Imagine working with a company that has no boundaries on exploring solutions

MAYZO

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Benefits of Beta Nucleation in Thermoforming

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Outline

- Introduction to Beta Nucleation in PP
- Pictures of Thermoformed cups made with and without beta nucleation
- Microvoid structure of cup sidewalls
- Improved material distribution and top load crush strength
- Improved high temperature performance
- Improved productivity
- Economic benefits
- Conclusions & Sustainability Advantages

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Differences Between Alpha and Beta Crystal Phases in PP

Alpha Phase

- Melts at ~ 164 ^{o}C
- Most common phase
- Many nucleants known: Some nucleants are also clarifiers
- Alpha nucleants increase modulus and reduce cycle time

Beta Phase

- Melts at ~ 150 ^{o}C
- More ductile: Increases impact strength and break elongation, and reduces tensile strength
- Microvoids if stretched in the solid state
- Generally cannot be produced in alpha nucleated PP

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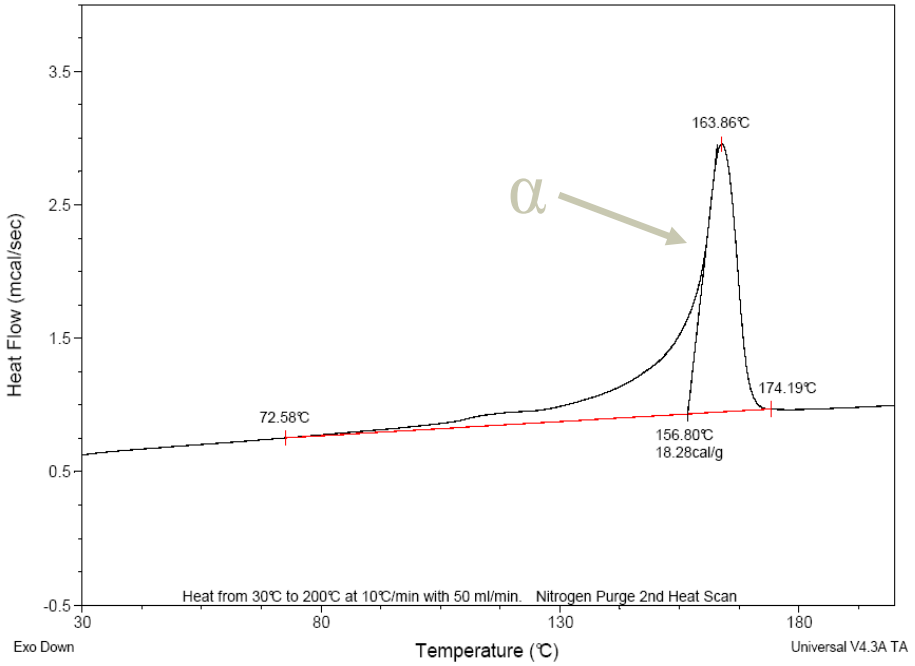
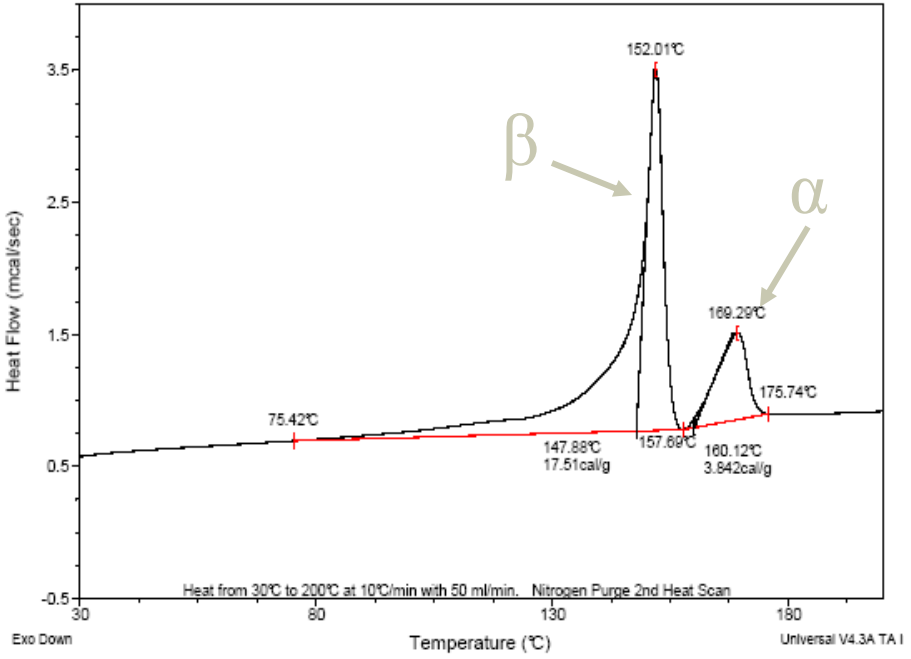
DSC Melting Curves for Alpha and Beta PP

