EASTMAN

# Independent third-party testing of Eastman Tritan™ copolyester and other materials

How tough is tough? How clear is clear?
How durable is durable?

Find out what an independent laboratory discovered by clicking START and navigating through the third-party testing.

START

Eastman **TRITAN**™
copolyester

# Measuring up to the toughest tests

## From the marketplace

Durability, clarity, impact resistance and other properties have contributed to the great success of Eastman Tritan™ copolyester in durables and housewares applications. These performance attributes have not been evaluated together in comprehensive third-party tests.

## From a third-party laboratory

An independent third-party laboratory recently accepted the challenge of testing performance characteristics that drive user satisfaction.

Click NEXT on each page to advance through results of third-party laboratory tests — or use the bottom navigation to go directly to specific test results.

For more information about Eastman Tritan™ copolyester, visit TritanTough.com.

# Tracking residential dishwasher durability

The combination of heat, water and cleansers turns a dishwasher into a torture chamber for housewares — degrading plastics and shortening product life.

**Before** this testing, the performance of Eastman Tritan™ copolyester was acknowledged through customer and internal testing, but not confirmed by a third-party test facility.

**After** 125 dishwasher cycles, the separation between Tritan and other materials is more clear.

For complete information about the testing for Dishwasher Durability, see **Dishwasher Protocols** at the end of this section.

## Dishwasher durability test results

| Material | Sample | Cycle 10 | Cycle 25 | Cycle 50 | Cycle 75 | Cycle 100 | Cycle 125 |
|---|---|---|---|---|---|---|---|
| Eastman Tritan™ copolyester TX1001 | Top Rack #1 | Lime scale | Lime scale | Lime scale | Lime scale | No change | Lime scale |
| | Top Rack #2 | Lime scale/bubbles | Lime scale | Lime scale | Lime scale | No change | No change |
| | Top Rack #3 | Lime scale | Lime scale | Lime scale | Lime scale | No change | No change |
| | Bottom Rack #1 | No change | Lime scale | Lime scale | Lime scale | Lime scale | Lime scale |
| | Bottom Rack #2 | Lime scale/bubbles | Lime scale | Lime scale | Lime scale | Lime scale | Lime scale |
| | Bottom Rack #3 | Lime scale/bubbles | Lime scale | Lime scale | Lime scale | Lime scale | No change |
| Eastman Tritan™ copolyester TX1501HF | Top Rack #1 | Lime scale | Lime scale | Lime scale | No change | Lime scale | Lime scale |
| | Top Rack #2 | Lime scale | Lime scale | Lime scale | Lime scale | Lime scale | Lime scale |
| | Top Rack #3 | Lime scale | Lime scale | Lime scale | Lime scale | No change | No change |
| | Bottom Rack #1 | No change | Lime scale | Lime scale | Lime scale | Lime scale | Lime scale |
| | Bottom Rack #2 | No change | Lime scale | Lime scale | Lime scale | Lime scale | Lime scale |
| | Bottom Rack #3 | No change | Lime scale | Lime scale | Lime scale | Lime scale | Lime scale |
| Eastman Tritan™ copolyester TX2001 | Top Rack #1 | Lime scale | Lime scale | Lime scale | Lime scale | Lime scale | Lime scale |
| | Top Rack #2 | Lime scale | Lime scale | Lime scale | Lime scale | Lime scale | Lime scale |
| | Top Rack #3 | Lime scale | Lime scale | Lime scale | Lime scale | Lime scale | Lime scale |
| | Bottom Rack #1 | No change | Lime scale | Lime scale | Lime scale | Lime scale | No change |
| | Bottom Rack #2 | Lime scale | Lime scale | Lime scale | Lime scale | No change | Lime scale |
| | Bottom Rack #3 | No change | Lime scale | Lime scale | Lime scale | Lime scale | Lime scale |

## Dishwasher durability test results (continued)

| Material | Sample | Cycle 10 | Cycle 25 | Cycle 50 | Cycle 75 | Cycle 100 | Cycle 125 |
|---|---|---|---|---|---|---|---|
| Polycarbonate | Top Rack #1 | Crazing | Lime scale/ crazing | Lime scale/ fracture | Not tested | Not tested | Not tested |
| | Top Rack #2 | Crazing | Lime scale/ crazing | Lime scale/ crazing/cracking | Cracking/ fracture | Not tested | Not tested |
| | Top Rack #3 | Crazing | Lime scale/ crazing | Lime scale/ crazing/cracking | Cracking/crazing | Fracture | Not tested |
| | Bottom Rack #1 | Crazing | Lime scale/ crazing | Lime scale/ cracking/crazing/ scrat | Cracking/crazing | Fracture | Not tested |
| | Bottom Rack #2 | Crazing | Lime scale/ crazing | Lime scale/ fracture/crazing | Not tested | Not tested | Not tested |
| | Bottom Rack #3 | Crazing | Lime scale/ cracking | Lime scale/ fracture/crazing | Not tested | Not tested | Not tested |
| Clarified Polypropylene | Top Rack #1 | No change | Lime scale | Lime scale | Lime scale | No change | Slight deformation |
| | Top Rack #2 | Lime scale | Lime scale | Lime scale | No change | No change | Slight deformation |
| | Top Rack #3 | Lime scale | Lime scale | Lime scale | No change | No change | Slight deformation |
| | Bottom Rack #1 | Lime scale | Lime scale | Lime scale | No change | No change | Slight deformation |
| | Bottom Rack #2 | No change | Lime scale | Lime scale | Lime scale | No change | Slight deformation |
| | Bottom Rack #3 | No change | Lime scale | Lime scale | No change | No change | Slight deformation |

## Dishwasher durability test results (continued)

| Material | Sample | Cycle 10 | Cycle 25 | Cycle 50 | Cycle 75 | Cycle 100 | Cycle 125 |
|---|---|---|---|---|---|---|---|
| Styrene Acrylonitrile (SAN) | Top Rack #1 | Lime scale | Lime scale | Lime scale/scuff | Lime scale/ scratching | No change | Scuff |
| | Top Rack #2 | Lime scale | Lime scale | Lime scale | Lime scale | Lime scale | Scuff |
| | Top Rack #3 | Lime scale | Lime scale/ crazing | Lime scale | Lime scale | Lime scale | Scuff |
| | Bottom Rack #1 | No change | Lime scale | Lime scale/ handle deformation | Lime scale | Lime scale | No change |
| | Bottom Rack #2 | Lime scale | Lime scale/ crazing | Lime scale | Lime scale | Lime scale | No change |
| | Bottom Rack #3 | Lime scale | Lime scale | Lime scale | Lime scale/ crazing | Lime scale | Scuff |
| Methyl Methacrylate Butadiene Styrene (MBS) | Top Rack #1 | Lime scale | Lime scale | Lime scale | Lime scale | Lime scale | No change |
| | Top Rack #2 | Lime scale | Lime scale | Lime scale | Lime scale | Lime scale | No change |
| | Top Rack #3 | Lime scale | Lime scale | Lime scale | No change | Lime scale | No change |
| | Bottom Rack #1 | No change | Lime scale | Lime scale | Lime scale/ deformation | Lime scale/ deformation | Deformation |
| | Bottom Rack #2 | Scratch | Lime scale | Lime scale/ deformation | Lime scale/ deformation | Deformation | Deformation |
| | Bottom Rack #3 | Lime scale | Lime scale | Lime scale | Lime scale/ deformation | Lime scale/ deformation | Deformation |

## Dishwasher durability test results (continued)

| Material | Sample | Cycle 10 | Cycle 25 | Cycle 50 | Cycle 75 | Cycle 100 | Cycle 125 |
|---|---|---|---|---|---|---|---|
| Acrylic | Top Rack #1 | Lime scale | Lime scale/ crazing | Lime scale/ crazing | Crazing | Lime scale/ crazing | Crazing |
| | Top Rack #2 | Lime scale | Lime scale/ crazing | Lime scale/ crazing | Lime scale/ crazing | Lime scale/ crazing | Crazing/lime scale |
| | Top Rack #3 | Lime scale | Lime scale | Lime scale/ crazing | Lime scale/ crazing | Lime scale/ crazing | Crazing |
| | Bottom Rack #1 | Lime scale | Lime scale | Crazing | Lime scale/ crazing | Lime scale/ crazing | Crazing |
| | Bottom Rack #2 | Lime scale/bubbles | Lime scale | Lime scale/ crazing | Lime scale/ crazing | Lime scale/ crazing | Crazing |
| | Bottom Rack #3 | Lime scale/bubbles | Lime scale | Lime scale/ crazing | Lime scale/ crazing | Lime scale/ crazing | Crazing |
| Methyl Methacrylate Styrene (MS) | Top Rack #1 | Lime scale | Lime scale | Lime scale/ hazing | Hazing | Hazing | Lime scale/ hazing |
| | Top Rack #2 | Lime scale | Lime scale/ hazing | Lime scale/ hazing | Hazing | Hazing | Lime scale/ hazing/ deformation |
| | Top Rack #3 | Lime scale | Lime scale/ hazing | Lime scale/ hazing | Hazing | Hazing | Lime scale/haze |
| | Bottom Rack #1 | Lime scale/hazing | Lime scale/ hazing | Lime scale/ hazing/ deformation | Lime scale/ hazing/ deformation | Lime scale/ deformation/ hazing | Hazing/ deformation |
| | Bottom Rack #2 | Lime scale/hazing | Lime scale/ hazing | Lime scale/ hazing | Lime scale/ hazing/ deformation | Lime scale/ deformation/ hazing | Hazing/ deformation |
| | Bottom Rack #3 | Lime scale/hazing | Lime scale/ hazing | Lime scale/ hazing | Lime scale/ hazing | Lime scale/ hazing | Lime scale/ hazing |

## Dishwasher durability test results (continued)

| Material | Sample | Cycle 10 | Cycle 25 | Cycle 50 | Cycle 75 | Cycle 100 | Cycle 125 |
|---|---|---|---|---|---|---|---|
| Transparent Acrylonitrile Butadiene Styrene (TABS) | Top Rack #1 | Lime scale | Lime scale | Lime scale | Lime scale | No change | No change |
| | Top Rack #2 | Lime scale | Lime scale | Lime scale | No change | No change | No change |
| | Top Rack #3 | Lime scale | Lime scale | Lime scale | Lime scale | No change | No change |
| | Bottom Rack #1 | Lime scale | Lime scale | Lime scale | Lime scale | Lime scale | No change |
| | Bottom Rack #2 | Lime scale | Lime scale | Lime scale | No change | Lime scale | No change |
| | Bottom Rack #3 | Lime scale | Lime scale | Lime scale | No change | Lime scale | Lime scale |
| Glass | Top Rack #1 | No change | Lime scale | No change | No change | No change | No change |
| | Top Rack #2 | No change | Lime scale | No change | No change | No change | No change |
| | Top Rack #3 | No change | Lime scale | No change | No change | Lime scale | No change |
| | Bottom Rack #1 | Lime scale | Lime scale | No change | Lime scale | No change | Lime scale |
| | Bottom Rack #2 | Lime scale | Lime scale | No change | Lime scale | Lime scale | No change |
| | Bottom Rack #3 | Lime scale | Lime scale | No change | Lime scale | No change | No change |

## Eastman Tritan™ copolyester TX1001

Before

After 125 dishwasher cycles

## Eastman Tritan™ copolyester TX1501HF

Before

After 125 dishwasher cycles

## Eastman Tritan™ copolyester TX2001

Before

After 125 dishwasher cycles

## Polycarbonate

Before

After 125 dishwasher cycles

## Clarified Polypropylene

Before

After 125 dishwasher cycles

## Styrene Acrylonitrile

Before

After 125 dishwasher cycles

## Methyl Methacrylate Butadiene Styrene (MBS)

Before

After 125 dishwasher cycles

## Acrylic

Before

After 125 dishwasher cycles

## Methyl Methacrylate Styrene (MS)

Before

After 125 dishwasher cycles

## Transparent Acrylonitrile Butadiene Styrene (TABS)

Before

After 125 dishwasher cycles

## Glass

Before

After 125 dishwasher cycles

# Protocols — Residential dishwasher durability

**Dishwasher specifications:**
Whirlpool® Convertible Portable Tall Tub Dishwasher WDP350PAAB
(Two identical machines used in tests)

**Operating temperatures:**
Dishwasher 1: 144.3°F
Dishwasher 2: 141.8°F

**Cycle time:**
Approximately 2 hours and 50 minutes

**Wash setting:**
Heavy Wash, High-Temp Heat Dry

**Detergent:**
Cascade® powder

**Rinse aid:**
None used

**Sample size:**
Six mugs of each material were tested — three on the top rack (T); three on the bottom (B)

**Identification:**
Mugs were individually etched with identification information before testing.

**Assessments:**
Samples assessed for changes and deformation (haze, crazing, cracking, failure) and photographed at the following cycle intervals: 0, 10, 25, 50, 75, 100, 125

*Samples randomly placed back into top or bottom racks after each assessment interval.*

Return to Dishwasher Durability main page.

# Testing stain resistance when the heat is on

User satisfaction is a product of both function and aesthetics.

- The ability to survive two minutes with the microwave at its highest setting is one thing.
- The ability to look good after two minutes of contact with spaghetti sauce is quite another.

In this third-party test, a panel rated staining caused by microwaving spaghetti sauce. For more information about the testing for staining and microwavability, see **Staining Protocols** at the end of this section.

The average ratings for formulations of Eastman Tritan™ copolyester and other materials are shown here.

## Stain test results

| Material | Average Rating (1 to 5; 5 is best) |
|---|---|
| Eastman Tritan™ copolyester TX1001 | 4 |
| Eastman Tritan™ copolyester TX1501HF | 4 |
| Eastman Tritan™ copolyester TX2001 | 4 |
| Polycarbonate | 5 |
| Clarified Polypropylene | 2.3 |
| Styrene Acryloritrile (SAN) | 5 |
| Methyl Methacrylate Butadiene Styrene (MBS) | 1.3 |
| Acrylic | 5 |
| Methyl Methacrylate Styrene (MS) | 1.7 |
| Transparent Acrylonitrile Butadiene Styrene (TABS) | 3.7 |
| Glass | 5 |

# Protocols — Staining (microwavability)

### Microwave specifications:

Kenmore® model 721.69122020

Mugs were filled half way with Ragu® Old World Style spaghetti sauce.

### Procedure:

1. Half-filled mugs were subjected to two minutes in a microwave oven at its highest setting.
2. Following microwave, each mug was emptied and subjected to one dishwasher cycle in a residential dishwasher.
3. Each cleaned sample was judged by a panel to describe the staining observed using the following scale:

    5 = No staining present

    4 = Slight staining present

    3 = Moderate staining present

    2 = Significant staining present

    1 = Severe staining present

Return to **Staining** main page.

# Third-party testing clears the air about clarity

When most people talk about "clarity" in housewares and durables, they refer to an imprecise visual observation about a clear material's ability to transmit light with low haze and true color.

So, how clear is "clear"?

When satisfied customers of Eastman Tritan™ copolyester say "clear," they know what it means to them. To help get everyone on the same page about clarity, third-party testing measured key criteria using scientific methods — ASTM D1003, Method B for transmittance and haze; L*, a*, b* scales for spectral analyses of color space readings (next page).

For more information about testing for the different characteristics of clarity, see **Clarity Protocols**.

# Clarity — putting a value on transmittance and haze

## Transmittance

| Material | Average Percent Transmittance (Higher percent = greater clarity) |
|---|---|
| Eastman Tritan™ copolyester TX1001 | 90.17 |
| Eastman Tritan™ copolyester TX1501HF | 90.49 |
| Eastman Tritan™ copolyester TX2001 | 90.06 |
| Polycarbonate | 88.25 |
| Clarified Polypropylene | 77.14 |
| Styrene Acrylonitrile (SAN) | 86.16 |
| Methyl Methacrylate Butadiene Styrene (MBS) | 88.15 |
| Acrylic | 92.58 |
| Methyl Methacrylate Styrene (MS) | 90.54 |
| Transparent Acrylonitrile Butadiene Styrene (TABS) | 88.49 |
| Glass | 90.69 |

## Haze

| Material | Average Percent Haze (Lower percent = greater clarity) |
|---|---|
| Eastman Tritan™ copolyester TX1001 | 0.72 |
| Eastman Tritan™ copolyester TX1501HF | 0.51 |
| Eastman Tritan™ copolyester TX2001 | 0.48 |
| Polycarbonate | 0.57 |
| Clarified Polypropylene | 40.21 |
| Styrene Acrylonitrile (SAN) | 0.49 |
| Methyl Methacrylate Butadiene Styrene (MBS) | 5.50 |
| Acrylic | 0.18 |
| Methyl Methacrylate Styrene (MS) | 0.72 |
| Transparent Acrylonitrile Butadiene Styrene (TABS) | 4.75 |
| Glass | 0.15 |

# Clarity — breaking down the colors you see

Third-party researchers evaluated color using readings on the L*, a*, b* color scale, based on the human eye's ability to perceive color in pairs of opposites:

- L* scale measures light vs. dark with a high number indicating light.
- a* scale measures red vs. green where a positive number indicates red and a negative number indicates green.
- b* scale measures yellow vs. blue where a positive number indicates yellow and a negative number indicates blue.

## Color

| Material | Average L* Scale (high = light vs. dark) | Average a* Scale (negative = green vs. red) | Average b* Scale (positive = yellow vs. blue) |
|---|---|---|---|
| Eastman Tritan™ copolyester TX1001 | 93.80 | -0.49 | 3.22 |
| Eastman Tritan™ copolyester TX1501HF | 94.11 | -0.47 | 2.99 |
| Eastman Tritan™ copolyester TX2001 | 93.71 | -0.43 | 2.94 |
| Polycarbonate | 92.91 | -0.63 | 2.39 |
| Clarified Polypropylene | 82.32 | -0.70 | 4.87 |
| Styrene Acrylonitrile (SAN) | 90.94 | -0.19 | 0.19 |
| Methyl Methacrylate Butadiene Styrene (MBS) | 92.72 | -0.34 | 3.89 |
| Acrylic | 94.69 | -0.27 | 2.98 |
| Methyl Methacrylate Styrene (MS) | 94.51 | -0.29 | 2.89 |
| Transparent Acrylonitrile Butadiene Styrene (TABS) | 92.57 | -0.67 | 8.42 |
| Glass | 94.30 | -1.35 | 2.97 |

# Protocols — Clarity (color, haze, transmittance)

Three (3) 4"x 4"x ⅛" plaques of each material were evaluated for percent haze and percent transmittance per ASTM D1003, Procedure B.

**Instrument:** X-Rite Color i7

**Illuminant:** C

**Observer:** 2°

In addition, the L*, a*, b* color space coordinates were determined for each plaque sample.

Instrument: X-Rite Color i7

Illuminant: D65

Observer: 10°

Return to Clarity main page.

# Measuring the toughness that impacts user satisfaction

Experience tells customers that polymers and glass offer a wide range of impact and shatter resistance. Third-party testing applied scientific methods to analyzing the performance of mug samples dropped onto their base and onto their rim.

For more information about the methods used to test drop impact, see **Drop Impact Protocols** at the end of this section.

## Results of drop impact test onto rim of mug

| Drop # | Eastman Tritan™ Copolyester TX1001 | | | Eastman Tritan™ Copolyester TX1501HF | | | Eastman Tritan™ Copolyester TX2001 | | | Polycarbonate | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Sample 1 | Sample 2 | Sample 3 | Sample 1 | Sample 2 | Sample 3 | Sample 1 | Sample 2 | Sample 3 | Sample 1 | Sample 2 | Sample 3 |
| 1 | No change | No change | No change | No change | No change | No change | No change | No change | No change | No change | No change | No change |
| 2 | No change | No change | No change | No change | No change | No change | No change | No change | No change | No change | No change | No change |
| 3 | No change | No change | No change | No change | Mark on handle corner | No change | No change | No change | No change | No change | No change | No change |
| 4 | No change | No change | No change | No change | No change | No change | No change | No change | No change | No change | No change | No change |
| 5 | No change | No change | No change | No change | No change | No change | No change | No change | No change | No change | No change | No change |
| 6 | No change | No change | No change | No change | No change | No change | No change | No change | Mark on handle corner | No change | No change | No change |
| 7 | No change | No change | No change | No change | No change | No change | No change | No change | No change | No change | No change | No change |
| 8 | Mark on handle | No change | No change | No change | No change | No change | No change | No change | No change | No change | No change | No change |
| 9 | No change | No change | No change | No change | No change | No change | No change | No change | No change | No change | No change | No change |
| 10 | No change | No change | No change | No change | No change | No change | No change | No change | No change | No change | No change | No change |

## Drop impact test onto rim of mug

| Drop # | Clarified Polypropylene | | | Styrene Acrylonitrile (SAN) | | | Methyl Methacrylate Butadiene Styrene (MBS) | | | Acrylic | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Sample 1 | Sample 2 | Sample 3 | Sample 1 | Sample 2 | Sample 3 | Sample 1 | Sample 2 | Sample 3 | Sample 1 | Sample 2 | Sample 3 |
| 1 | No change | No change | No change | No change | Chipped handle | No change | No change | No change | No change | No change | Chipped handle | No change |
| 2 | No change | No change | No change | Chipped handle | No change | Crazing on top | No change | No change | No change | No change | No change | No change |
| 3 | No change | No change | No change | Large crack | No change | Large crack | No change | No change | No change | No change | No change | No change |
| 4 | No change | No change | No change | Not tested | No change | Not tested | No change | No change | No change | Chipped handle | No change | No change |
| 5 | Mark on top | No change | Mark on top | Not tested | No change | Not tested | No change | No change | No change | No change | No change | No change |
| 6 | No change | No change | No change | Not tested | No change | Not tested | No change | No change | No change | No change | No change | No change |
| 7 | No change | No change | No change | Not tested | No change | Not tested | No change | No change | Mark on handle | Large crack | No change | No change |
| 8 | No change | No change | No change | Not tested | No change | Not tested | No change | Mark on handle | No change | Not tested | Chipped top | Broke handle |
| 9 | No change | No change | No change | Not tested | No change | Not tested | No change | No change | No change | Not tested | No change | Not tested |
| 10 | No change | No change | No change | Not tested | Crazing | Not tested | No change | No change | No change | Not tested | No change | Not tested |

## Drop impact test onto rim of mug

| Drop # | Methyl Methacrylate Styrene (MS) | | | Transparent Acrylonitrile Butadiene Styrene (TABS) | | | Glass | | |
|---|---|---|---|---|---|---|---|---|---|
| | Sample 1 | Sample 2 | Sample 3 | Sample 1 | Sample 2 | Sample 3 | Sample 1 | Sample 2 | Sample 3 |
| 1 | No change | No change | No change | No change | No change | No change | No change | No change | No change |
| 2 | No change | No change | No change | No change | No change | No change | No change | No change | Mug shattered |
| 3 | No change | No change | No change | No change | No change | No change | No change | No change | Not tested |
| 4 | No change | No change | No change | No change | No change | No change | No change | No change | Not tested |
| 5 | No change | No change | No change | No change | No change | No change | No change | No change | Not tested |
| 6 | No change | Large crack | Damage on top | No change | No change | No change | No change | No change | Not tested |
| 7 | No change | No change | No change | No change | No change | No change | No change | No change | Not tested |
| 8 | No change | No change | Chipped top | No change | No change | No change | No change | No change | Not tested |
| 9 | No change | No change | No change | No change | No change | No change | No change | No change | Not tested |
| 10 | No change | No change | No change | Mark on handle corner | No change | No change | No change | No change | Not tested |

## Results of drop impact test onto base of mug

| Drop # | Eastman Tritan™ Copolyester TX1001 | | | Eastman Tritan™ Copolyester TX1501HF | | | Eastman Tritan™ Copolyester TX2001 | | | Polycarbonate | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Sample 1 | Sample 2 | Sample 3 | Sample 1 | Sample 2 | Sample 3 | Sample 1 | Sample 2 | Sample 3 | Sample 1 | Sample 2 | Sample 3 |
| 1 | No change | No change | No change | No change | No change | No change | No change | No change | No change | No change | No change | No change |
| 2 | No change | No change | No change | No change | No change | No change | No change | No change | No change | No change | No change | No change |
| 3 | No change | No change | No change | No change | No change | No change | No change | No change | No change | No change | Mark on bottom | No change |
| 4 | No change | No change | No change | No change | No change | No change | No change | No change | No change | No change | No change | No change |
| 5 | No change | No change | No change | No change | No change | No change | No change | No change | No change | No change | No change | No change |
| 6 | No change | No change | No change | No change | No change | No change | Mark on bottom | No change | No change | Mark on bottom | No change | No change |
| 7 | No change | No change | No change | No change | No change | No change | No change | No change | No change | No change | No change | No change |
| 8 | No change | No change | No change | No change | No change | No change | No change | No change | No change | Mark on bottom | No change | No change |
| 9 | No change | No change | No change | No change | No change | No change | No change | No change | No change | No change | No change | No change |
| 10 | No change | No change | No change | No change | No change | No change | No change | No change | No change | No change | No change | No change |

## Drop impact test onto base of mug

| Drop # | Clarified Polypropylene | | | Styrene Acrylonitrile (SAN) | | | Methyl Methacrylate Butadiene Styrene (MBS) | | | Acrylic | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Sample 1 | Sample 2 | Sample 3 | Sample 1 | Sample 2 | Sample 3 | Sample 1 | Sample 2 | Sample 3 | Sample 1 | Sample 2 | Sample 3 |
| 1 | No change | No change | No change | No change | No change | No change | No change | No change | No change | No change | No change | No change |
| 2 | No change | No change | No change | No change | No change | No change | No change | Mark on bottom | No change | No change | No change | No change |
| 3 | No change | No change | No change | No change | No change | Chip on bottom | No change | No change | No change | No change | No change | No change |
| 4 | No change | No change | No change | No change | Chip on bottom | No change | Mark on bottom | No change | No change | No change | No change | No change |
| 5 | No change | No change | No change | No change | No change | No change | No change | No change | No change | No change | No change | No change |
| 6 | No change | No change | No change | No change | No change | No change | Mark on bottom | No change | No change | No change | No change | No change |
| 7 | No change | No change | No change | No change | No change | No change | Mark on bottom | No change | Bottom damage | No change | No change | No change |
| 8 | No change | No change | No change | Chip on bottom | No change | No change | No change | No change | No change | No change | No change | Chipped bottom |
| 9 | No change | No change | No change | No change | No change | No change | No change | No change | No change | No change | No change | No change |
| 10 | No change | No change | No change | No change | No change | No change | No change | No change | No change | No change | Chipped bottom | No change |

## Drop impact test onto base of mug

| Drop # | Methyl Methacrylate Styrene (MS) | | | Transparent Acrylonitrile Butadiene Styrene (TABS) | | | Glass | | |
|---|---|---|---|---|---|---|---|---|---|
| | Sample 1 | Sample 2 | Sample 3 | Sample 1 | Sample 2 | Sample 3 | Sample 1 | Sample 2 | Sample 3 |
| 1 | Chipped bottom | No change | No change | No change | No change | No change | No change | No change | No change |
| 2 | No change | No change | No change | No change | No change | No change | No change | No change | No change |
| 3 | No change | Mark on bottom | No change | No change | No change | No change | No change | No change | No change |
| 4 | Mark on bottom | Mark on bottom | No change | No change | No change | No change | No change | No change | No change |
| 5 | No change | No change | Mark on bottom | No change | No change | No change | No change | No change | No change |
| 6 | No change | No change | No change | No change | No change | No change | No change | No change | No change |
| 7 | No change | No change | No change | No change | No change | No change | No change | No change | No change |
| 8 | Chipped bottom | No change | No change | No change | No change | No change | No change | No change | No change |
| 9 | No change | No change | No change | No change | No change | No change | No change | No change | No change |
| 10 | No change | No change | Mark on bottom | No change | No change | No change | No change | No change | No change |

# Protocols — Drop impact (toughness)

Three (3) samples of each material were subjected to a Drop Impact test as follows:

1. The sample was photographed prior to testing.
2. The sample was filled with a sandbag weighing 3691.2 g (0.862 lbs.) — equivalent to the mug filled with liquid.
3. The sample was dropped onto its base from a height of 48" onto a flat surface of vinyl over concrete.
4. The sample was dropped 10 times or until failure occurred, whichever occurred first.
5. After each drop, the sample was analyzed for damage. Any damage observed was photographed.
6. If no failure occurred when the sample was dropped onto its base, the sample was dropped onto its rim, empty, 10 times or until failure occurred, whichever occurred first.

Return to **Drop Impact** main page.

# Testing for weight and consistency

A molded housewares item has a higher perceived value for the consumer — and greater value for the manufacturer — if it has a robust mass and dimensional uniformity.

Third-party testing measured test samples to evaluate length, width and thickness of plaques and the mass of plaques and mugs.

For complete information about how mass testing was conducted, see **Mass Protocols** at the end of this section.

## Mass test results

| Material | Measurement Unit | Average |
|---|---|---|
| Eastman Tritan™ copolyester TX1001 | Length (in) | 3.971 |
| | Width (in) | 3.974 |
| | Thickness (in) | 0.125 |
| | Mass (g) | 38.0 |
| | Mug Mass (g) | 184.7 |
| Eastman Tritan™ copolyester TX1501HF | Length (in) | 3.976 |
| | Width (in) | 3.980 |
| | Thickness (in) | 0.125 |
| | Mass (g) | 38.5 |
| | Mug Mass (g) | 185.3 |
| Eastman Tritan™ copolyester TX2001 | Length (in) | 3.968 |
| | Width (in) | 3.974 |
| | Thickness (in) | 0.125 |
| | Mass (g) | 37.8 |
| | Mug Mass (g) | 182.5 |
| Polycarbonate | Length (in) | 3.967 |
| | Width (in) | 3.973 |
| | Thickness (in) | 0.125 |
| | Mass (g) | 38.8 |
| | Mug Mass (g) | 185.3 |

| Material | Measurement Unit | Average |
|---|---|---|
| Clarified Polypropylene | Length (in) | 3.921 |
| | Width (in) | 3.926 |
| | Thickness (in) | 0.123 |
| | Mass (g) | 28.1 |
| | Mug Mass (g) | 135.4 |
| Styrene Acrylonitrile (SAN) | Length (in) | 3.980 |
| | Width (in) | 3.984 |
| | Thickness (in) | 0.127 |
| | Mass (g) | 34.9 |
| | Mug Mass (g) | 166.9 |
| Methyl Methacrylate Butadiene Styrene (MBS) | Length (in) | 3.981 |
| | Width (in) | 3.987 |
| | Thickness (in) | 0.126 |
| | Mass (g) | 34.7 |
| | Mug Mass (g) | 161.8 |
| Acrylic | Length (in) | 3.974 |
| | Width (in) | 3.979 |
| | Thickness (in) | 0.125 |
| | Mass (g) | 38.4 |
| | Mug Mass (g) | 182.1 |

## Mass test results (continued)

| Material | Measurement Unit | Average |
|---|---|---|
| Methyl Methacrylate Styrene (MS) | Length (in) | 3.977 |
| | Width (in) | 3.982 |
| | Thickness (in) | 0.125 |
| | Mass (g) | 34.9 |
| | Mug Mass (g) | 166.6 |
| Transparent Acrylonitrile Butadiene Styrene (TABS) | Length (in) | 3.965 |
| | Width (in) | 3.967 |
| | Thickness (in) | 0.124 |
| | Mass (g) | 34.5 |
| | Mug Mass (g) | 165.9 |
| Glass | Length (in) | 4.017 |
| | Width (in) | 4.012 |
| | Thickness (in) | 0.088 |
| | Mass (g) | 57.8 |
| | Mug Mass (g) | 640.1 |

# Protocols — Mass (heaviness)

For each material evaluated, three (3) 4"x 4"x ⅛" plaques and three (3) mugs were evaluated as follows:

1. The length, width and thickness of each plaque was measured and recorded.
2. The mass of each plaque and mug was measured and recorded.

Return to **Mass** main page.

# Third-party laboratory information and test background

An independent third-party laboratory (Bureau Veritas Consumer Product Services, Inc.) was contracted to apply scientific methods and provide accurate results for a comparative analysis of durables food contact materials.

Mugs were injection-molded from each test polymer for all tests except clarity, mass and acoustics. Glass samples were purchased to be similar in shape, thickness and quality. Clarity testing utilized a 4" x 4" x ⅛" plaque of each material.

**Materials tested:**

Three formulations of Eastman Tritan™ copolyester
- Tritan copolyester TX1001
- Tritan copolyester TX1501HF
- Tritan copolyester TX2001

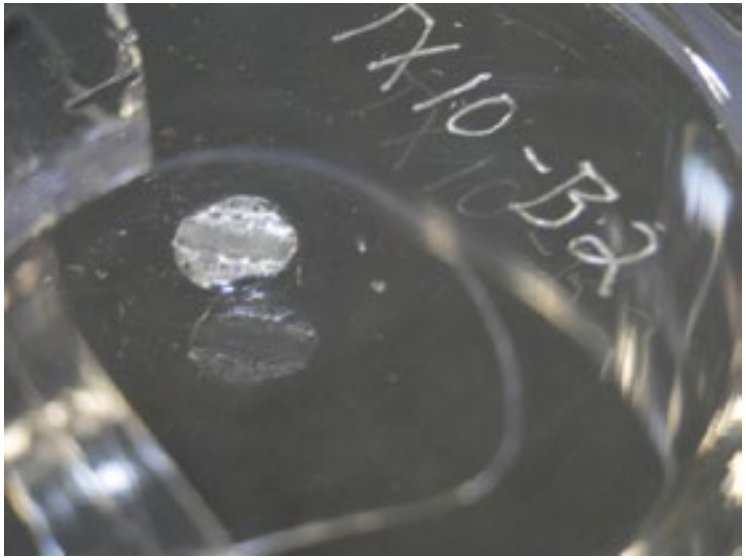
Polycarbonate
Clarified Polypropylene
Styrene Acrylonitrile (SAN)
Methyl Methacrylate Butadiene Styrene (MBS)
Acrylic
Methyl Methacrylate Styrene (MS)
Transparent Acrylonitrile Butadiene Styrene (TABS) Glass

# Appendix—Testing Photos

As part of the third-party testing, the research laboratory (Bureau Veritas Consumer Product Services, Inc.) photographed test results, including deformities and failures. Here are representative photos, aligned with the sections listed in the bottom navigation.

