



# Selecting the proper polyamide for multilayer food packaging films: intrinsic factors leading to performance considerations

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Technical & Application Development

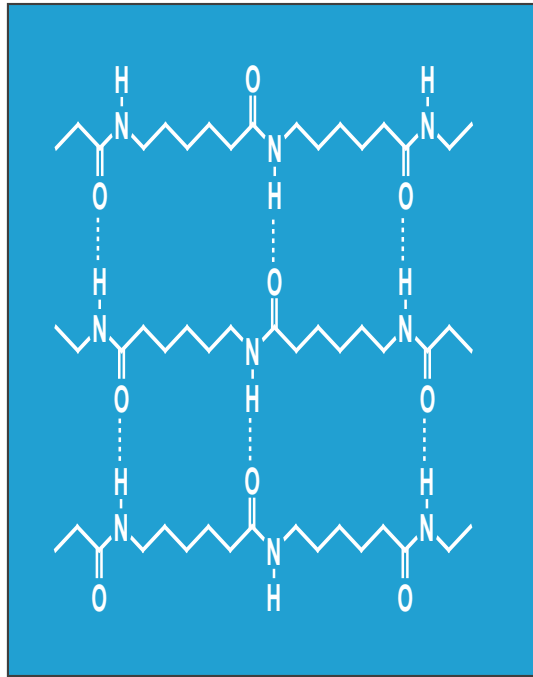
BASF Corporation

# Polyamides are so useful for numerous reasons

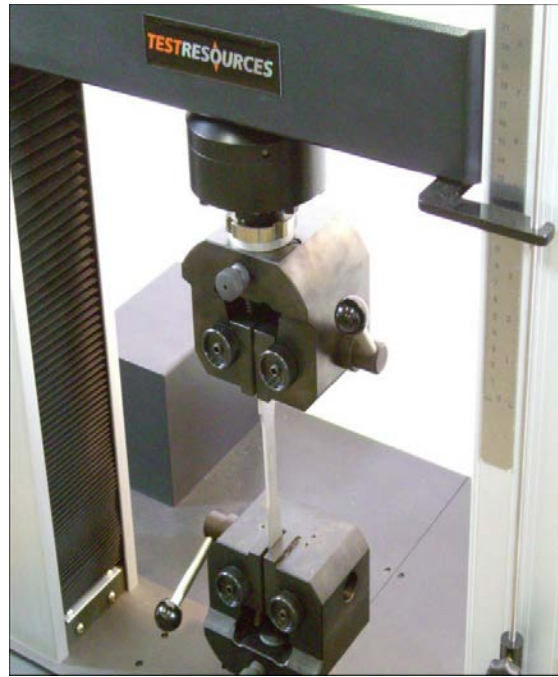


- High Mechanical Strength
  - *Fishing line, Rope, Bristles*
- Easily co-extruded
  - *Multilayer structures with dissimilar polymers possible*
- Heat & Chemical Resistance
  - *Roasting bags, Intake manifolds*
- Thermoformable
  - *High residual corner thickness*
- Barrier
  - *Barrier mulch film*
- Abrasion Resistance
  - *Weed trimmer, wire jacketing*

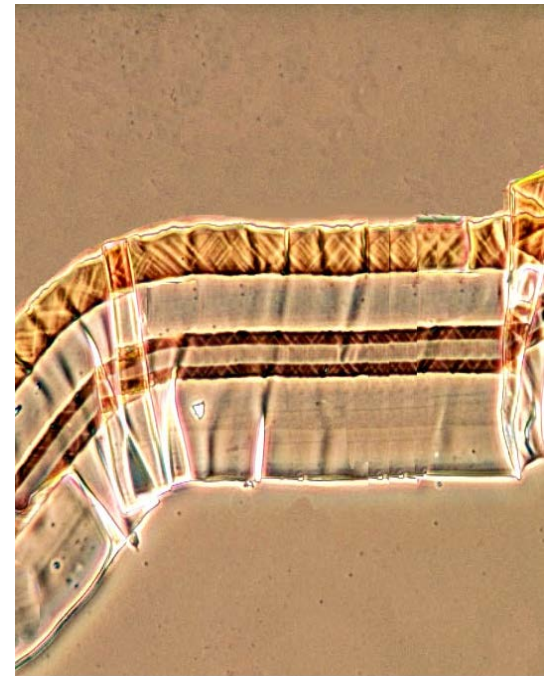
# Intrinsic factors can dramatically alter the final properties of the film



Intrinsic



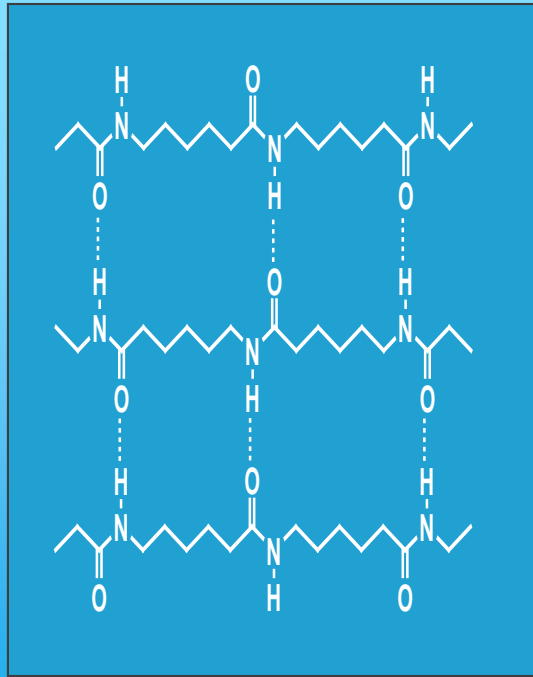
Mechanical Properties



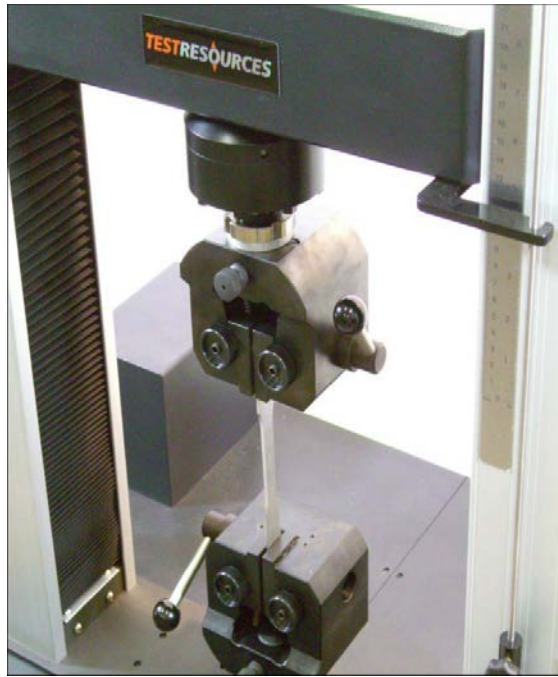
Structural



# Key polyamide intrinsic factors



Intrinsic

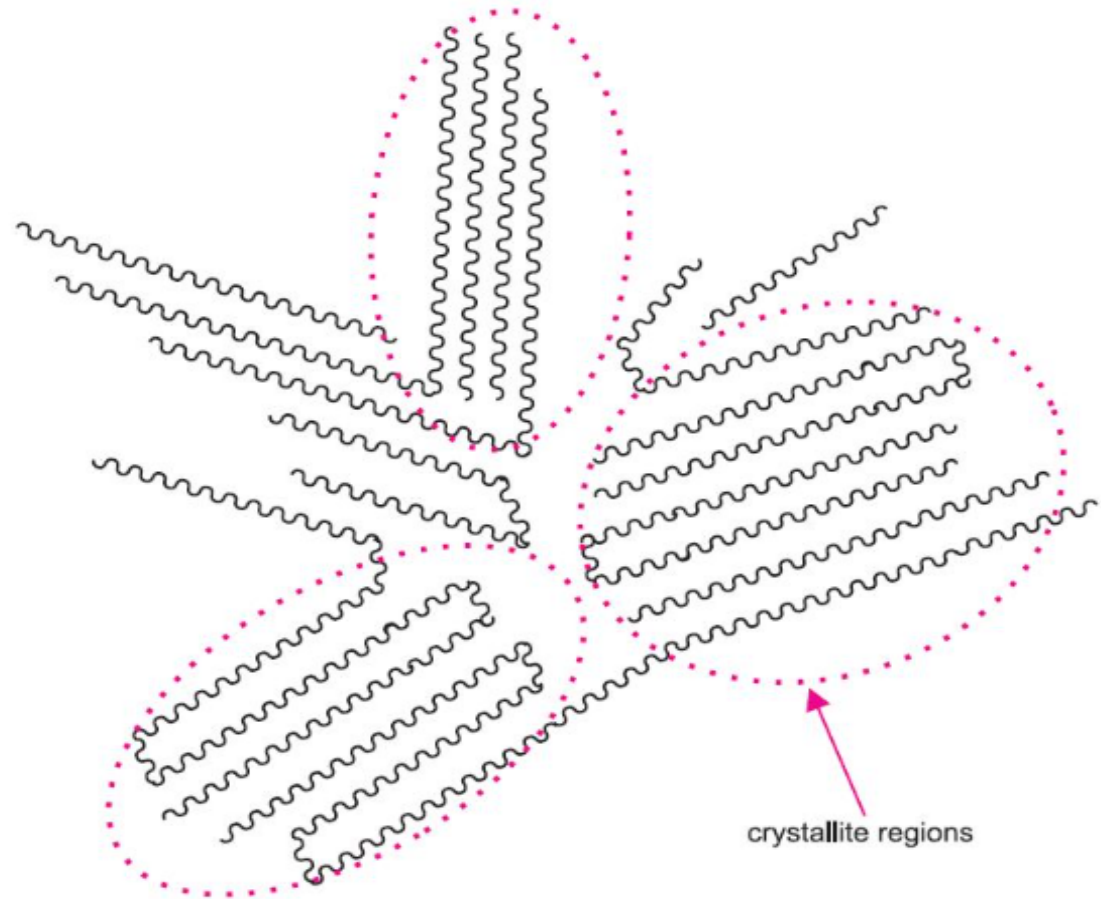


Mechanical Properties



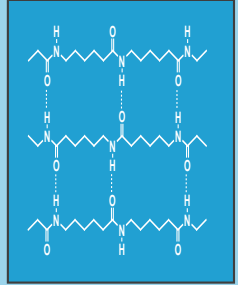
Structural

The diagram illustrates a cross-linked polyamide network. It consists of three horizontal polymer chains, each represented by a zigzag line. These chains are interconnected by amide bonds (—NH—C(=O)—). The cross-linking occurs between the carbonyl groups of one chain and the nitrogen atoms of another chain, forming a three-dimensional grid-like structure. The repeating unit of the polymer is shown as —[NH—(CH<sub>2</sub>)<sub>6</sub>—N(C<sub>2</sub>H<sub>5</sub>)—C(=O)—(CH<sub>2</sub>)<sub>4</sub>—C(=O)—NH—(CH<sub>2</sub>)<sub>6</sub>—N(C<sub>2</sub>H<sub>5</sub>)—]—.



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# Flexible packaging's polyamide crystallinity spectrum



(Polyamide 66)

(Polyamide 6)

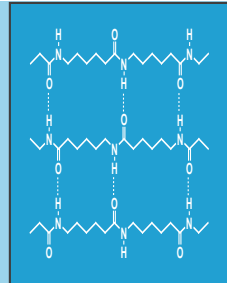
(Polyamide 6/66)

C37LC

- Decreasing crystallinity / higher transparency / less haze
- Increased softness / higher flexibility / better thermoforming
- Higher blow up ratio
- Lower melting point / lower processing temperature / higher frost line
- Fewer wrinkles during blown film collapse process
- Increased shrinkage from orientation process
- Increasing puncture resistance @ constant force
- Higher tear strength / Lower tensile strength



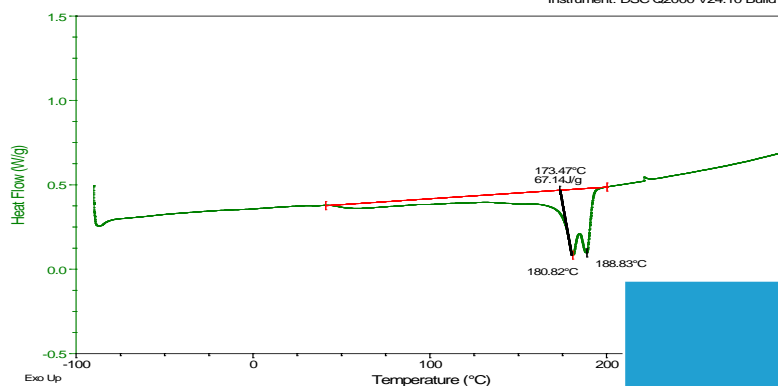
# Intrinsic crystallinity comparison



Sample: UM C40L extruded film  
Size: 2.0900 mg  
Method: Heat/Cool/Heat 10 to 300

DSC

File: C:\...\UM C40L extruded film an3.001  
Operator: D. Grimsley, J. Woodrum  
Run Date: 11-Apr-2017 10:28  
Instrument: DSC Q2000 V24.10 Build 122

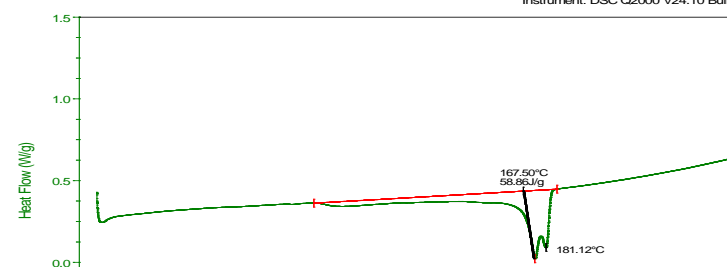


DSC of the second heat cycle for UM C40L extruded film.

Sample: UM C37LC extruded film  
Size: 2.3700 mg  
Method: Heat/Cool/Heat 10 to 300

DSC

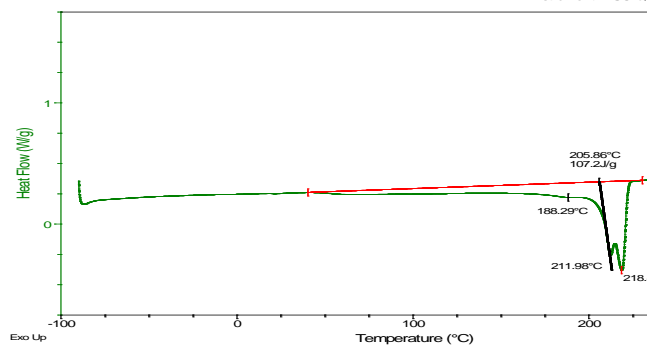
File: C:\...\UM C37LC extruded film an3.001  
Operator: D. Grimsley, J. Woodrum  
Run Date: 11-Apr-2017 13:22  
Instrument: DSC Q2000 V24.10 Build 122



Sample: UM B40L extruded film  
Size: 2.7500 mg  
Method: Heat/Cool/Heat 10 to 300

DSC

File: C:\...\UM B40L extruded film an3.001  
Operator: D. Grimsley, J. Woodrum  
Run Date: 11-Apr-2017 13:22  
Instrument: DSC Q2000 V24.10 Build 122

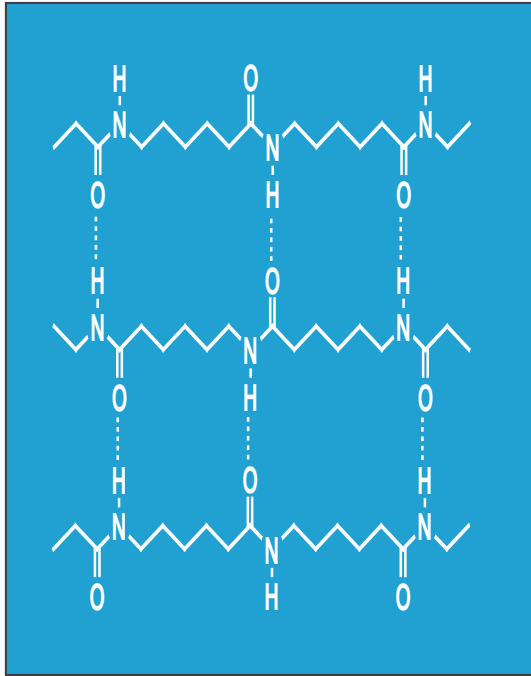


DSC of the second heat cycle for UM B40L extruded film.

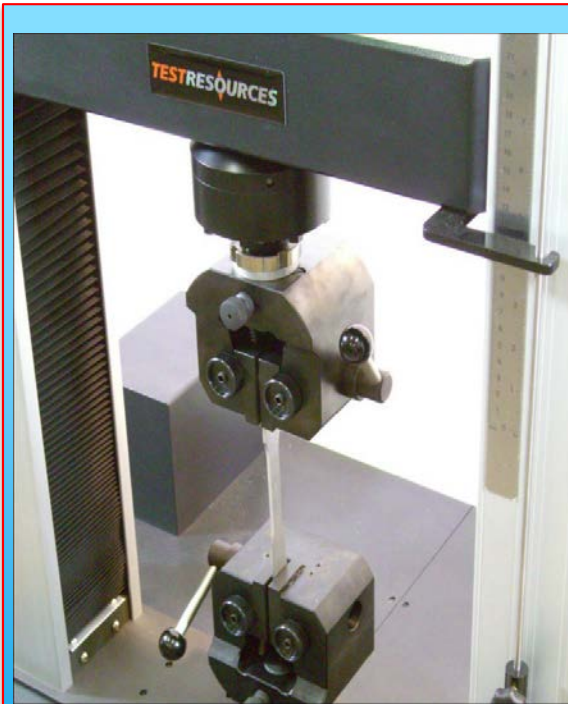
Samples	% Crystallinity	Entalphy (J/g)
UM C40L extruded film	29.2%	31.3
UM C37LC extruded film	25.6%	27.6
UM B40L extruded film	46.6%	50



# Key polyamide process factors



Intrinsic

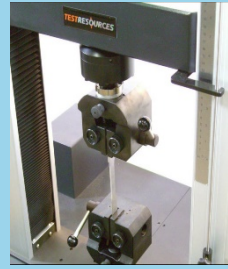


Mechanical Properties



Structural

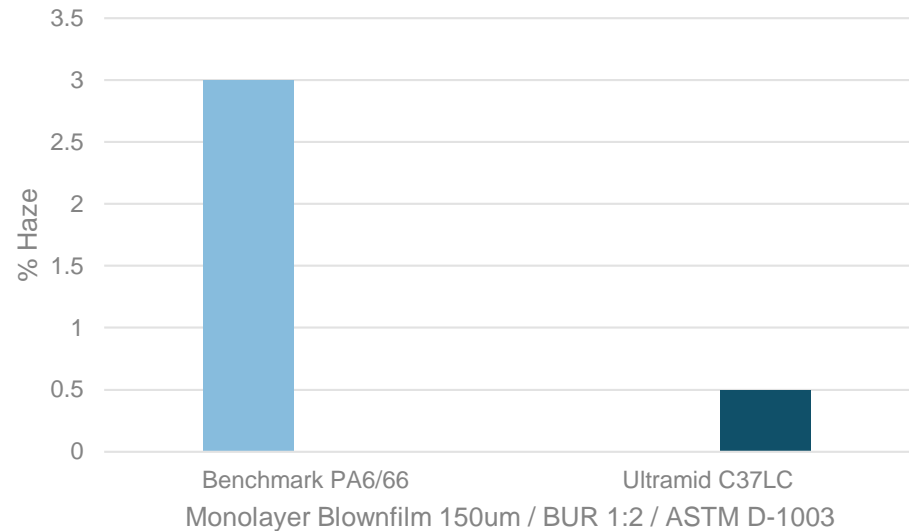
# PA crystallinity differences show in various ways including film haziness



PA 6/66 (haze 3.0)

