

# **Durables and consumer goods overview**



# Durables and consumer goods overview

These are the reusable products that you interact with every day in a multitude of environments



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# Durables and consumer goods market map

## ■ Food contact

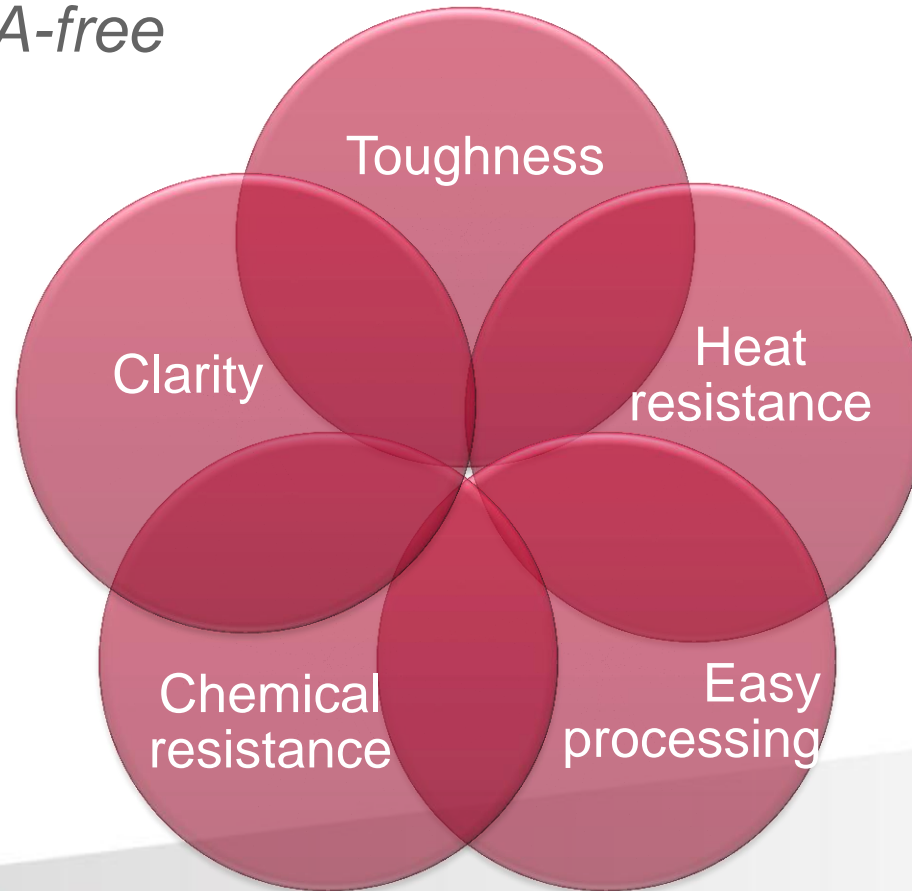
- Consumer housewares
- Commercial housewares
- Sports bottles
- Small appliances
- Infant care
- Water filtration

## ■ Non-food contact

- Appliances
- Leisure and safety
- Ophthalmics
- Oral care
- Stationary
- Tools
- In-Mold Decorations
- Toys

# What is Eastman Tritan™ copolyester

*A new generation copolyester which has a unique balance of properties – great chemical resistance with easy processing, clarity, toughness, improved heat resistance, as well as BPA-free*



# Technical information



# Overview of polymer properties

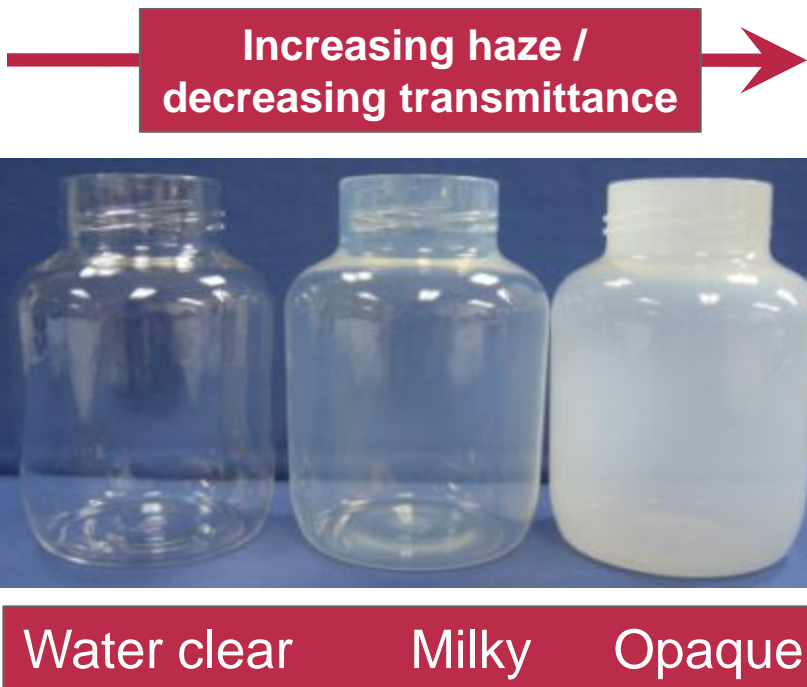
| Polymer                     | Appearance | Scratch resistance | Heat resistance | Toughness | Chemical resistance | BPA free |
|-----------------------------|------------|--------------------|-----------------|-----------|---------------------|----------|
| Eastman Tritan™ copolyester | ++         | o                  | o               | ++        | ++                  | yes      |
| Polycarbonate (PC)          | o          | o                  | ++              | ++        | +                   | no       |
| Acrylic (AC)                | ++         | +                  | o               | --        | --                  | yes      |
| Methacrylate-Styrene (MS)   | ++         | -                  | -               | --        | --                  | yes      |
| SAN (AS)                    | -          | -                  | o               | --        | --                  | yes      |

**++ Best**
**+ Good**
**o Average**
**- Poor**
**-- Worst**

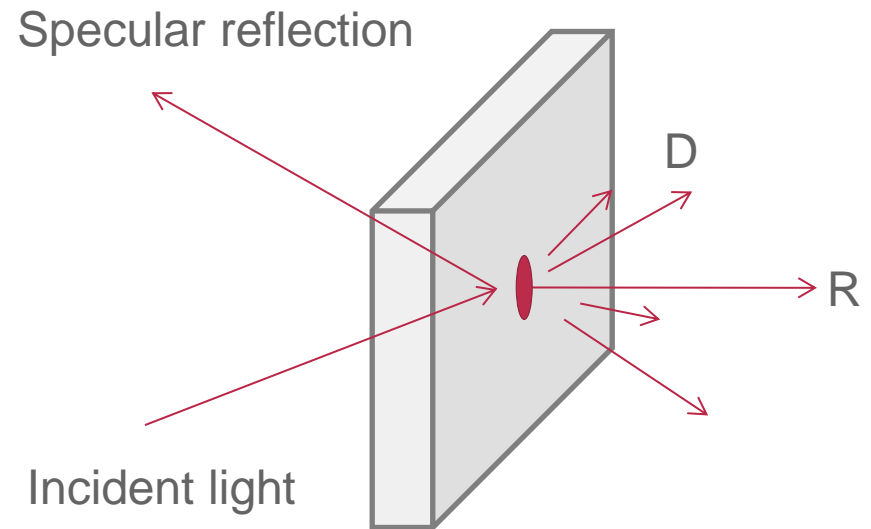
Eastman Tritan™ copolyester has the best combination of properties for durable housewares and appliance applications.

# Clarity – transmittance and haze

- Can be defined as:



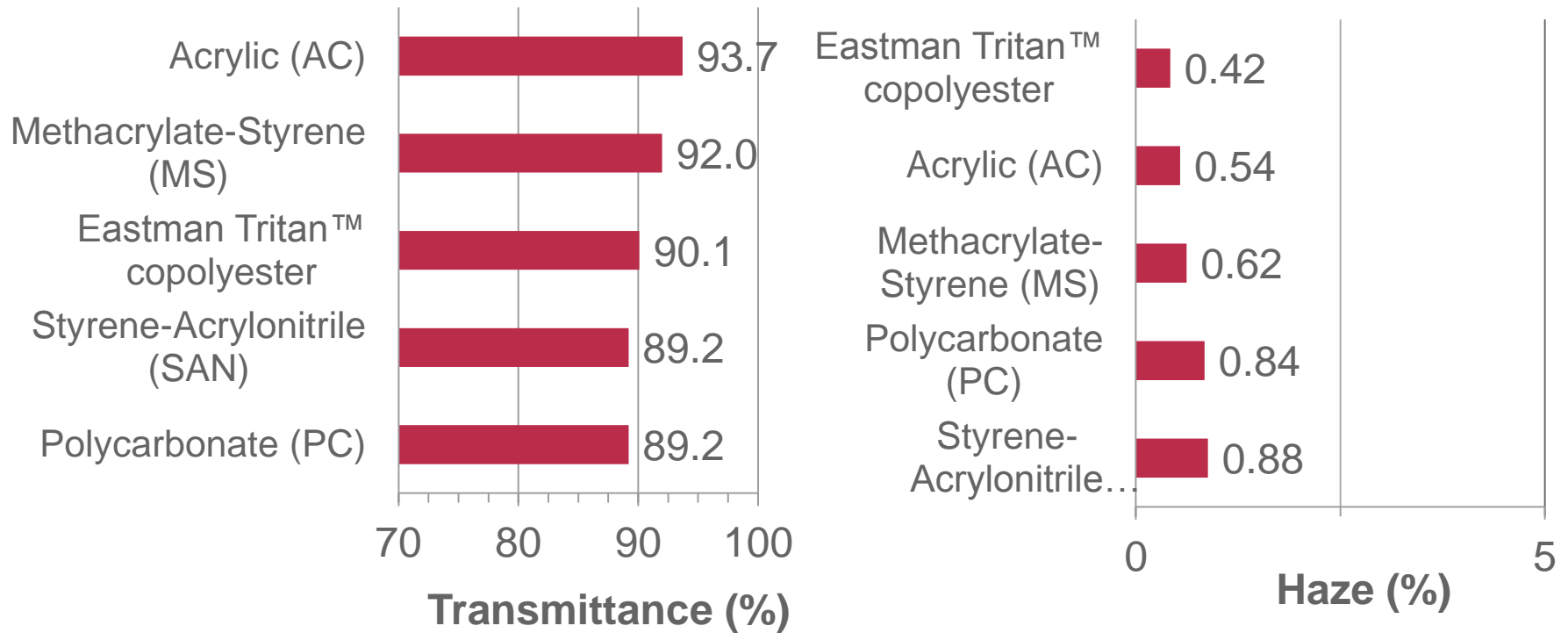
- Can be measured by:



Total trans. (T) = diffuse trans. (D)  
+ regular trans. (R)

Haze = diffuse transmittance (D) /  
total transmission (T)

# Appearance – transmittance and haze



Eastman Tritan™ copolyester has excellent clarity due to a combination of good transmittance and very low haze.



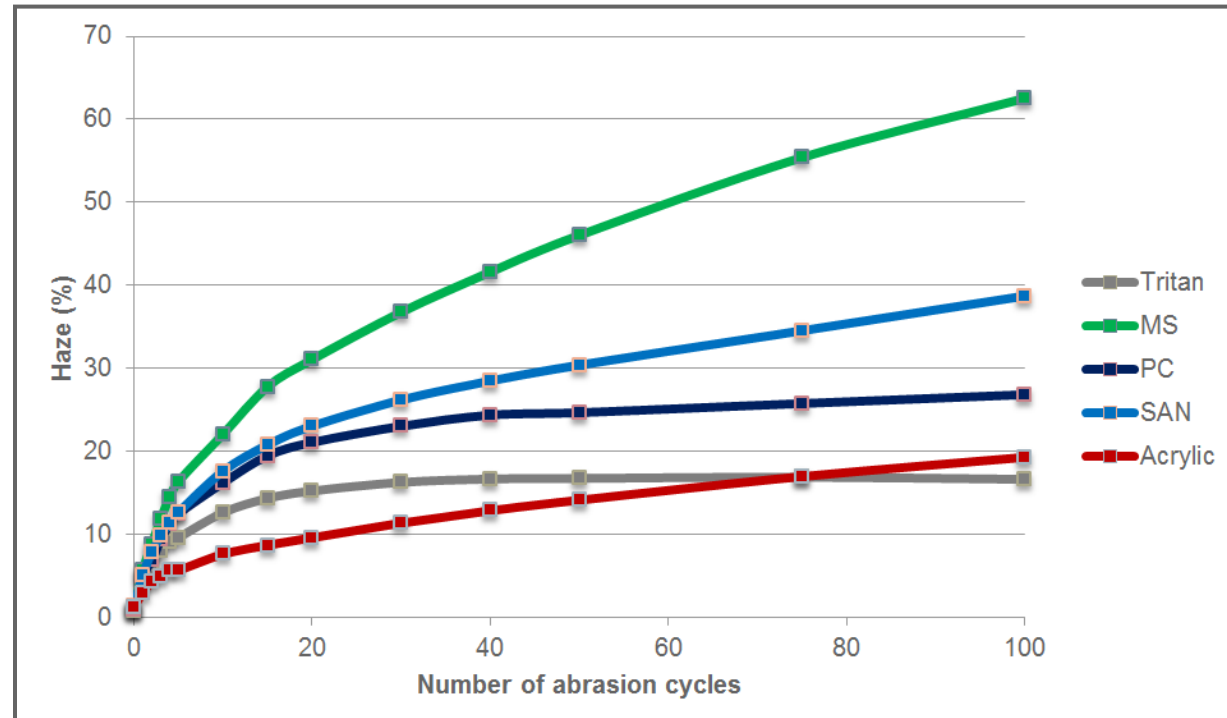
# Scratch resistance

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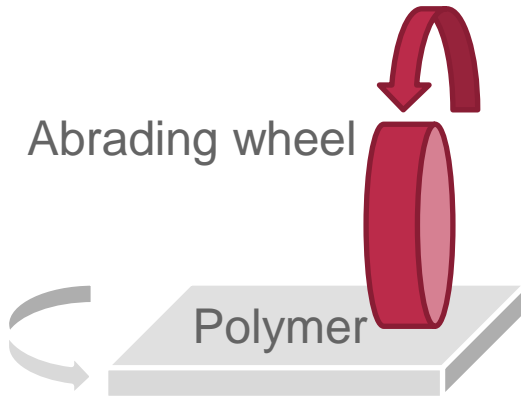
## Taber abrasion test



## Taber Abrasion Resistance



Abrading wheel

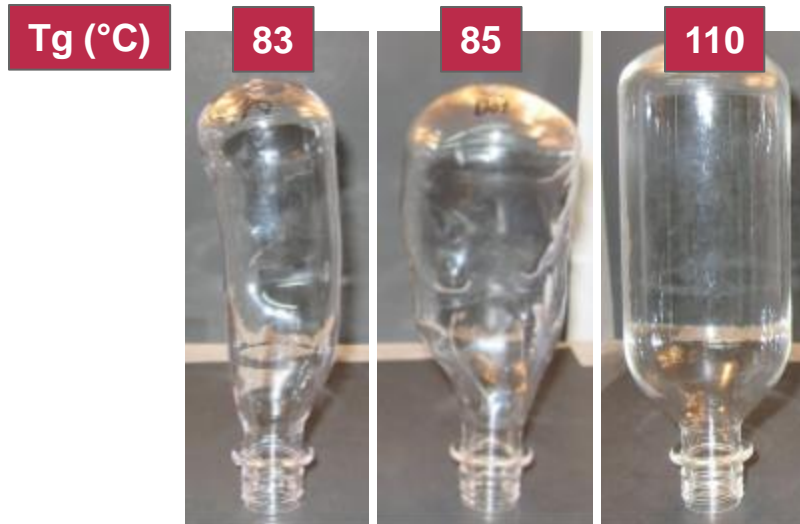


Haze is measured as a function of number of cycles

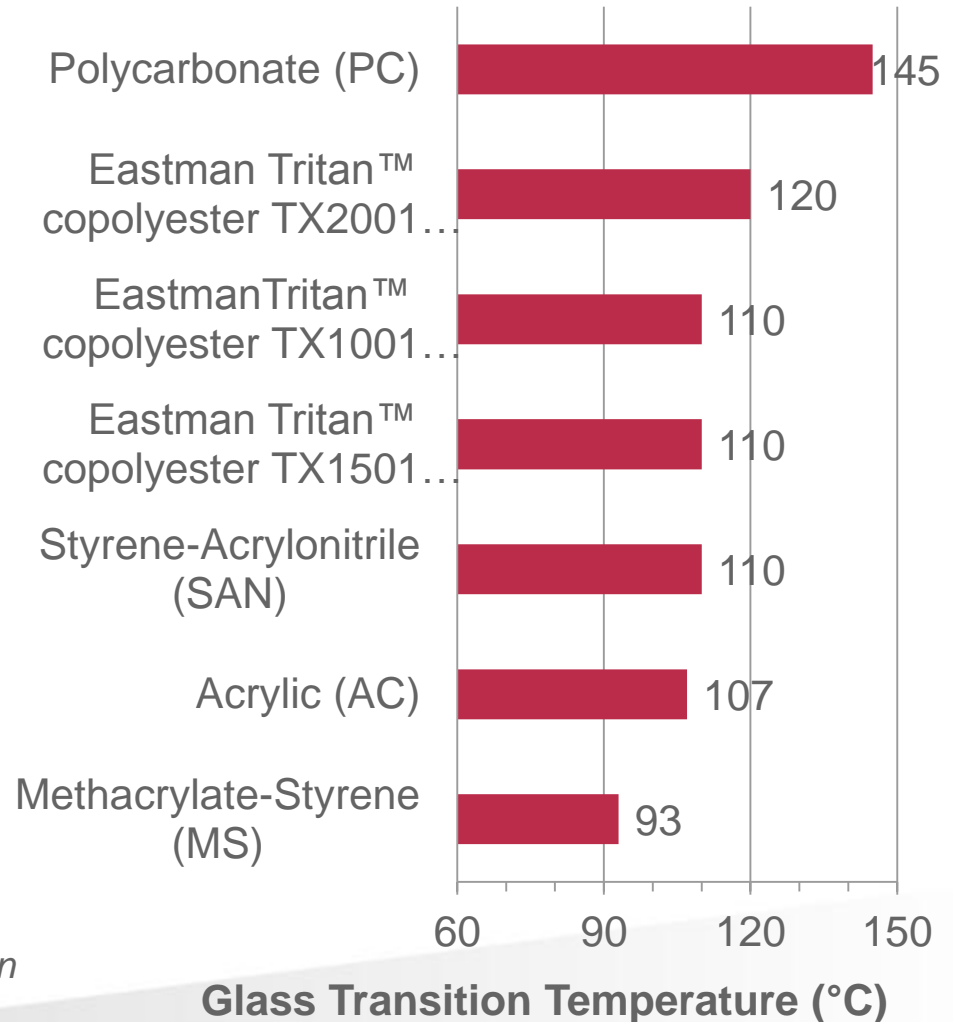
Eastman Tritan™ copolyester has better scratch resistance than as MS and SAN, and slightly better to similar scratch resistance as compared to PC. Acrylic has better scratch resistance than Tritan™.

# Glass transition temperature (Tg)

- Higher Tg's mean
  - Higher temperature resistance
  - Reduced creep under load
  - Faster molding rates



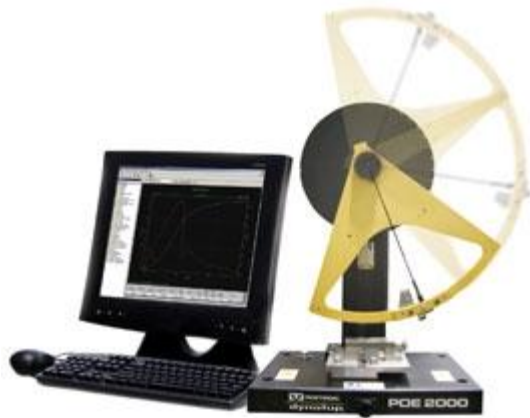
Variable Tg materials after one residential dishwasher cycle, 69°C, 100% humidity, 45 min



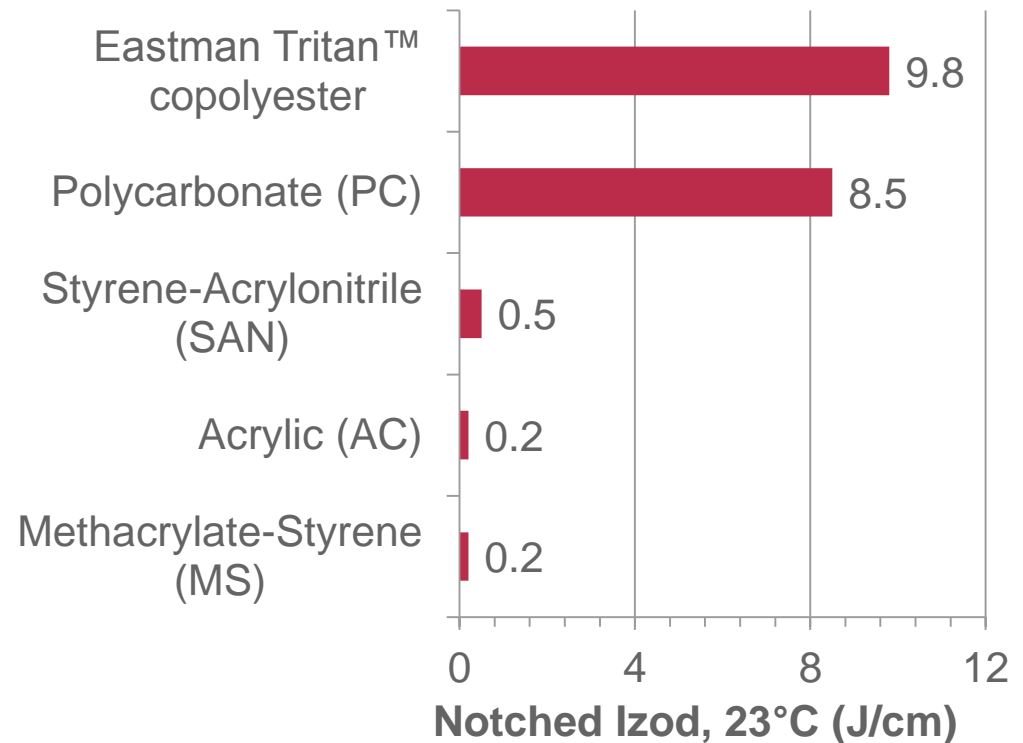
# Toughness

## Notched Izod

- Toughness can be correlated with durability of the material.



[http://www.instron.us/wa/products/impact/series\\_POE2000e.aspx](http://www.instron.us/wa/products/impact/series_POE2000e.aspx)

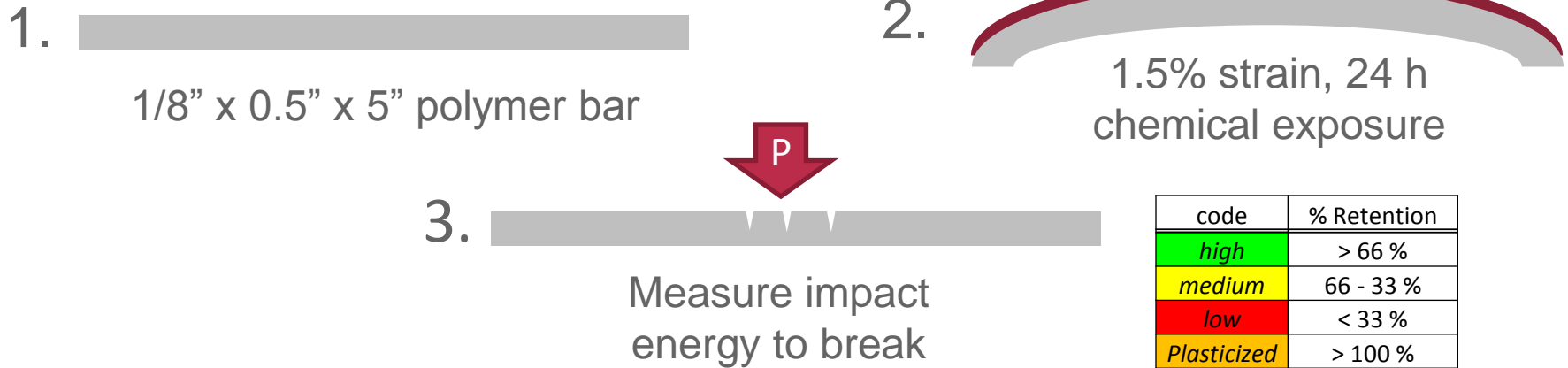


Eastman Tritan™ copolyester and PC have superior toughness, which translates to excellent drop impact resistance.

[www.tritantough.com](http://www.tritantough.com)

# Chemical resistance

## Experimental:



| code        | % Retention |
|-------------|-------------|
| high        | > 66 %      |
| medium      | 66 - 33 %   |
| low         | < 33 %      |
| Plasticized | > 100 %     |

| Sample                      | Control (joules) | Canola oil                | 409  | Spray & wash | Jet dry | WD40 |
|-----------------------------|------------------|---------------------------|------|--------------|---------|------|
|                             |                  | % retention in properties |      |              |         |      |
| Eastman Tritan™ copolyester | 4.4              | 86%                       | 91%  | 90%          | 90%     | 85%  |
| Polycarbonate (PC)          | 5.4              | 71%                       | 30%  | 93%          | 95%     | 82%  |
| Acrylic (AC)                | 0.8              | 0%                        | 39%  | 37%          | 36%     | 49%  |
| Methacrylate-Styrene (MS)   | 1.0              | 55%                       | 125% | 121%         | 107%    | 54%  |
| Styrene-Acrylonitrile (SAN) | 1.0              | 59%                       | 92%  | 64%          | 60%     | 79%  |

Eastman Tritan™ copolyester has superior toughness and chemical resistance to common household chemicals and to the harsh dishwasher environment.

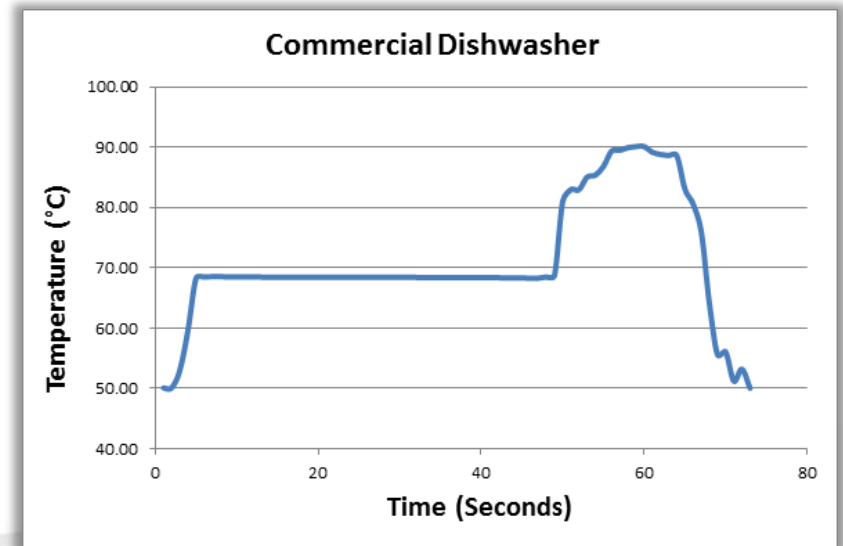
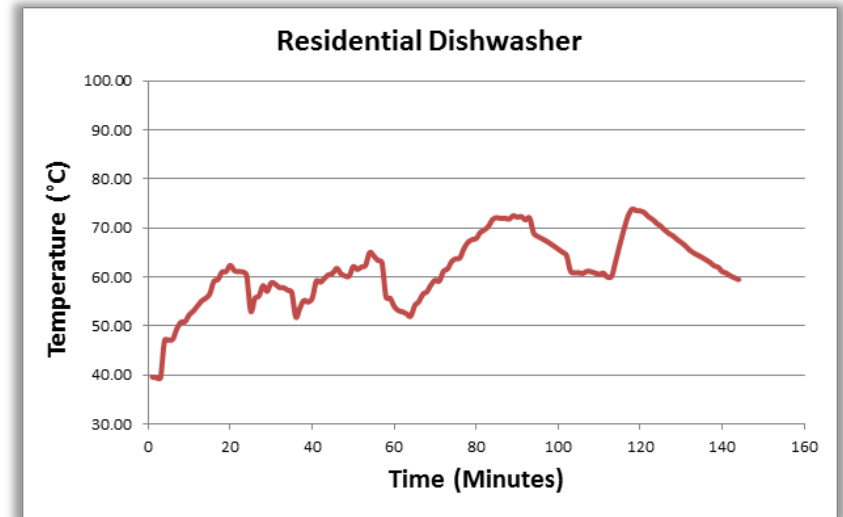
# Dishwasher Durability

Many aspects to consider regarding dishwasher durability:

- Heat resistance
- Chemical resistance
- Hydrolysis resistance
- Scratch resistance

***Factors combine to make the dishwasher a very challenging environment for many plastics***

- Dishwashing could be the ultimate FFU testing for durable housewares



Critical that the houseware article do not haze, scratch, chip, crack, deform or lose impact strength.

# Beer mug testing

- Motivation to look at performance of same materials in a different part design
- Beer mug molded at Eastman
- Tested materials:
  - Eastman Tritan™ copolyester
  - Polycarbonate (PC)
  - Styrene-Acrylonitrile (SAN)
  - Methacrylate-Styrene (MS)
  - Acrylic (AC)
- Dropped after 30, 50, 75, 100 and 125 residential dishwasher cycles
- Filled with water to nearly full
- Dropped from 4 feet / bottom impact
- Maximum 25 drops



# Beer mug testing results

| <i>Target name</i>          | <i>Initial</i> | <i>30 cycles</i> | <i>50 cycles</i> | <i>75 cycles</i> | <i>100 cycles</i> | <i>125 cycles</i> |
|-----------------------------|----------------|------------------|------------------|------------------|-------------------|-------------------|
| Eastman Tritan™ copolyester | > 25           | > 25             | > 25             | > 25             | > 25              | > 25              |
| Polycarbonate (PC)          | > 25           | 1 – shatter      | 1 – shatter      | 1 – shatter      | 1 – shatter       | 1 – shatter       |
| Acrylic (AC)                | 2 – crack      | 10 – chip        | 1 – shatter      | 3 – shatter      | 1 – halved        | 1 – halved        |
| Methacrylate-Styrene (MS)   | 2 – chip       | 5 – chip         | 2 – crack        | 1 – crack        | 1 – chip          | 1 – chip          |
| Styrene-Acrylonitrile (SAN) | 1 – crack      | 2 – crack        | 7 – chip         | 1 – chip         | 1 – chip          | 1 - chip          |

- In this study, acrylic (AC) and styrenic (MS & AS) housewares failed after a single drop and had inferior toughness compared to Eastman Tritan™ copolyester
- PC failed due to cracking in the dishwasher and subsequently shattered on impact

# Dishwasher + drop test results



Acrylic after 75 dishwasher cycles and drop test



Methacrylate styrene after 50 dishwasher cycles and drop test



TABS after 30 dishwasher cycles and no drop test



Impact modified styrene after 75 dishwasher cycles and drop test



Polycarbonate after 125 dishwasher cycles and no drop test



SAN after 30 cycles and drop test



## Dishwasher photos



Eastman Tritan™ copolyester after 125 cycles and 25 drops

# Dishwasher durability: validation

A number of tests have been performed to establish the dishwasher durability of parts made from Eastman Tritan™ copolyester TX1001 and TX2001

| Testing                                    | Testing location | Temperature and time    | Chemical                | # of cycles       | Tritan performance | Competitive material performance |
|--|------------------|-------------------------|-------------------------|-------------------|--------------------|----------------------------------|
| Residential dishwashers                    | Eastman          | 65°C peak / 2 hr cycle  | Liquid Cascade          | 125               | No visual effect   |                                  |
| Residential dishwashers: 1% applied strain | Eastman          | 69°C peak / 2 hr cycle  | Powder Cascade          | 50                | No visual effect   | PC failed in 3 cycles            |
| Labware dishwasher                         | Customer         | 65°C peak / 1 hr cycle  | Detergent               | 125 (Consecutive) | No visual effect   |                                  |
| Commercial dishwasher                      | Eastman          | 85°C peak / 1 min cycle | Detergent               | 400               | No visual effect   |                                  |
| Commercial dishwasher                      | Eastman          | 85°C peak / 1 min cycle | Detergent and sanitizer | 500               | No visual effect   | PC failed after 30 cycles        |

# Overview of polymer properties

| Polymer                     | Appearance | Scratch resistance | Heat resistance | Toughness | Chemical resistance | BPA free |
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Eastman Tritan™ copolyester has the best combination of properties for durable housewares and appliance applications.