# Residential dishwasher durability

## Eastman Tritan™ copolyester TX1001




After 10 cycles, three of six samples exhibited mild bubbling.
No other deformities observed through 125 cycles.

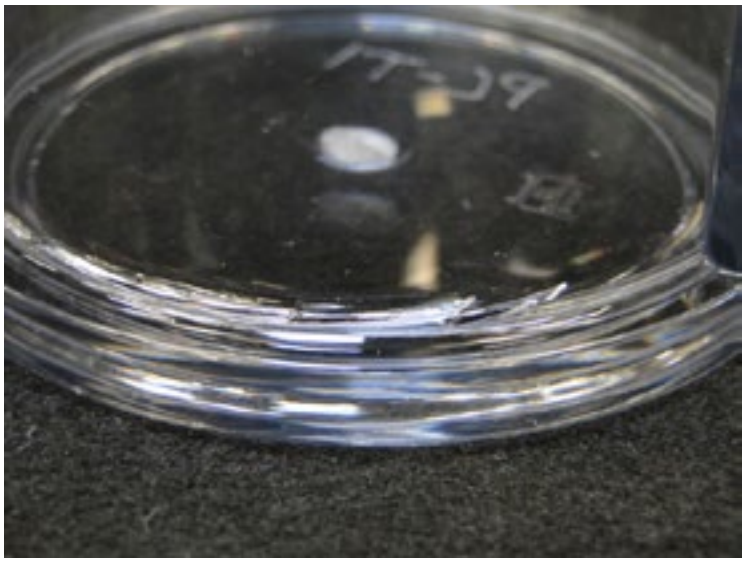
## Eastman Tritan™ copolyester TX1501HF

No damage or deformities observed through 125 cycles.

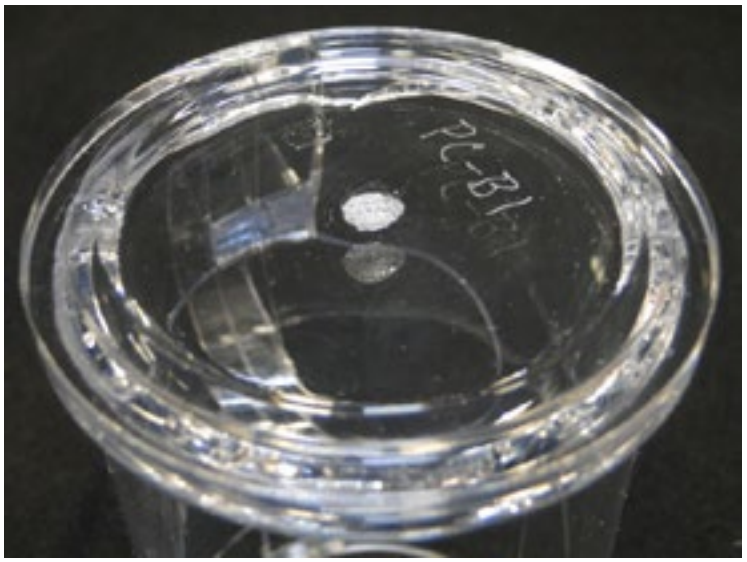
## Eastman Tritan™ copolyester TX2001

No damage or deformities observed through 125 cycles.

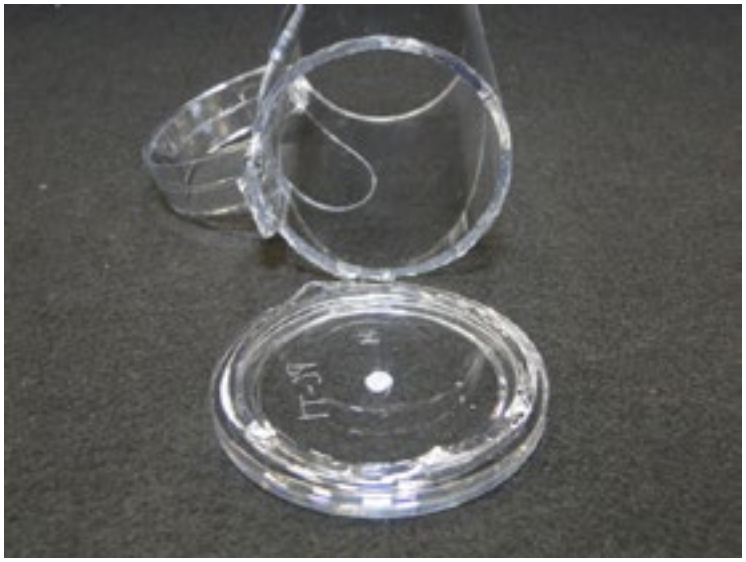
## Polycarbonate



Typical crazing in all samples at 10 cycles.



Crazing in all samples at 25 cycles; cracking in one sample.



After 50 cycles three of six samples failed.

After 75 cycles, another sample failed.

*continued from previous page*

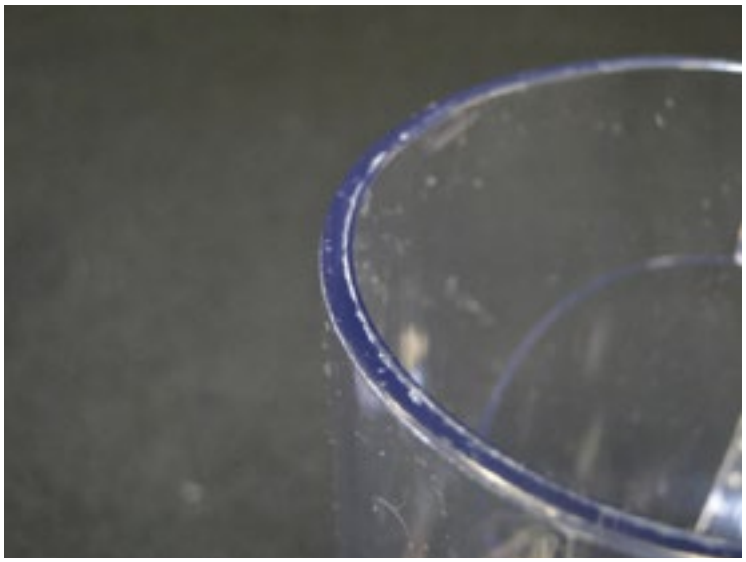
## Polycarbonate

Final two samples failed with cracking after 100 cycles.