Alpha PP

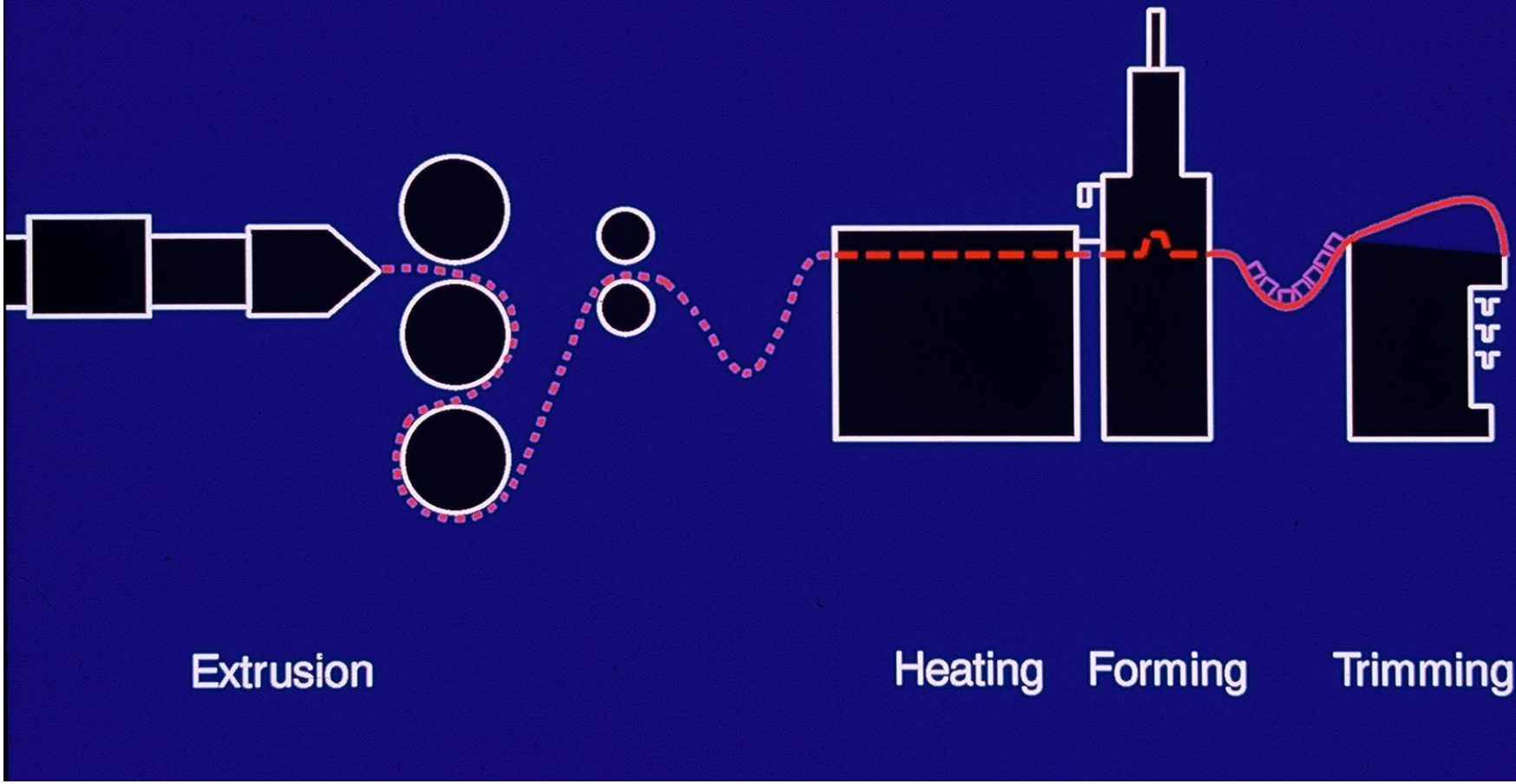


Beta PP



Thermoforming

Schematic of In-Line Thermoforming



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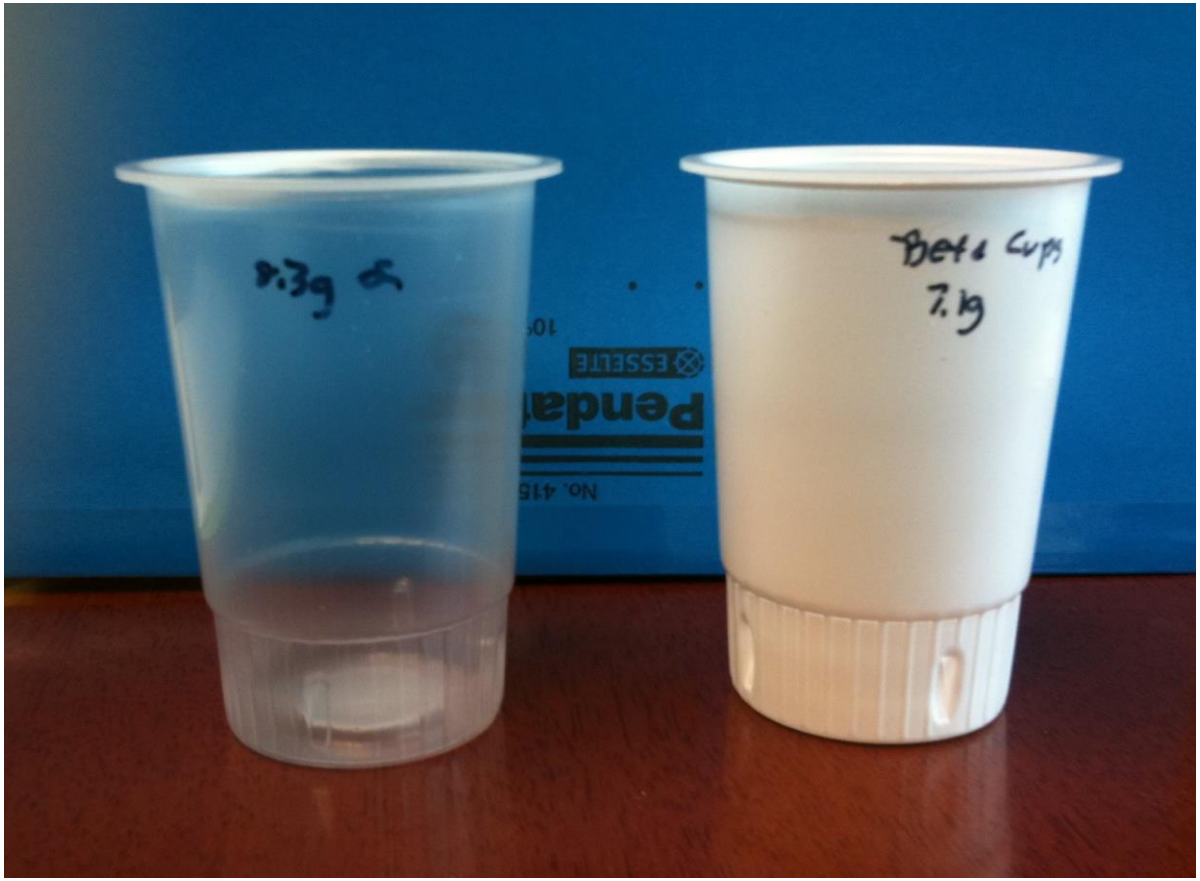
Thermoformed Cups Made with Non-nucleated and β-Nucleated PP (0.65% MPM 2000)

Note: No TiO_2 used in Beta nucleated Cup



14% weight reduction

Non-nucleated: 8.3g β-nucleated: 7.1g

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Thermoformed 16 oz cups (11g) Cups Made with Non-nucleated and β-Nucleated PP

Note: No TiO_2 used in Beta nucleated PP

Control Non-nucleated **Beta Nucleated**

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Cups Formed at Different Temperatures

Non-nucleated **β-Nuc (157 °C)** **β-Nuc (147 °C)**

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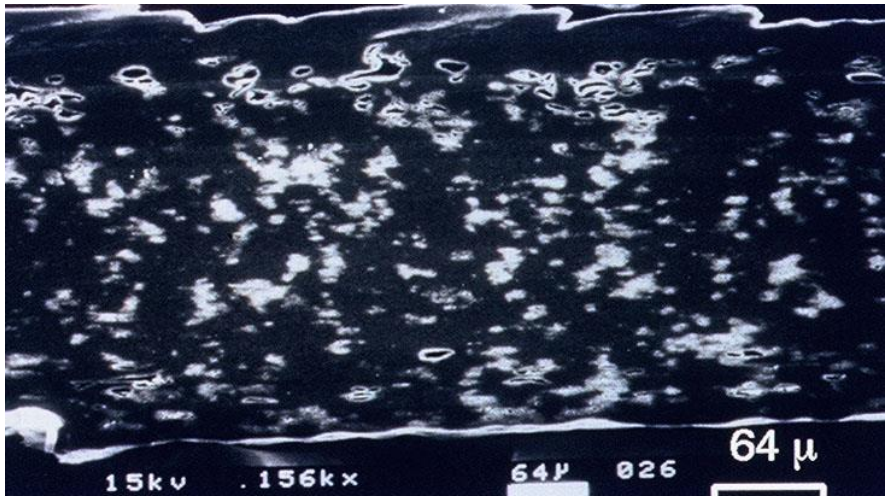
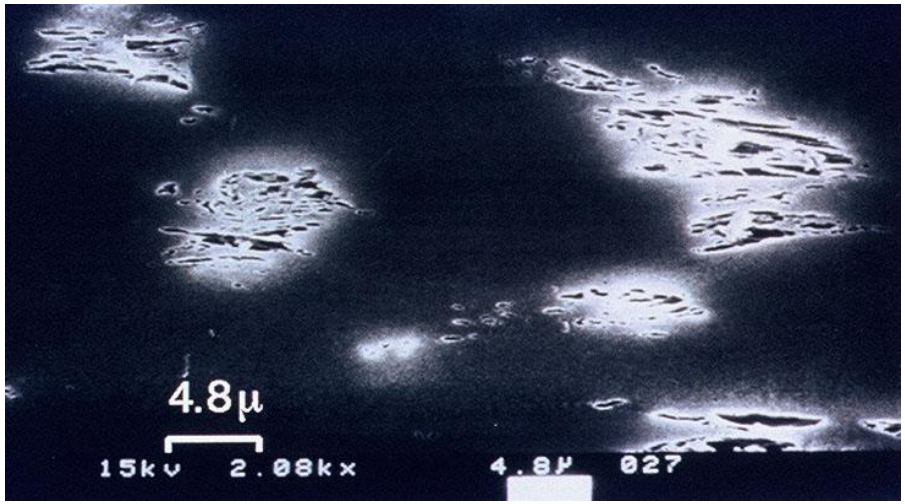
SEM Micrographs of Microvoided Container Cross-section

Note: Isolated clusters of sub-micron sized voids in the container sidewall produce whitening and density reduction without loss of barrier properties



Low Magnification



High Magnification

Note: The microvoids are close celled and do not lead to breathability

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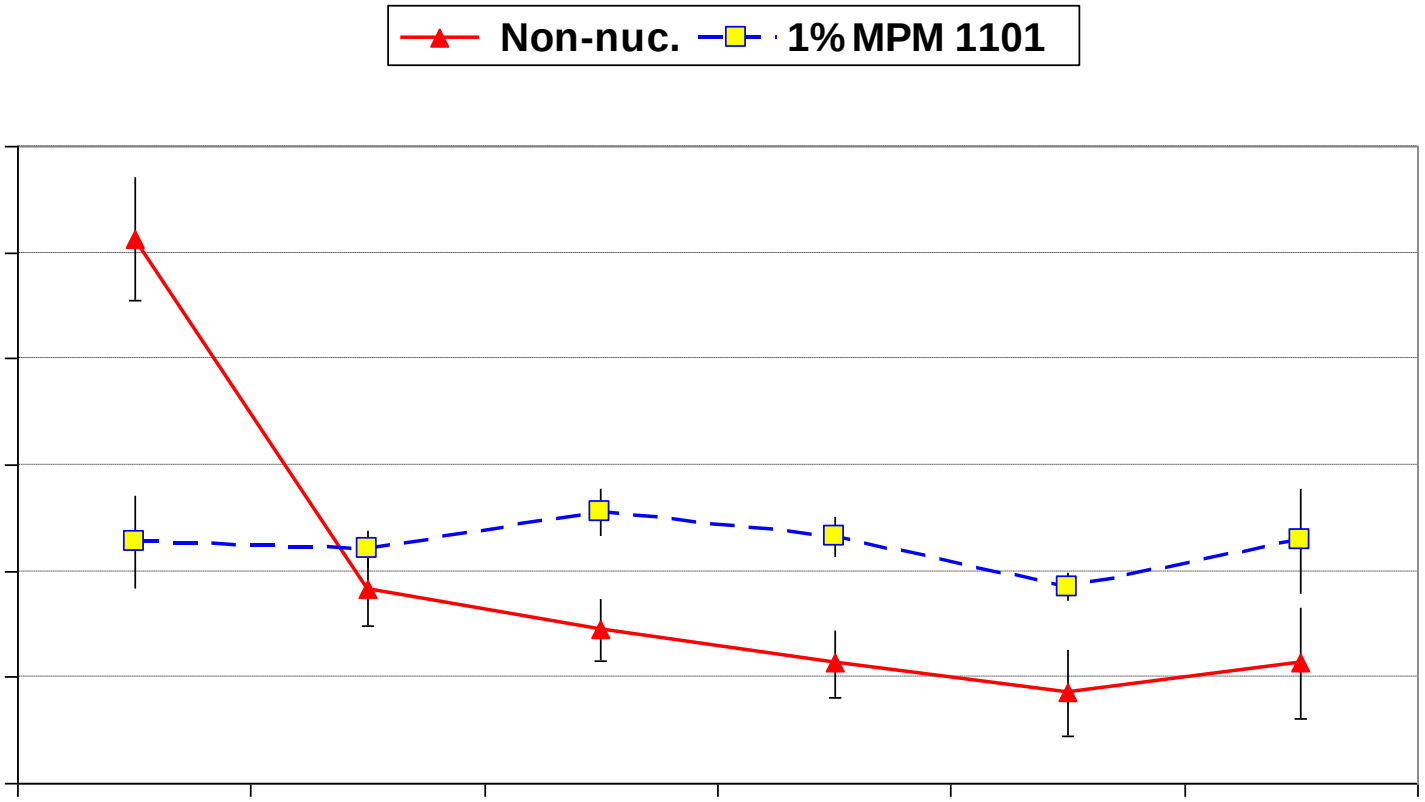
Sidewall Thickness Distribution in Thermoformed Cups



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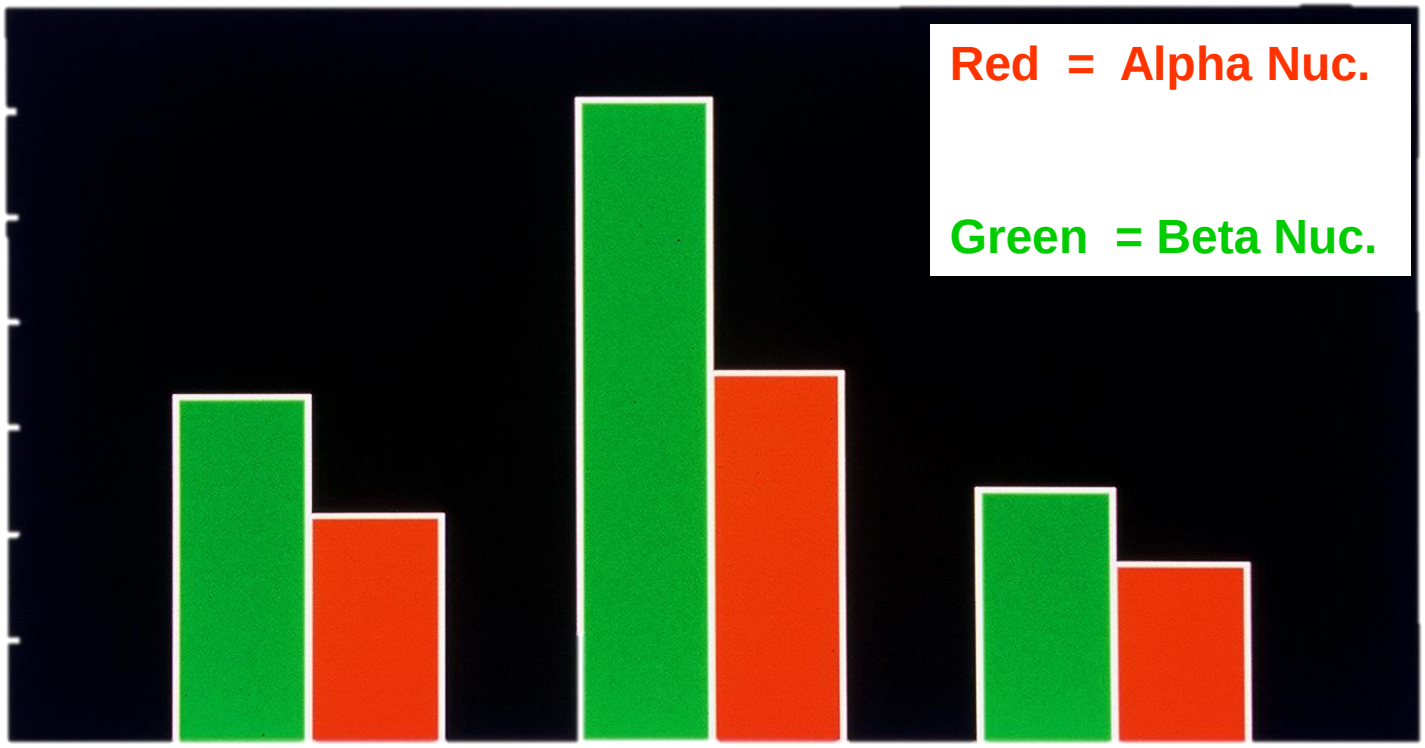
Top Load Crush Strength of Polypropylene Containers With and Without β-Nucleation



Note: At same container weight, β nucleated products have higher top-load

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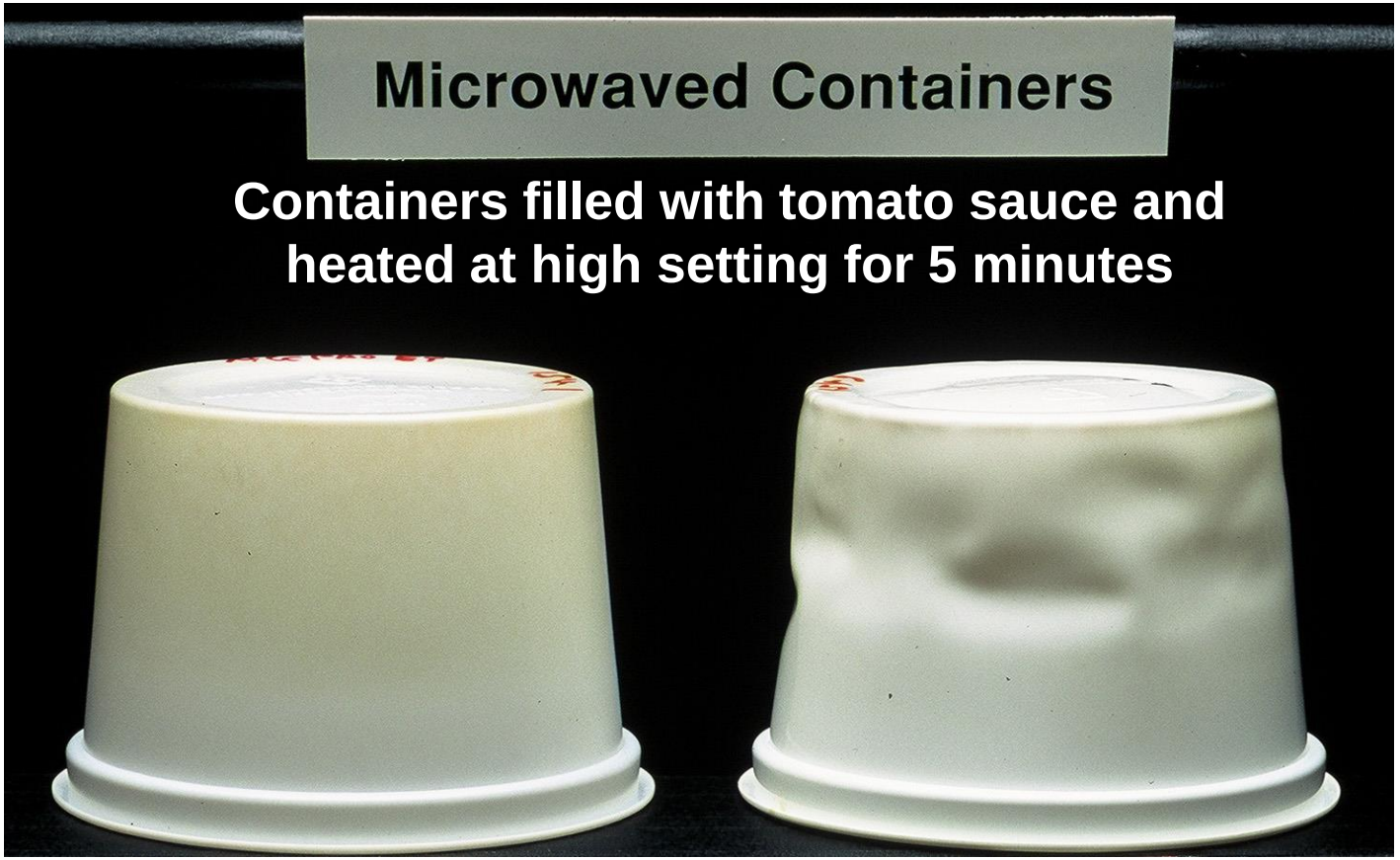
High Temperature Dimensional Stability of Beta vs Alpha Nucleated PP