# Product data sheets

- [Eastman Tritan™ copolyester TX1001](#)
- [Eastman Tritan™ copolyester TX1501HF](#)
- [Eastman Tritan™ copolyester TX2001](#)

# Staining

- Eastman Tritan™ copolyester TX1000 and TX2000 can stain on extended exposure to heated foods
- Certain foods in contact with these materials for long periods of time, such as turmeric (curry and yellow mustard) and tomato sauce can cause discoloration
- Polycarbonate has excellent stain resistance; polypropylene is much worse. Eastman Tritan™ copolyester is intermediate between these two materials, but closer to PC

# Staining fundamentals

- Microwaving food can lead to staining
- Staining is highly dependent on:
  - Food
  - time & Temperature (tT)
  - Container size
  - Container wall thickness
- Aggressive foods that stain most:
  - Tomato paste/spaghetti
  - Turmeric (mustard and curry)

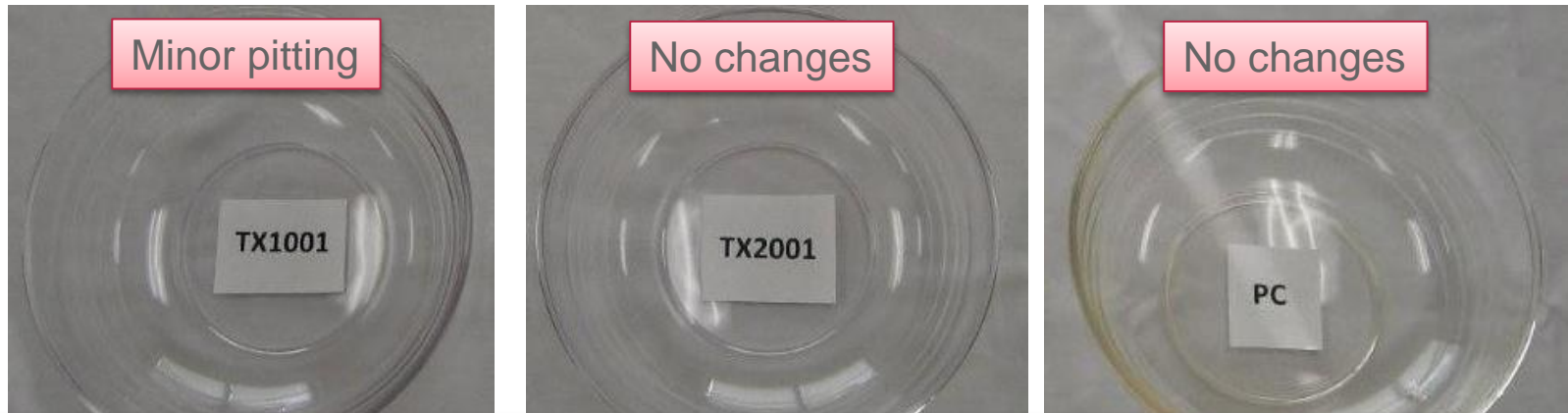
TX1001, 23°C, 24h

TX1001, 50°C, 24h

TX1001, 75°C, 24h



## Chili 2 minutes microwave testing



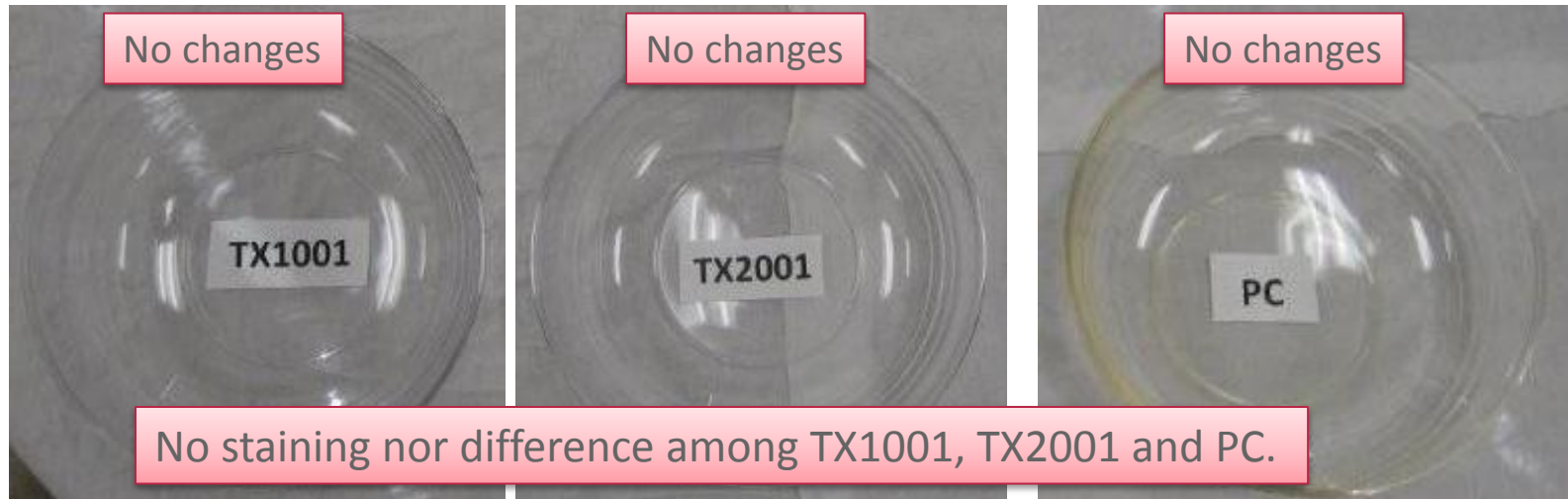
No difference between TX2001 and PC under standard conditions.

## Spaghetti sauce 2 minutes microwave testing



Increased Tg of TX2001 improves stain resistance to aggressive foods.