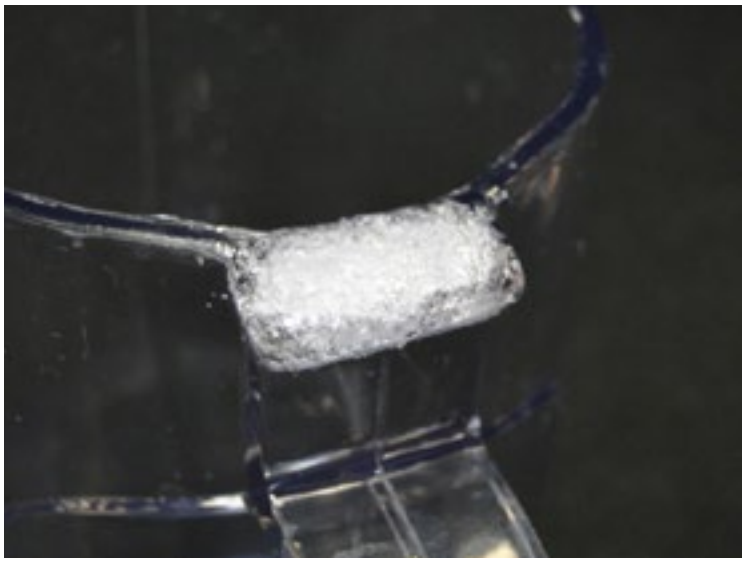
## Clarified Polypropylene

Final two samples failed with deformation after 100 cycles.

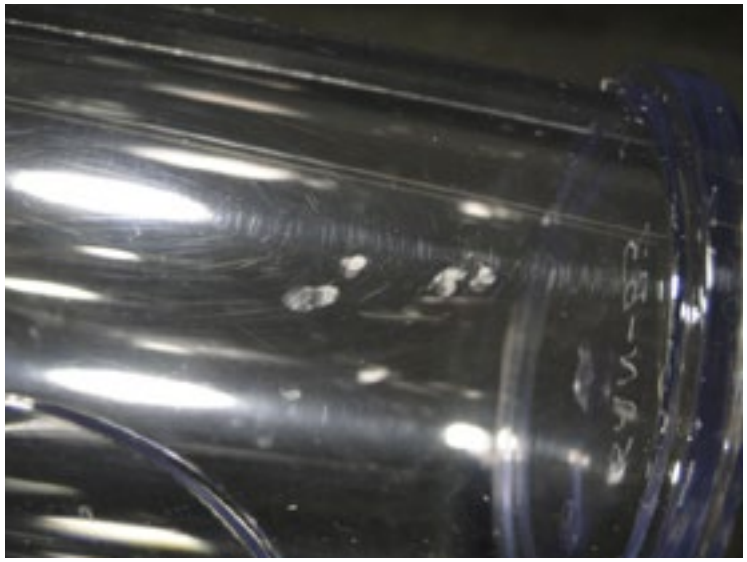
## Styrene Acrylonitrile (SAN)



Typical crazing observed on two samples after 25 cycles.

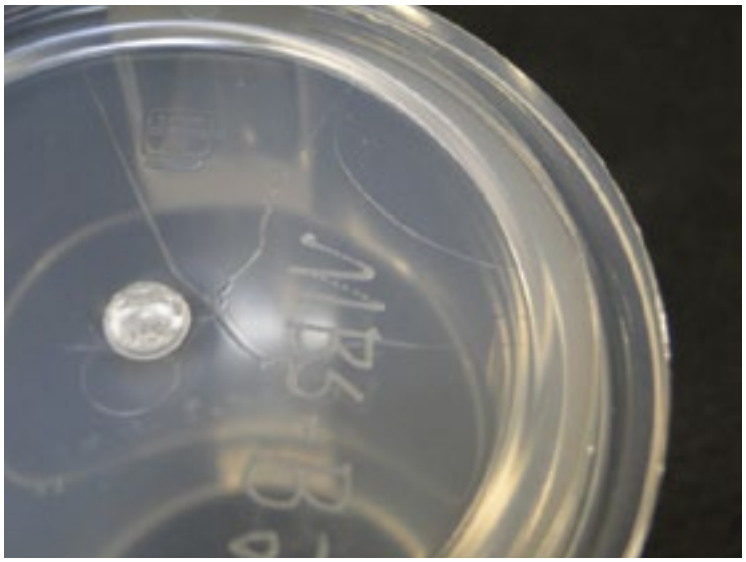


Handle deformation observed on one sample after 50 cycles.



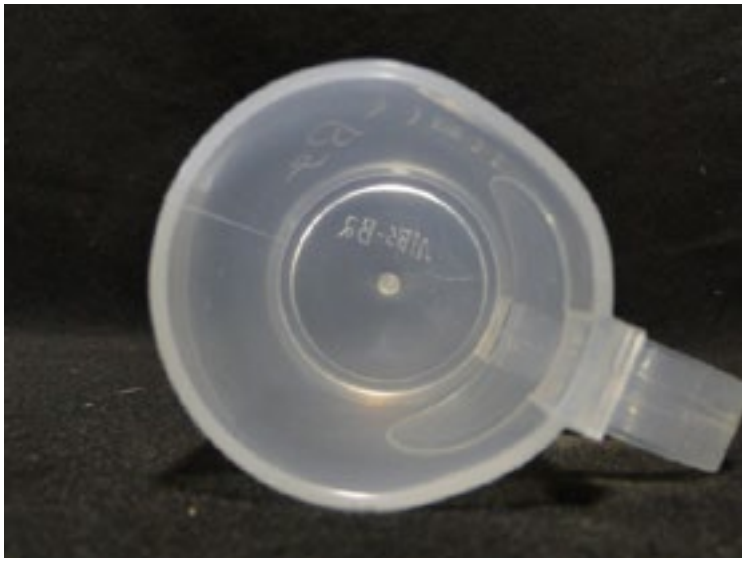
Typical crazing, scratching, and scuffing found on some samples after 75 cycles.