Beta Nucleated **Alpha Nucleated**

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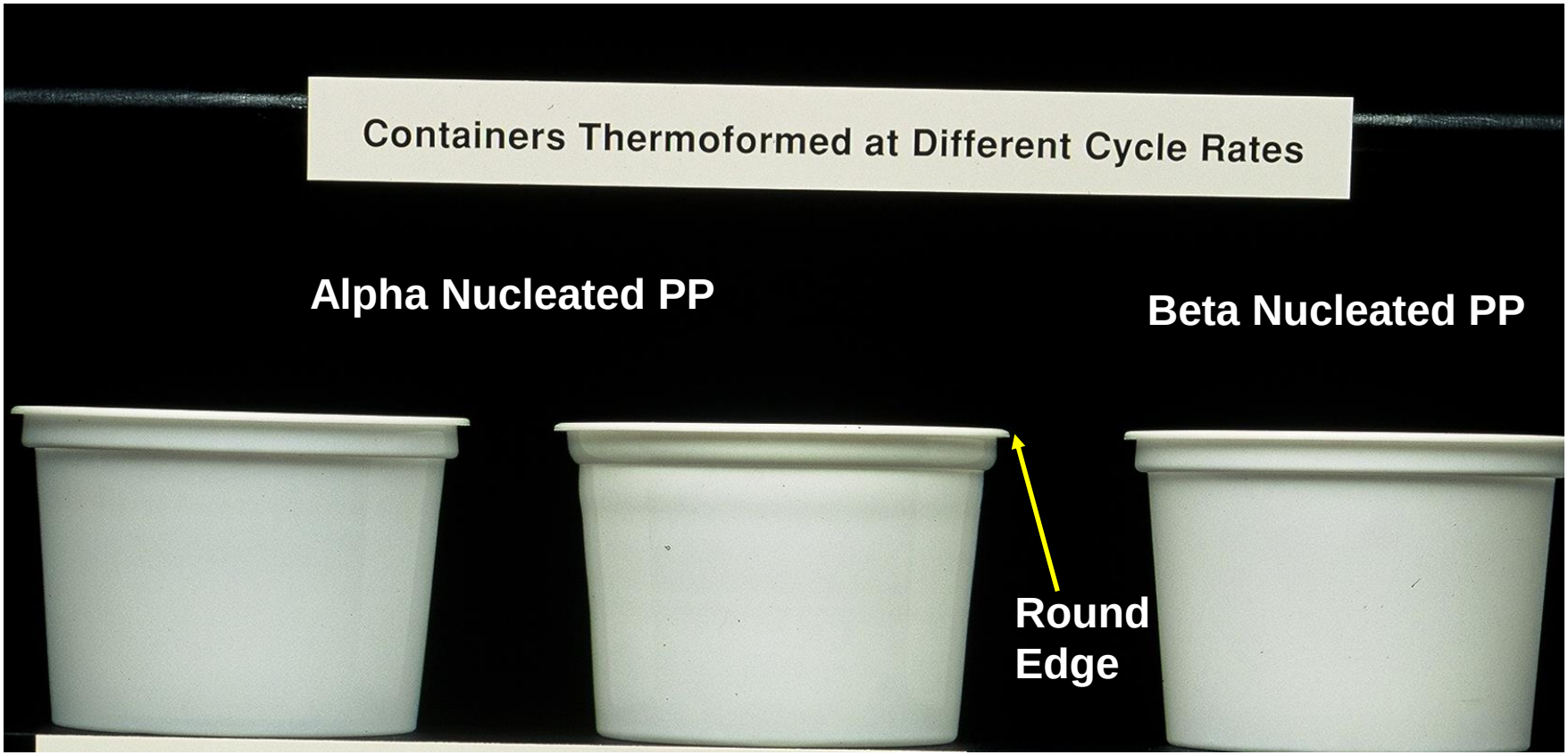
Effect of Cycle Time on Part Definition For Alpha and Beta Nucleated PP Containers