# Coffee 2 minutes microwave testing



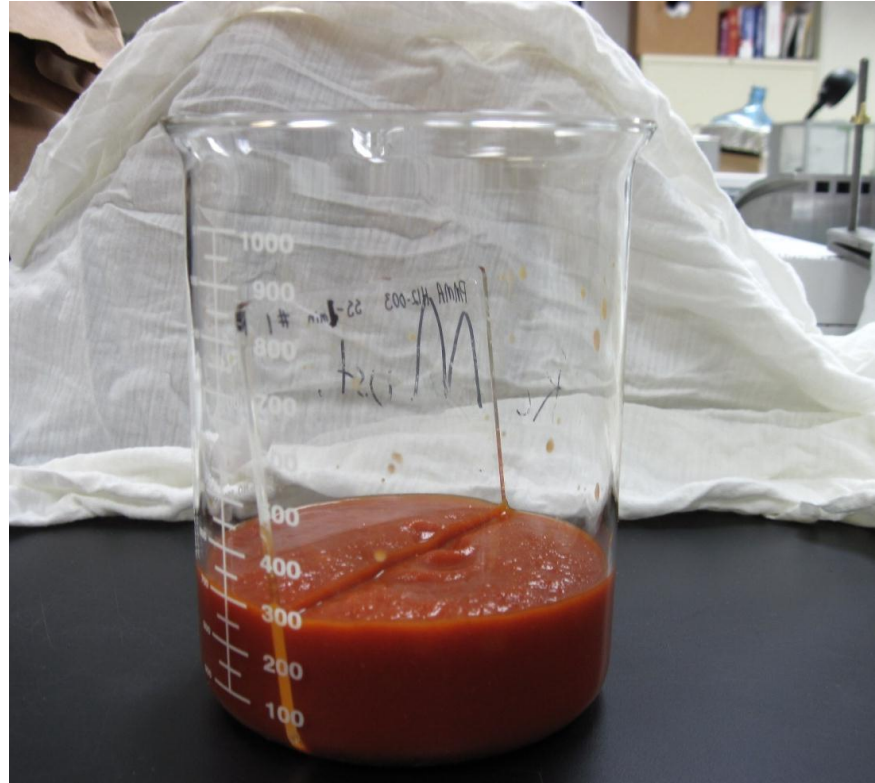
## Staining conclusions

- Staining depends on the material, food, time, temperature and container size and shape
- Eastman Tritan™ copolyesters have good stain resistance. Polycarbonate has better stain resistance.
- Passed customer testing with:  
Tomato paste, butter, chocolate syrup, ketchup, corn oil, mustard, Tabasco®, Fantastic® cleaner, teriyaki sauce, vanilla extract.

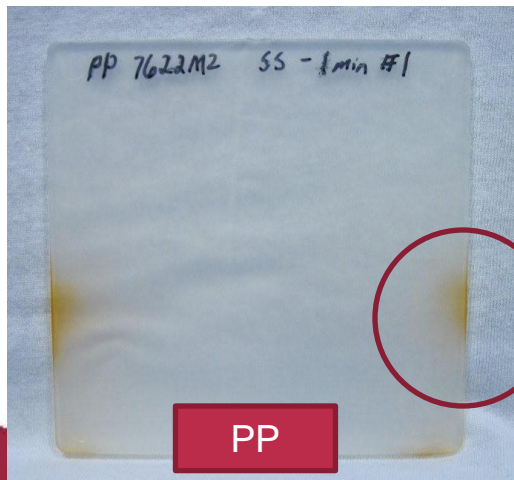
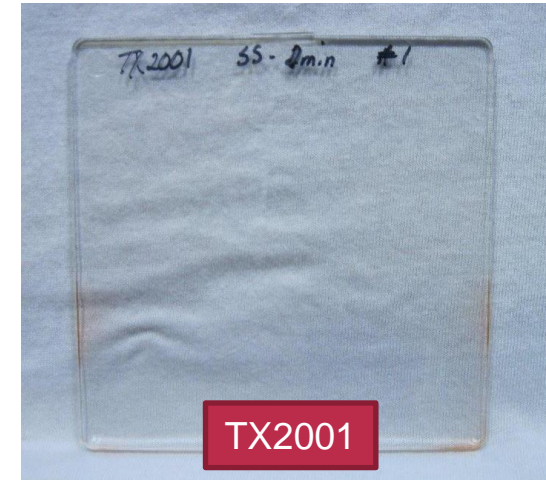
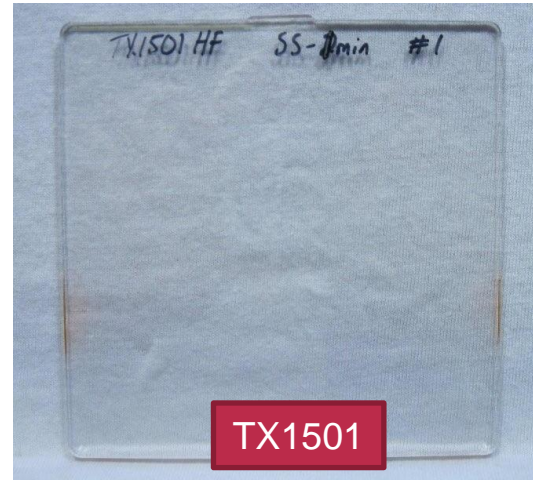
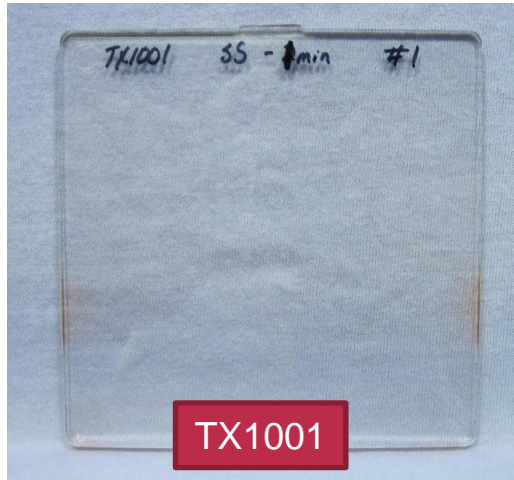


# Microwave testing part 2

- 4" x 4" x 1/8" plaques.
- Spaghetti sauce (most aggressive food)
- One minute exposure
- Eastman Tritan™ copolyester vs. polypropylene (PP)



# Microwave testing part 2 results



| Spaghetti sauce | TX1001 (Standard) | TX1501 (High flow) | TX2001 (High Tg) | PP     |
|-----------------|-------------------|--------------------|------------------|--------|
| 1 min           | slight            | slight             | slight           | severe |

Polypropylene severely stained in the microwave.

# Drying and molding conditions for Eastman Tritan™ copolyester

- Drying
  - Dry at 190°F for 4+ hours
  - Dry air at below -30°F dew point using an air flow 1 cfm/lb/hr
- Molding
  - Residence time of less than 5-6 minutes
  - Screw designed for amorphous polyesters
  - Melt temperature 540°—550°F typical (barrel settings may be different)
  - Mold temperature 140°—150°F typical



# Consumer housewares market



# Housewares overview

## Transform your thinking about clear polymers



Eastman Tritan™ copolyester is a significant and welcome breakthrough that transforms the performance of copolyesters.

### Market needs

- Clear, tough, and chemical resistant – which creates a new standard for consumer and commercial housewares and sports bottles.

# Attributes for the housewares market

Eastman has transformed how the industry thinks of clear materials because of a unique balance of properties:

- Clarity
- Toughness
- Dishwasher durability
- Density
- Design flexibility
- Ease of tinting
- Bisphenol-A (BPA) free



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# Selected housewares applications



# Products for the housewares market

| Eastman™ specialty copolyester | Clarity   | Toughness | Chemical resistance | Heat resistance                                   | Other properties                                  |
|--------------------------------|-----------|-----------|---------------------|---|---|
| Eastar™ copolyester            | High      | High      | High                | Moderate  | Food-contact-compliant formulations               |
| DuraStar™ polymer              | Very High | High      | High                | Moderate  | Good flow, dries quickly                          |
| Eastman Tritan™ copolyester    | High      | High      | High                | Moderately high (compared with polycarbonate[PC]) | Outstanding dishwasher durability; processability |



# Competitive materials in housewares market

**Table 1** Comparison of properties

| Property                      | Eastman Tritan™ copolyester | Polycarbonate (PC) | Transparent ABS (TABS) | PMMA | SMMA | SAN  | Glass |
|-------------------------------|-----------------------------|--------------------|------------------------|------|------|------|-------|
| Clarity                       | ●                           | ●                  | ◐                      | ●    | ●    | ◐    | ●     |
| Toughness (impact resistance) | ●                           | ●                  | ◐                      | ○    | ○    | ○    | ○     |
| Dishwasher durability         | ●                           | ◐                  | ◐                      | ◐    | ◐    | ◐    | ●     |
| Density (g/cm <sup>3</sup> )* | 1.18                        | 1.2                | 1.1                    | 1.17 | 1.07 | 1.07 | 2.5   |

\*Specific gravity measured according to ASTM D792.

