version of the publication, or visit the DOI to the publisher’s website.
• The final author version and the galley proof are versions of the publication after peer review.
• The final published version features the final layout of the paper including the volume, issue and page numbers.

Link to publication

General rights
Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

• Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
• You may not further distribute the material or use it for any profit-making activity or commercial gain
• You may freely distribute the URL identifying the publication in the public portal.

If the publication is distributed under the terms of Article 25fa of the Dutch Copyright Act, indicated by the “Taverne” license above, please follow below link for the End User Agreement:
www.tue.nl/taverne

Take down policy
If you believe that this document breaches copyright please contact us at:
openaccess@tue.nl
providing details and we will investigate your claim.

Download date: 21. Apr. 2019
Interfacial tension and coalescence in polymer blends

C. Tufano, G.W.M. Peters and H.E.H. Meijer
Eindhoven University of Technology, Department of Mechanical Engineering

Introduction
The final properties of polymer blends are, to a great extend, determined by the morphology. It’s well known that interfacial tension is a key parameter in the evolution of morphology during blending. The goal of this work is to study the evolution of interfacial tension with time and temperature and the influence of such variations on drop coalescence.

Materials

<table>
<thead>
<tr>
<th>Blend</th>
<th>Drop/Matrix</th>
<th>$\Delta R_{th}$ [μm]</th>
<th>$R_0$ [mm]</th>
</tr>
</thead>
<tbody>
<tr>
<td>A2</td>
<td>PB635/PDMS62700</td>
<td>55</td>
<td>1.13</td>
</tr>
<tr>
<td>B4</td>
<td>PBD8000/PDMS62700</td>
<td>0.5</td>
<td>1.22</td>
</tr>
</tbody>
</table>

Table 1. Blends; $\Delta R_{th}$, drop size change in matrix after 4h at 23°C.

A2 is a very diffusive system, B4 is not (see $\Delta R_{th}$ Table1).

Results

Interfacial tension

![Interfacial tension for the two blends as function of temperature and time measured with a sessile drop apparatus.](image)

Drop radius
Experiments for the same viscosity ratio and same temperature have been performed using SALS. The theory of Debye-Bueche gives the radius of the droplets.

$$I(q) = K\xi^3 F(q\xi); \quad F(x) = 1/(1 + x^2)^2$$

K: a function of the scattering contrast, q: scatter vector magnitude, $\xi$: structure correlation distance and $R^2 = 10\xi^2$, see Fig.2 and Fig.3. For system A2 the trend of the radius follows the variation of interfacial tension (see Fig.4, left). Repeating the A2 experiment after 48h: no diffusion effects left, so the trend of radii is different (see Fig.4, right).

![Drop size evolution with time at constant temperature.](image)

Mathematical Models
Drop radii from a drainage model. Three cases: immobile, partially mobile and fully mobile interfaces.

$$R_{Imm.} = \left(\frac{8}{9}\right)^{1/4} h_{cr}^{1/2} \ast (\eta_c \ast \dot{\gamma}/\sigma)^{-1/2}$$

$$R_{P.M.} = \left(\frac{4}{\sqrt{3}} \ast \dot{\gamma}\right)^{2/5} \ast p^{-2/5} \ast (\eta_c \ast \dot{\gamma}/\sigma)^{-3/5}$$

$$R_{F.M.} \ast \ln \left(\frac{R_{F.M.}}{h_{cr}}\right) = \frac{2}{3} \ast (\eta_c \ast \dot{\gamma}/\sigma)^{-1}$$

$\eta_c$: viscosity continuous phase, $\dot{\gamma}$: shear rate, $\gamma$: interfacial tension, $h_{cr}$: critical film thickness, $p$: viscosity ratio. For system A2 the initial, minimum and "plateau" value of $\gamma$ have been used. For system B4 only one value of $\gamma$ is used. Table 2 shows the results: none of these cases is able to predict the radii values found experimentally.

<table>
<thead>
<tr>
<th></th>
<th>$A_2^{\sigma_{\gamma}}$</th>
<th>$A_2^{\sigma_{\eta}}$</th>
<th>$A_2^{\sigma_{plate}}$</th>
<th>$B4$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\sigma$ [N/m]</td>
<td>0.0024</td>
<td>1.70E-03</td>
<td>2.10E-03</td>
<td>4.10E-03</td>
</tr>
<tr>
<td>$R_{Imm.}$ [μm]</td>
<td>10.19</td>
<td>8.58</td>
<td>9.53</td>
<td>13.32</td>
</tr>
<tr>
<td>$R_{P.M.}$ [μm]</td>
<td>56.41</td>
<td>45.87</td>
<td>52.07</td>
<td>46.92</td>
</tr>
<tr>
<td>$R_{F.M.}$ [μm]</td>
<td>105.61</td>
<td>78.18</td>
<td>93.98</td>
<td>169</td>
</tr>
<tr>
<td>$R_{Exp.}$ [μm]</td>
<td>2.45</td>
<td>2.2</td>
<td>2.6</td>
<td>2.2 - 3</td>
</tr>
</tbody>
</table>

Table 2. Calculated drop radii.

Conclusions
- Diffuse interface strongly affects the morphology of the blends.
- Existing mathematical models do not apply.

References: