2010 SHORT COURSE
Coextrusion

Gary Oliver
Extrusion Dies Industries, LLC
Outline

• Why Coextrude?
• Visco-Elastic Concepts
  – Laminar Flow
  – Shear Viscosity, Elongational Viscosity
  – Elastic Secondary Flows, Encapsulation
• Dynamic Coextrusion Problems
  – Wave, Zig-zag
• Approaches to Coextrusion
  – Feedblock with Single Manifold Die
  – Distribution Block with Multimanifold Die
Why Coextrude?

- Utilize desirable properties of each polymer
- Avoid multi-pass lamination or coating.
Why Coextrude?

- Gas Barrier
- Moisture Barrier
- Heat Sealability
- Toughness
Shear Viscosity

- Polymer molecules are large and entangled.
- As the plastic is sheared, dis-entanglement and alignment occurs, which reduces the resistance to flow.
Shear Viscosity

Apparent Shear Viscosity (Pa-s)

Sample ID
- Red squares: Resin 1, 270°C
- Blue crosses: Resin 2, 270°C
- Purple triangles: Resin 3, 270°C

Apparent Shear Rate (1/s)
Elongational Viscosity

- Resistance to stretching. Melt strength is a related measure.
- Linear polymers (LLDPE, HDPE, PP) have poor melt strength.
- Branched polymers (LDPE) have high melt strength.
Elastic Effects: Secondary Flows

- PS & LDPE are highly elastic (resist stretching) so the streamlines are rigid, which can result in vortex patterns.

- HDPE has low elasticity, so the flexible streamlines can fill square corners. Two layers of HDPE flowing together will remain less disturbed.

- Ref. TAPPI papers by Joe Dooley.
Capillary Rheometer

Single Resins
Rapid Sampling
Multiple Temperatures

Resin Blends
20 Gram Sample
No Mixing

Dynisco LCR 7001
Rheological Analysis

Resin Blends
Single Screw
Twin Screw

Thermo Scientific
HAAKE PolyLab System
Viscous Encapsulation

- Material of lowest viscosity seeks the area of the highest shear.

Flow Direction
Viscosity A (Yellow) < Viscosity B (Blue)
Shear Viscosity

- Shear Rate is highest at the wall
- Lowest Viscosity material is preferred in outer layer
- “Rule of Thumb” viscosity ratios of 3:1 maximum
Wave Instability

• Appears most often in asymmetrical structures

• Most common with thin skin layers. Less likely to occur when the core layer is thick and has highest viscosity. The skin layers are in the area of highest shear.
Zig-Zag Instability

- Can cause an intermixing of the interface boundary, which can reduce clarity.
- A lower shear-viscosity skin layer is more stable.
- High shear areas, like tight gaps can cause this instability.
Feedblock with Single Manifold Die

Layers combine first, then spread through the die together.
Feedblock with Single Manifold Die

Sequencing options: Spools or Plates
Dow Style Modular Feedblock
Dow Style Modular Feedblock
Welex Feedblock
Black Clawson Micro-Layer Feedblock
Cloeren Adjustable Feedblocks
Cloeren Fixed Feedblocks
EDI Adjustable Feedblock & Single Manifold Die

Usually combine many layers in a sequential fashion. The combination geometry can be variable or fixed during production.
EDI Fixed Geometry Coextrusion Feedblocks
Cloeren InfiNano™ Feedblock
Dow Multiplier Technology
EDI Multiplier Technology
Velocity Profile of Structure

Highest Shear Area is at the wall

Polymer / Polymer Interfaces
Multi-Manifold Coextrusion

- Most accurate way to coextrude.
- Melt temperature differences can be accommodated.
Multi-Manifold Coextrusion

- Most precise way to create a naked edge or an encapsulated edge.
Summary

Laminar flow makes coextrusion possible.

Shear viscosity and elongational viscosity can drive different types of interface deformations or coextrusion instabilities.

There are a number of tooling options for layer sequencing and control of layer width and uniformity.

Streamlined adjustable feedblocks provide versatility.

Multimanifold dies can accommodate large differences in melt temperature and viscosity.