14.9 CPM

(standard conditions)

16.6 CPM

(unacceptable)

18 CPM

(20% Increased Cycle rate)

Improved Material Distribution in Black Pigmented Food Trays

- Black trays exhibited thin spots due to poor material distribution
- The processing window was also very narrow, and webbing was observed when the sheet got too hot
- Attempts to improve the situation by altering the process and using a pre-heat oven only led to slight improvements and added additional processing issues and higher energy consumption
- Beta nucleation using MPM 2000 dramatically improved the material distribution, and eliminated the webbing, without the use of a pre-heat oven

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Trays With no Carbon Black

Control (no beta) **With 1% MPM 2000**

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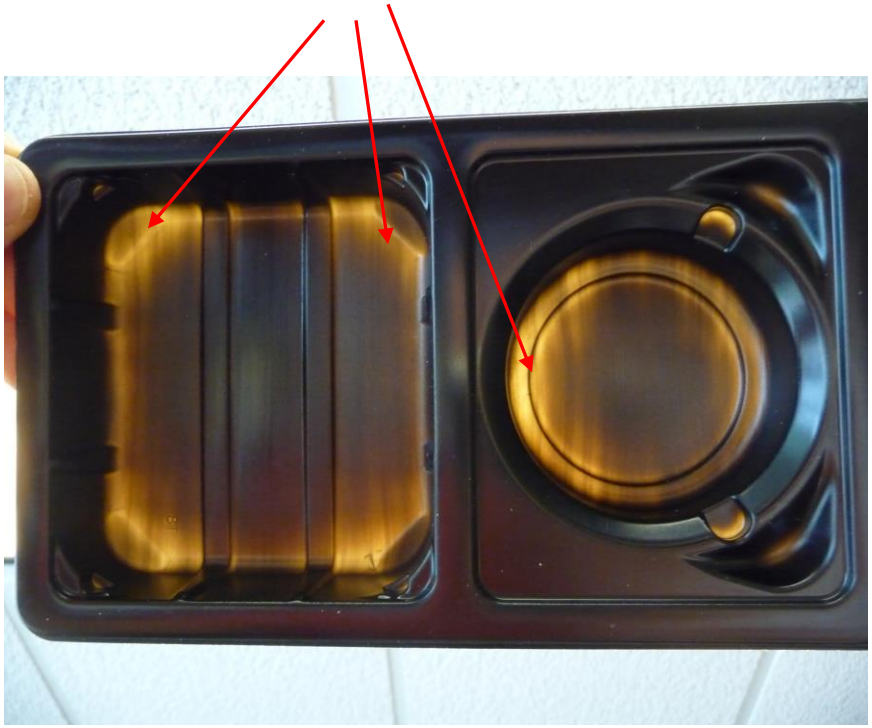
Backlit Trays

Note thin spots



Control Tray – No Beta

More uniform polymer distribution

Tray with 1% MPM 2000

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Benefits of Beta Nucleation for Thermoformed PP Food Packaging

- **Reduction in Part Weight**
  - Up to 20% weight reduction
- **Improved Productivity**
  - Up to 25% reduction in cycle time
- **Improved Dimensional Stability at High Use Temperatures**
- **Improved Material Distribution Leading to Higher Crush Strength and Rigidity**
  - Thicker and more uniform sidewalls
- **Broader Processing Window**
  - Less sagging and lower processing temperatures
- **White/Opaque Appearance with little or no White Pigment**
- **Beta Masterbatches have FDA Food Contact Approval for all food types**

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Sustainability Benefits and Reduced Carbon Footprint

- **Less plastic usage** with no loss in product function
- **Less energy consumed** during production of packaging
  - 25% higher productivity means more output per hour of machine time
  - Lower thermoforming temperatures lead to less energy use
- **Less energy used in transportation** of final product due to lighter package weight
- **Improved recyclability** since little or no white pigment (TiO2) is used to make white containers, and the beta nucleation of the PP resin produces improved mechanical properties (higher impact strength) in products made from the recycled resin
- **Lower Costs!** More **"Green $"** in the pocket of the packaging producer and the food company