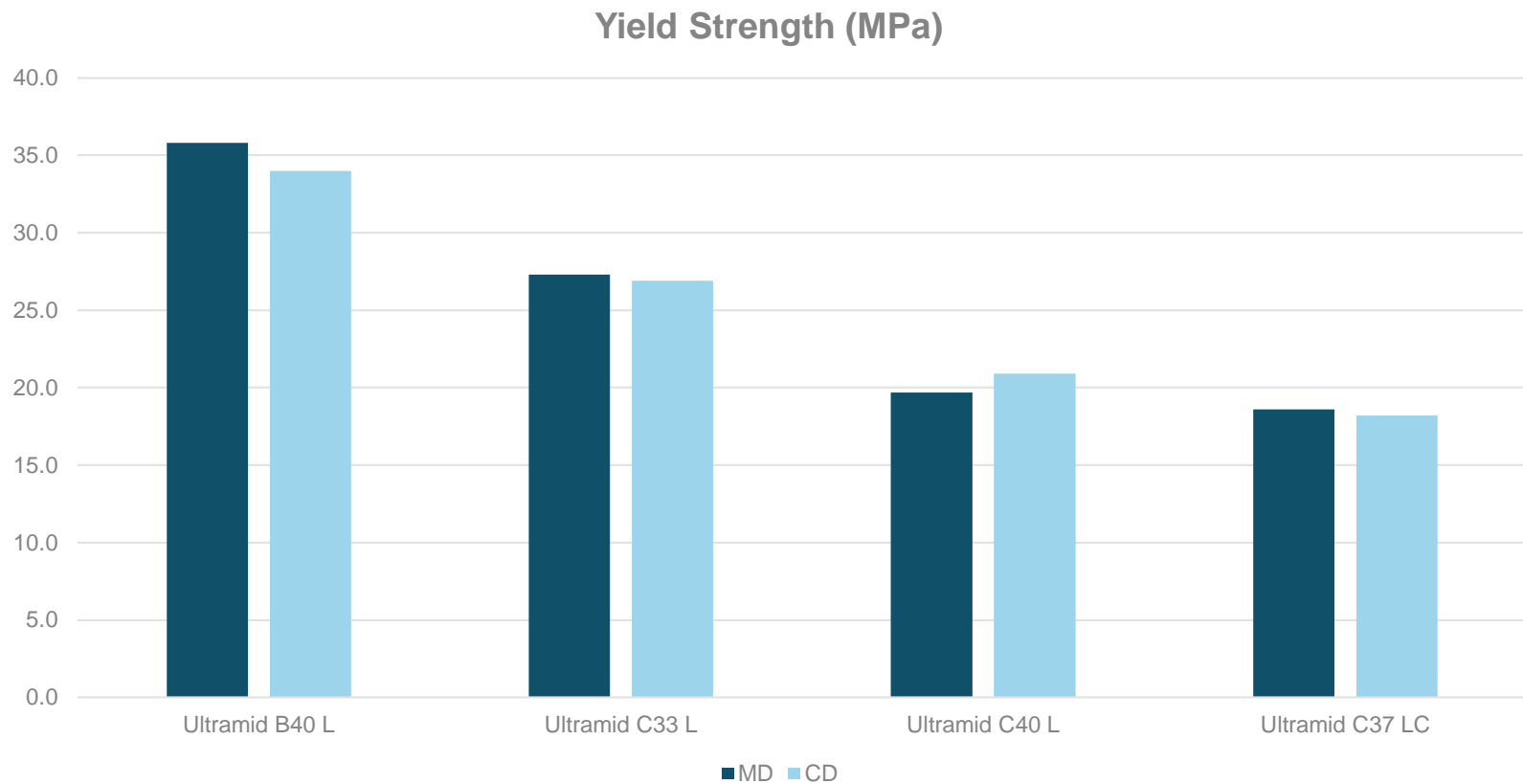


Very low crystallinity  
PA6/66 (Ultramid® C37LC) (haze 0.45)

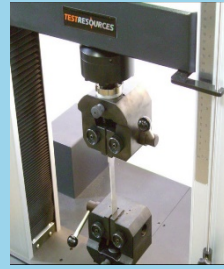


Blown Film 150 $\mu$ m / BUR 1:2 / ASTM D-1003

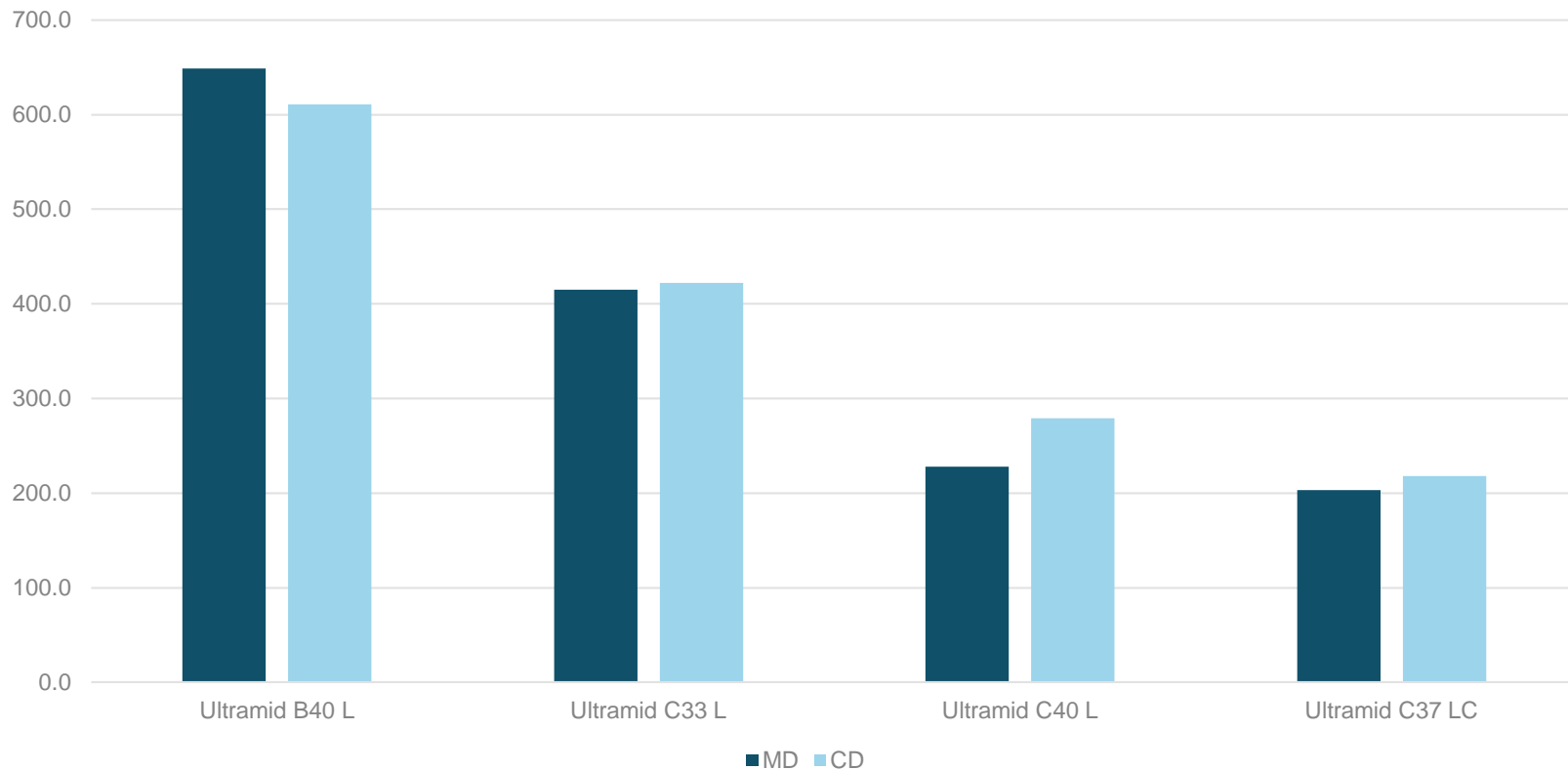
# Crystallinity affects polymer strength and elongation



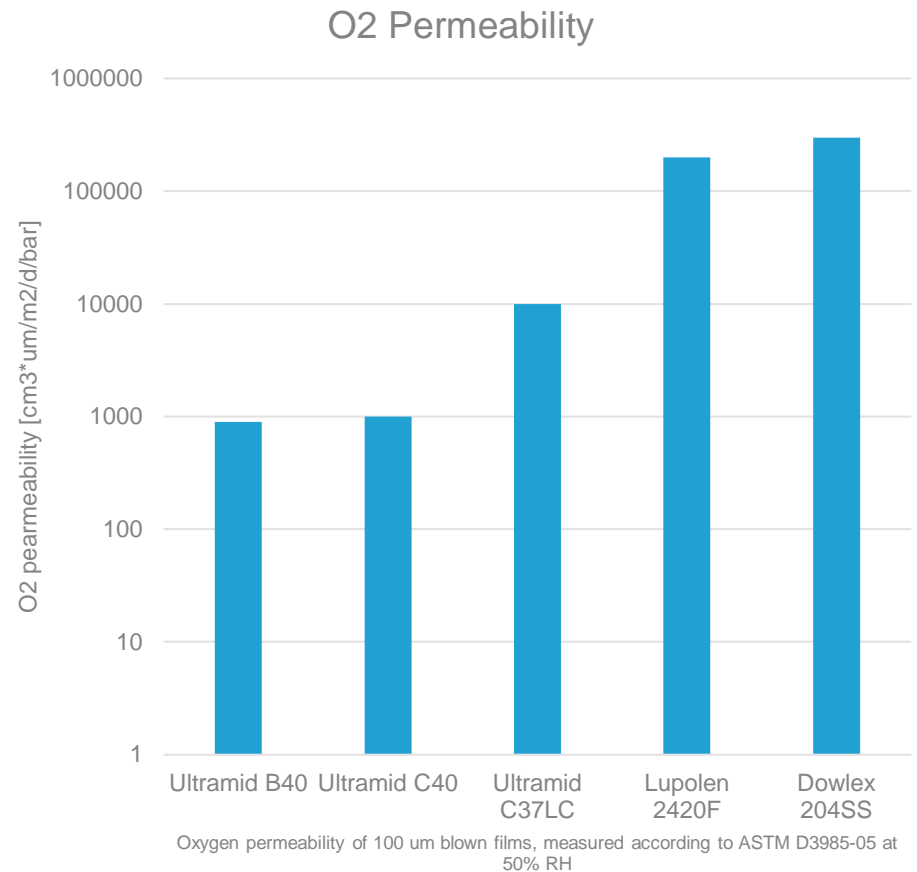
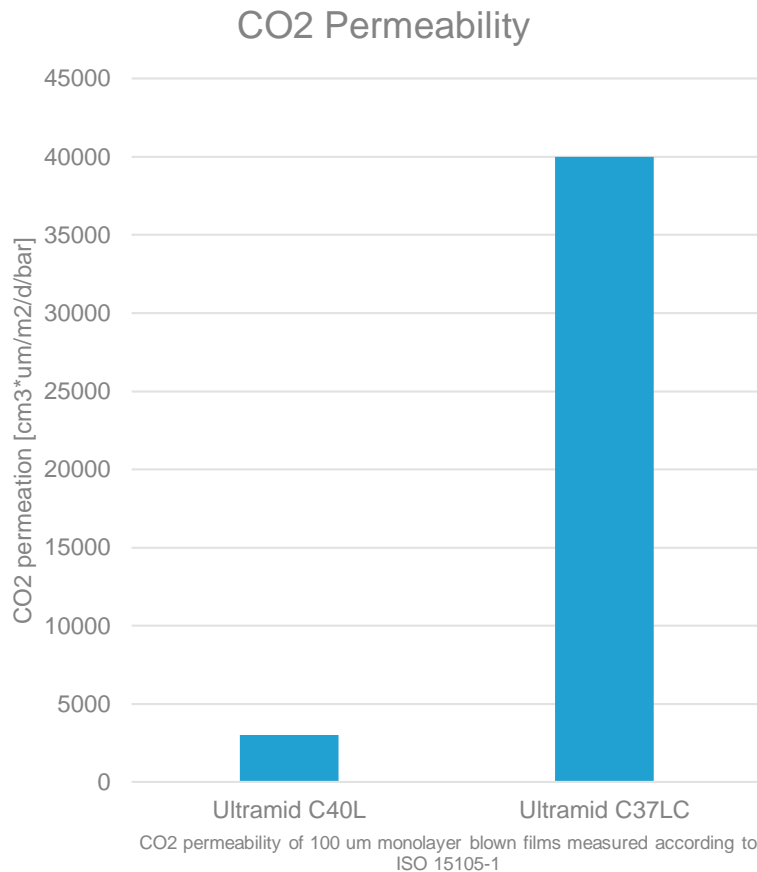
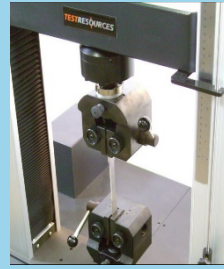
# Homopolyamides display a higher degree of crystallinity rendering it a stiffer material



Elastic Modulus (MPa)

