Superior Tear Resistance from a Polyamide: Is the flexible packaging world ready for a LLDPA?

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Polyamides are useful for numerous reasons

- High Mechanical Strength
  - *Fishing line, Rope, Bristles*

- Easily co-extruded
  - *Multilayer structures with dissimilar polymers possible*

- Heat & Chemical Resistance
  - *Roasting bags, Intake manifolds*

- Thermoformable
  - *High residual corner thickness*

- Barrier
  - *Barrier mulch film*

- Abrasion Resistance
  - *Weed trimmer, wire jacketing*
Toughness of Polyamides set them apart

Puncture Energy (N*mm); ISO 7765-2; φ 2.5mm, 50μm cast film; normalized PP=1
Elmendorf tear is lower, though

ISO 6383-2; 100μm monolayer blown film; BUR 2:1
Structure affects properties

Linear

Short Chain Branching

Long Chain Branching
Ultramid® Flex F38: A new class of polyamide
Density Comparison

ISO 1183-3; 100μm monolayer blown film
Novel structure reduces water uptake
…and ensures softness even when dry

Injection molded samples; ISO 527-2; dry, 23C
Elastic Modulus Comparison

Injection molded samples; ISO 527-2; data normalized to PA6 Dry = 100%
But is Ultramid® Flex F38 like PA12?

Charpy Impact Resistance [kJ/m²]

- Ultramid® B40 L
- Ultramid® C40 L
- Ultramid® Flex F
- PA12

Injection molded samples; ISO 179-2/1eA(S)
Ultramid® Flex F38 retains puncture strength

ISO 7765-2; Ø 2.5mm, 40μm monolayer blown film
...and provides even higher puncture energy

ISO 7765-2; $\phi$ 2.5mm, 40$\mu$m monolayer blown film
While Elmendorf tear resistance is dramatically higher in monolayer films

ISO 6383-2; 100μm monolayer blown film; BUR 2:1
...and multilayer films

Elmendorf Tear Strength [N]

ISO 6383-2; 100μm multilayer blown film; BUR 2:1; LDPE//Tie//PA//EVOH//PA//Tie//LDPE
Haze is nearly non-existent (0.3%!)

ASTM D-1003; 40μm monolayer blown film
It’s even possible to see clearly through 3” of film
OTR @ 50% RH [g x 1μm/m² x d x bar]

- Ultramid® B40 L
- Ultramid® C40 L
- Ultramid® Flex F

OTR is still 10x lower than PE

ASTM F1249, ASTM D3985-05, ISO 15105-1; 100μm monolayer blown film
WVTR is lower

WVTR @ 85% RH [g x 1µm/m² x d x bar]

- Ultramid® B40 L
- Ultramid® C40 L
- Ultramid® Flex F

ASTM F1249, ASTM D3985-05, ISO 15105-1; 100µm monolayer blown film
CO₂ barrier allows for excellent breathability

CO₂ Transmission @ 0% RH [g x 1µm/m² x d x bar]

ASTM F1249, ASTM D3985-05, ISO 15105-1; 100µm monolayer blown film
Where does this new class of PA belong?

- Tear Resistant
- Softer
- Puncture Resistant
- Extreme Clarity
- Partially Bio-based
- Chemically Resistant
- Formable
- Unique balance of barrier properties
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