- Poor
- ◐ Fair
- ◑ Good
- ◒ Very good
- Excellent

# Appliances market



# Appliances overview

Eastman Chemical Company is a leading supplier of clear plastic resins that inspire innovation. These performance-matched resins can help create value-added components that enhance the value of small appliances, floor care equipment and major appliances.

## Market needs

- Discover innovative ways to satisfy consumers – and differentiate products and brands



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# Small appliance overview

Eastman Tritan™ copolyester is an exciting and significant breakthrough that builds on the quality and versatility of heritage copolyesters

## Market needs

- Deliver greater heat resistance and easier processability of small appliance components



# Attributes for the appliances market

Eastman Tritan™ copolyester has transformed how the industry thinks of clear materials because of its unique balance of properties.

- Clarity
- Toughness
- Dishwasher durability
- Density
- Design flexibility
- Ease of tinting
- Bisphenol-A (BPA) free
- Sustainability
- Processability



# Selected applications for the appliance market



# Products for the appliance market

| Eastman™ specialty copolyester | Clarity   | Toughness | Chemical resistance | Heat resistance  | Other properties                                  |
|--------------------------------|-----------|-----------|---------------------|--|---|
| Eastar™ copolyesters           | High      | High      | High                | Moderate   | Food-contact-compliant formulations               |
| DuraStar™ polymer              | Very high | High      | High                | Moderate   | Good flow; dries quickly                          |
| Eastman Tritan™ copolyester    | High      | High      | High                | Moderately high (compared with polycarbonate [PC])         | Outstanding dishwasher durability; processability |
| Tenite™ cellulosics            | High      | High      | High                | Moderate (lower plasticizer yields higher heat resistance) | Good handling properties                          |

# Competitive materials in the appliance market

| Property                      | Eastman Tritan™ copolyester | Glass | Polycarbonate (PC) | SAN  |
|-------------------------------|-----------------------------|-------|--------------------|------|
| Clarity                       | ●                           | ●     | ●                  | ●    |
| Toughness (impact resistance) | ●                           | ○     | ●                  | ○    |
| Dishwasher durability         | ●                           | ●     | ◐                  | ●    |
| Density (g/cm <sup>3</sup> )* | 1.18                        | 2.5   | 1.2                | 1.07 |

\*Specific gravity measured according to ASTM D792.

- Poor
- ◐ Fair
- ◑ Good
- ◒ Very good
- Excellent



# Sports bottles market

# Hydration trends

- Healthy habits: active hydration
- Back to the tap!
- Sustainability + reusability
- BPA-free!
- At home, gym, and office...



# Eastman Tritan™ copolyester

## Features and benefits for hydration products

### ■ Performance

- Outstanding toughness + lightweight
- Stain-resistant
- Dishwasher safe
- Excellent insulating properties
- Does not absorb/impart taste or smell

### ■ Differentiation

- Glass-like clarity
- Low-residual stress – true design flexibility

### ■ Sustainability

- Extremely durable – enables long-life reusables
- BPA free
- EA free
- Advantaged environmental footprint



# Eastman Tritan™ copolyester

## The Clear Choice

- Value to the brand:
  - A premium material for development of a new, differentiated design
  - A durable, quality material for a product that lasts
  - A versatile material unmatched performance and innovative design
- Value to the consumer:
  - Not the same old metal bottle
  - Clearly easier to clean
  - Lighter-weight for active lifestyles
  - Improved thermal insulation, maintains internal temperatures longer
  - Versatility, suitable for cold and hot drinks

| Material                    | Clarity | Break resistance | Thermal insulation |
|-----------------------------|---------|------------------|--------------------|
| Eastman Tritan™ copolyester | +       | +                | +                  |
| 18/8 stainless steel        | -       | +                | 0                  |
| Aluminum                    | -       | +                | 0                  |



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# Eastman Tritan™ copolyester

## The Clear Choice

- Value to the brand:
  - A premium material for development of a new, differentiated design
  - A durable, quality material for a product that lasts
  - A versatile material unmatched performance and innovative design
  - A material that doesn't retain taste or odor
- Value to the consumer:
  - Not the same old plastic bottle
  - Clearly easier to clean
  - No carryover to taste or smell
  - Improved thermal insulation, less sweat

| Material                    | Clarity | Break resistance | Thermal insulation |
|-----------------------------|---------|------------------|--------------------|
| Eastman Tritan™ copolyester | +++     | +++              | +++                |
| PP                          | ++      | ++               | +                  |
| LDPE                        | +       | ++               | +                  |



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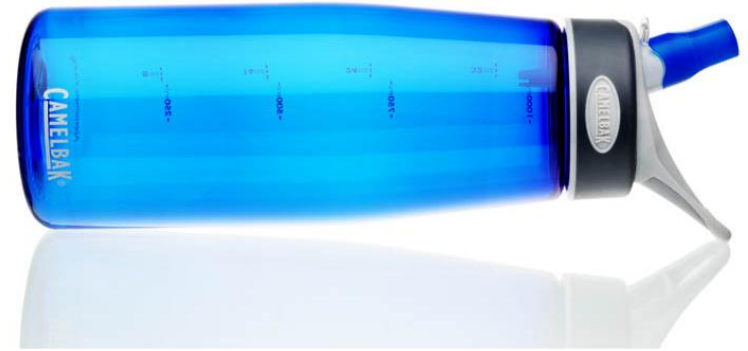
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**Sustainability**

# Sports bottles sustainability

## Durability

- Outstanding toughness
- Excellent break and dent resistance
- Dishwasher performance to 1000's of cycles, extending life of the product
- Material enabling a long-life, truly reusable bottle



| Material                    | Break-resistance | Dent resistance | Dishwasher durability |
|-----------------------------|------------------|-----------------|-----------------------|
| Eastman Tritan™ copolyester | +++              | +++             | +++                   |
| 18/8 stainless steel        | +++              | ++              | ++                    |
| Aluminum                    | +++              | +               | +                     |
| PP/LDPE                     | ++               | +++             | ++                    |

# General disclaimer

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