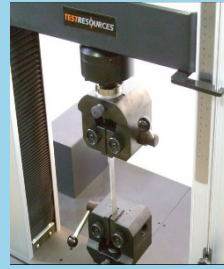


# A high degrees of crystallinity also correspond to better barrier properties

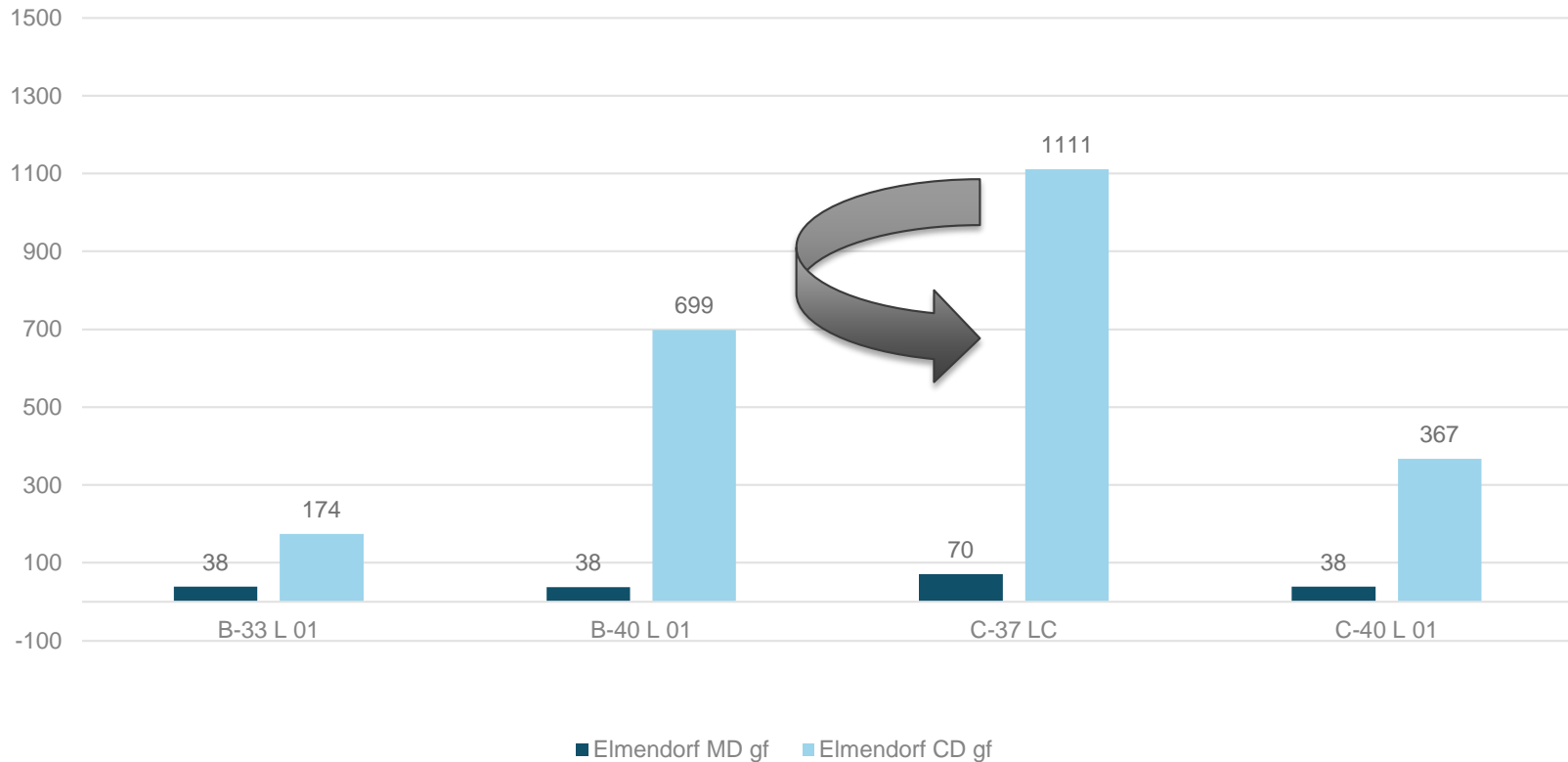




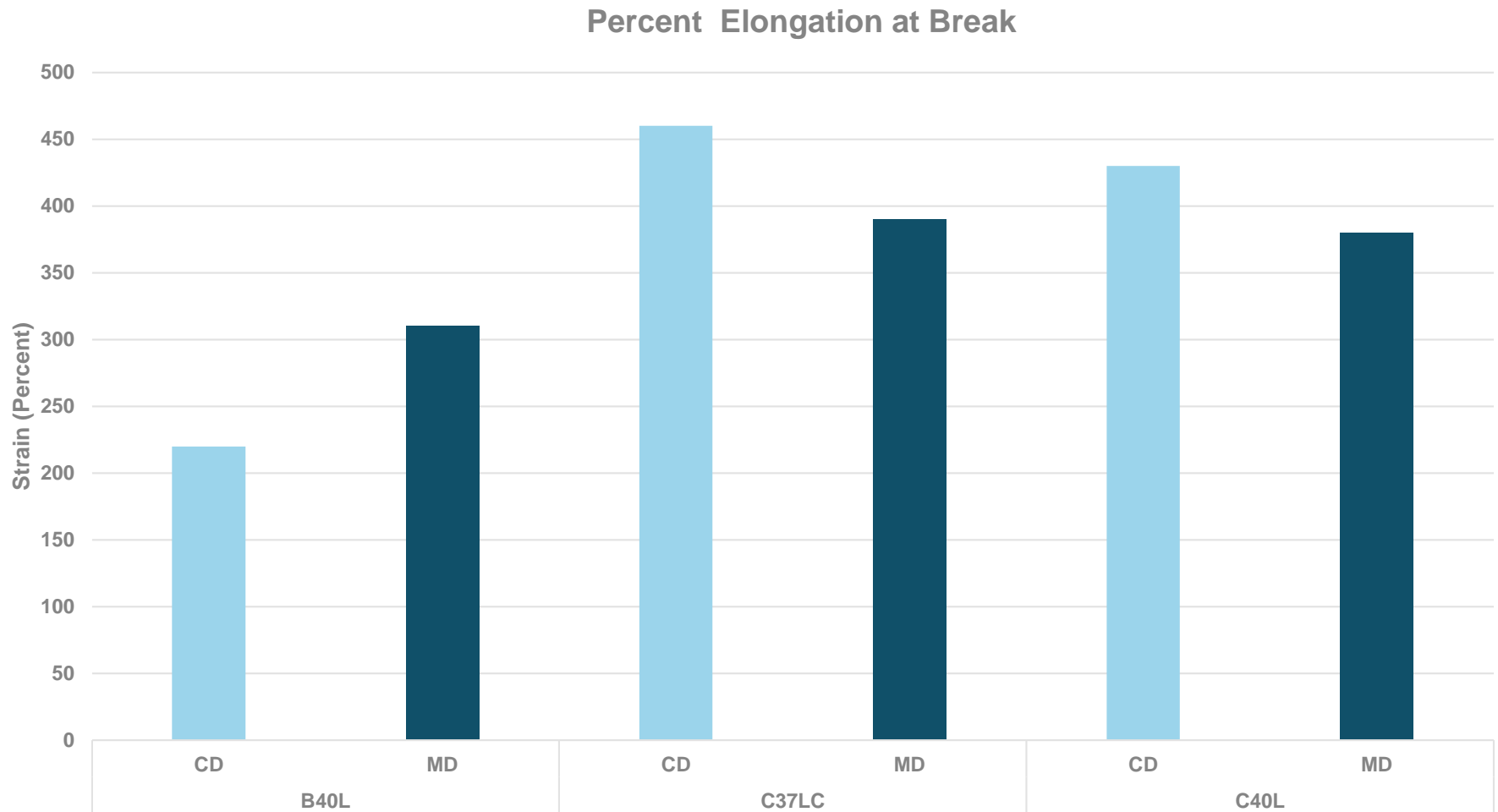
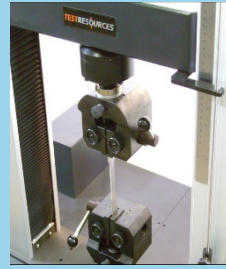
On the other hand, homopolyamides are more susceptible to tear propagation



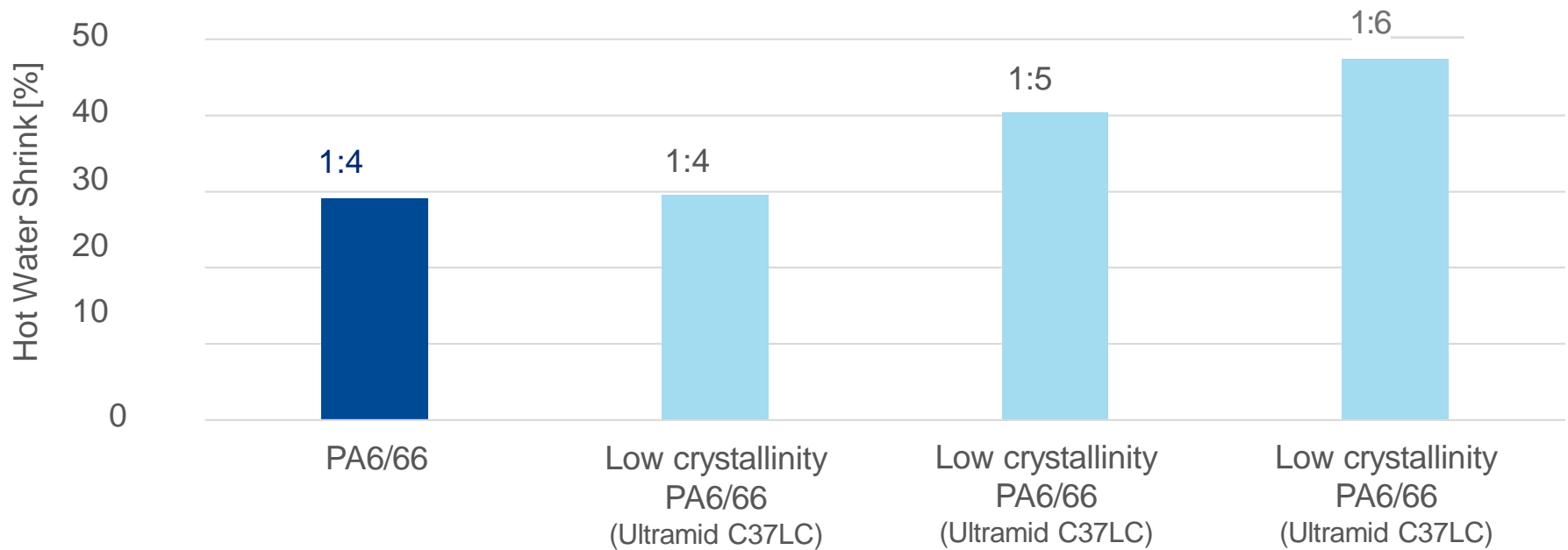
### Elmendorf Tear Ultramid® Nylon



# High crystallinity polyamides don't stretch as well

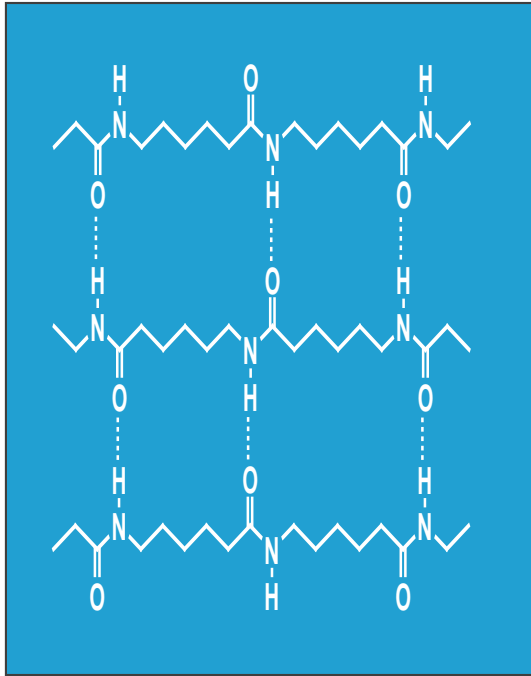


# Higher orientation is possible with low crystallinity copolyamides

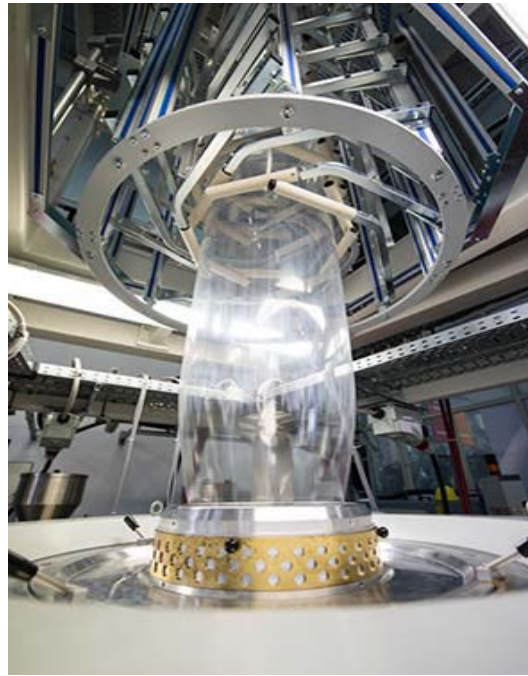


Tape stretch ratio at max. machine force

# Key polyamide structural factors



Intrinsic

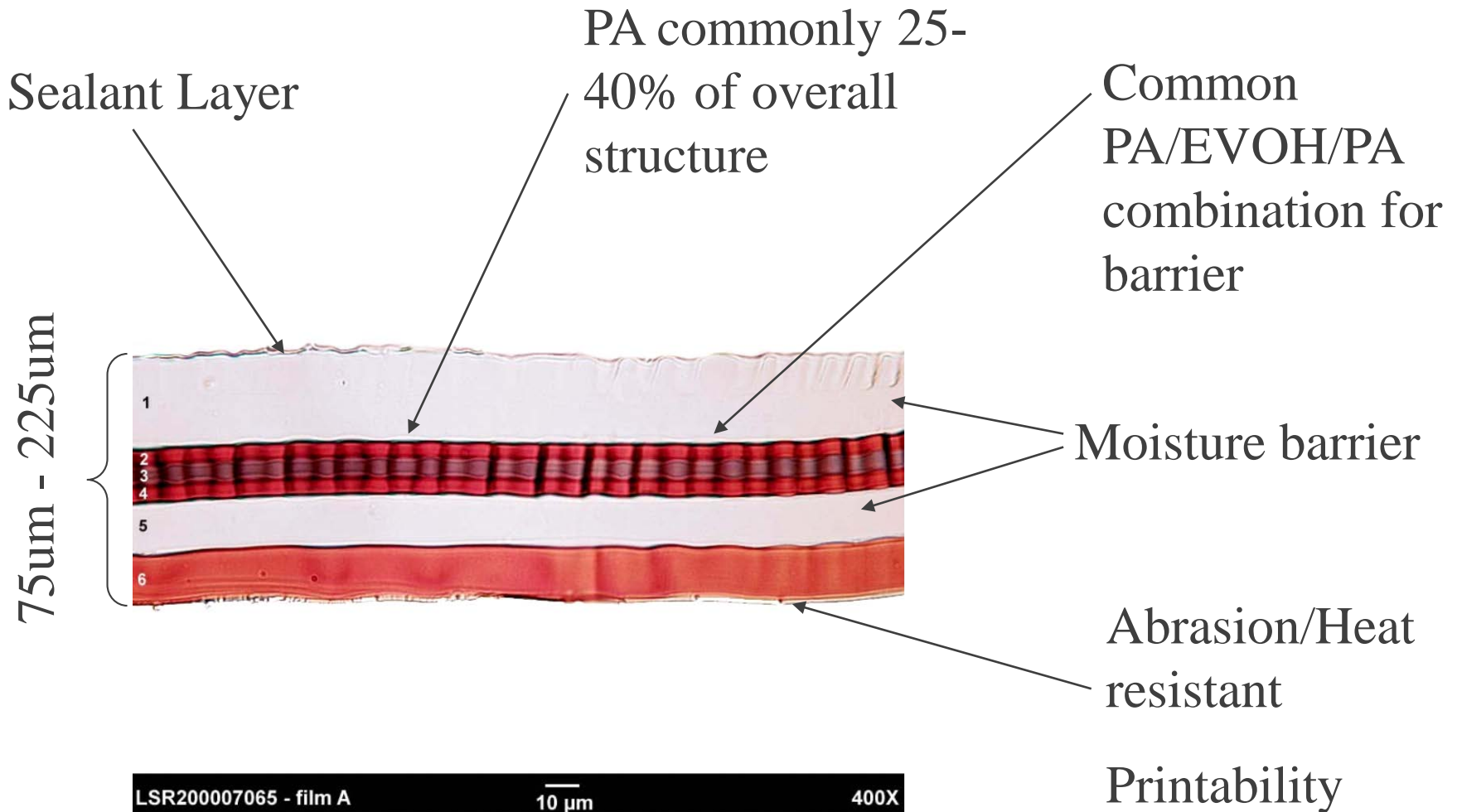


Mechanical Properties



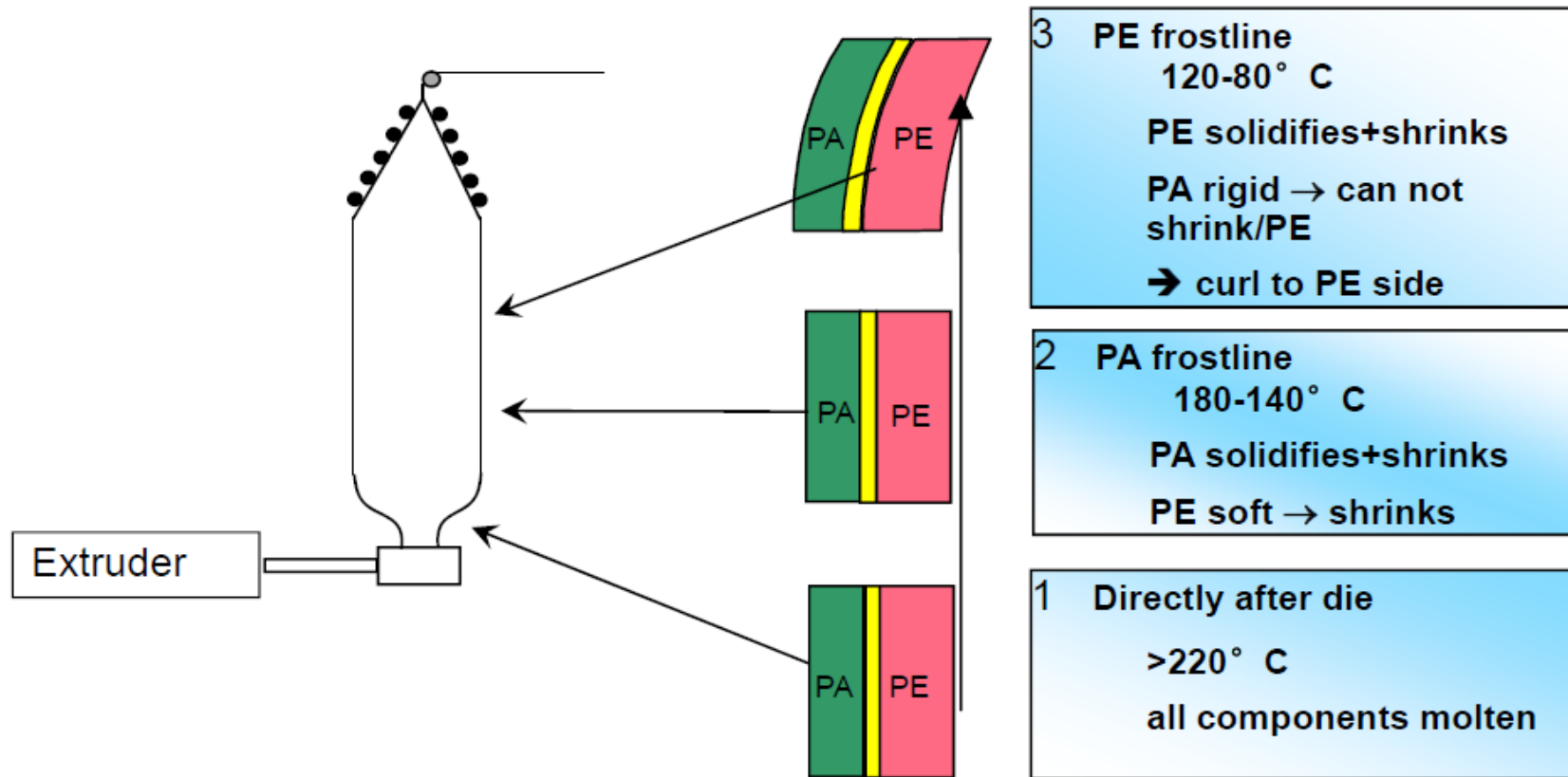
Structural

# Most food packaging applications are multilayer structures

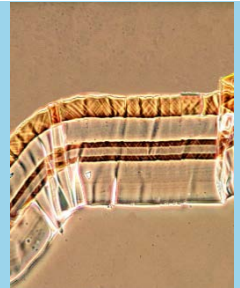




# Blown film curl as a function of asymmetry



# Lower melting point and crystallinity improves processing

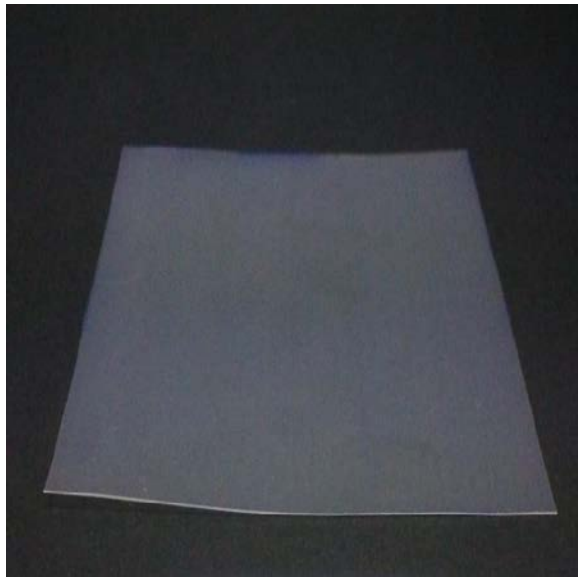


- Higher bubble stability
- Higher frost line towards PE/PP
- Reduced curl

Very low crystallinity

PA6/66

(Ultramid C37LC)



PA6/66

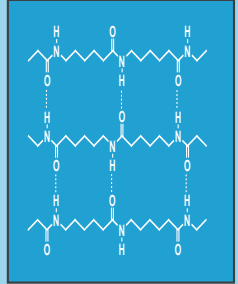


PA6



A.) LDPE	64µm
B.) Tie	18µm
C.) Polyamide	25µm
D.) Tie	18µm
E.) LDPE	30µm
F.) Tie	18µm
G.) Polyamide	25µm

# Flexible packaging's polyamide crystallinity spectrum



(Polyamide 66)

(Polyamide 6)

(Polyamide 6/66)

C37LC

- Higher transparency / less haze
- Increased softness / higher flexibility / better thermoforming
- Higher tear strength
- Lower tensile strength
- Lower melting point / lower processing temperature / higher frost line
- Fewer wrinkles during blown film collapse process
- Increased shrinkage from orientation process
- Increasing puncture resistance

For more information contact:

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