## Methyl Methacrylate Butadiene Styrene (MBS)



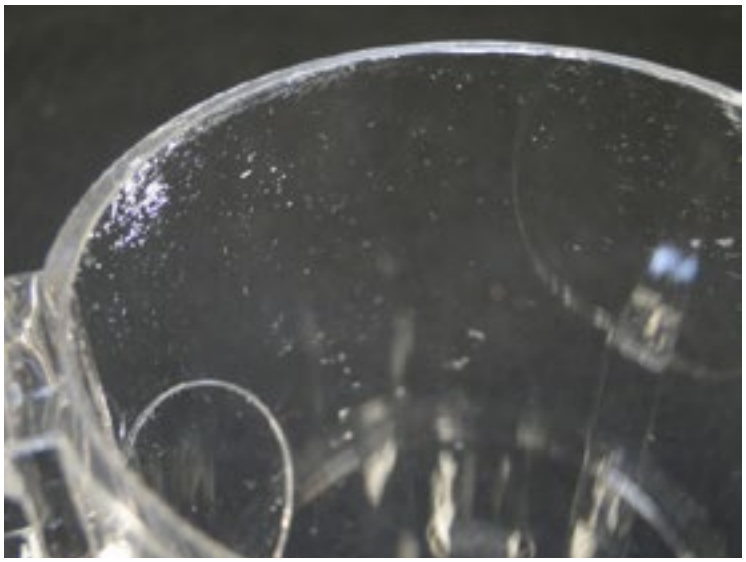
Scratching observed on one sample after 10 cycles.

Deformation observed on bottom-rack sample after 50 cycles.

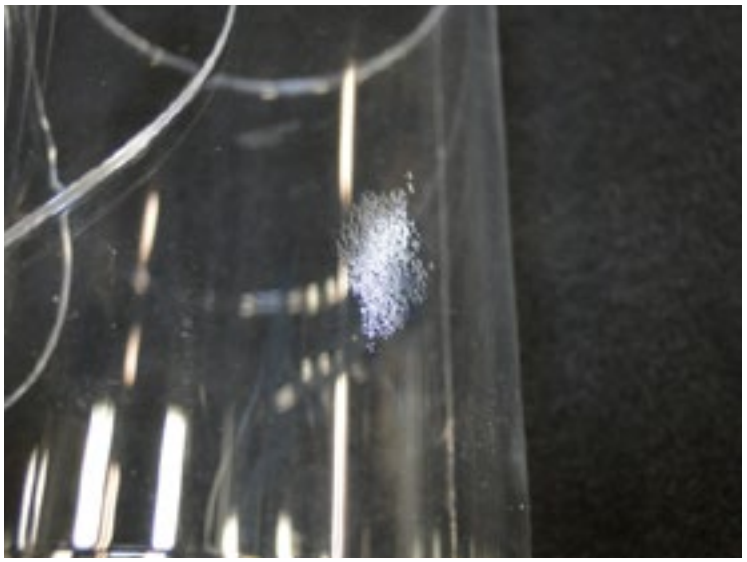


Deformation observed on two more bottom-rack samples after 75 cycles.

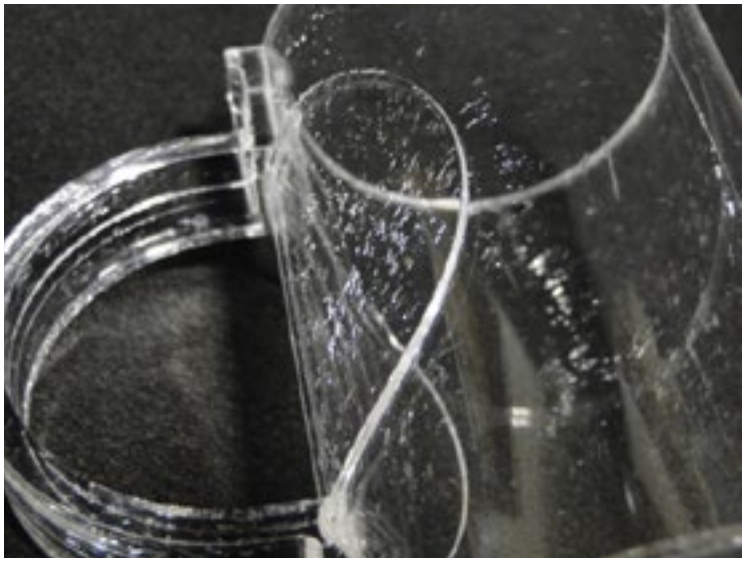
## Acrylic



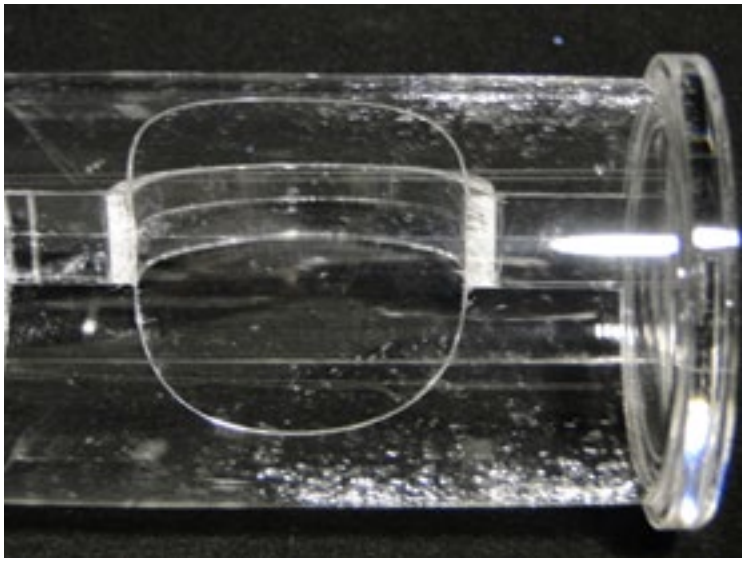
After 25 cycles, crazing was observed on two top-rack samples.



After 50 cycles, crazing was observed on several bottom- and top-rack samples.



After 75 cycles, crazing was observed on all six samples.



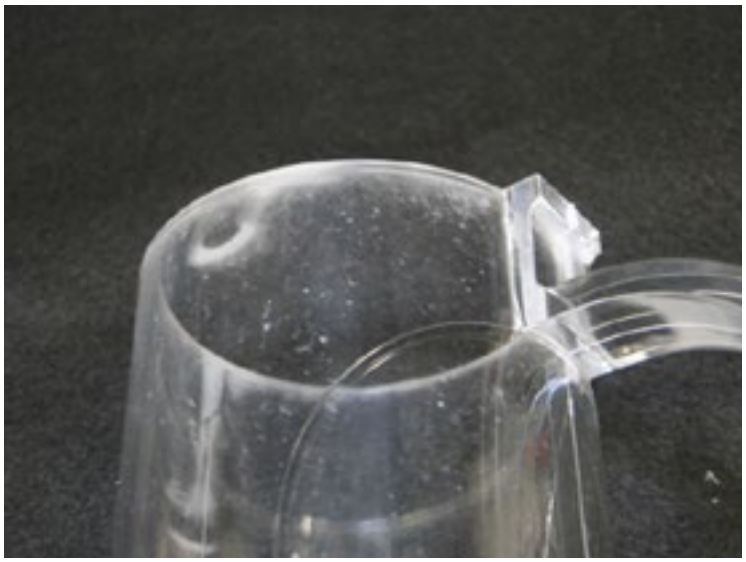
Typical progression of crazing after 100 cycles.

*continued from previous page*

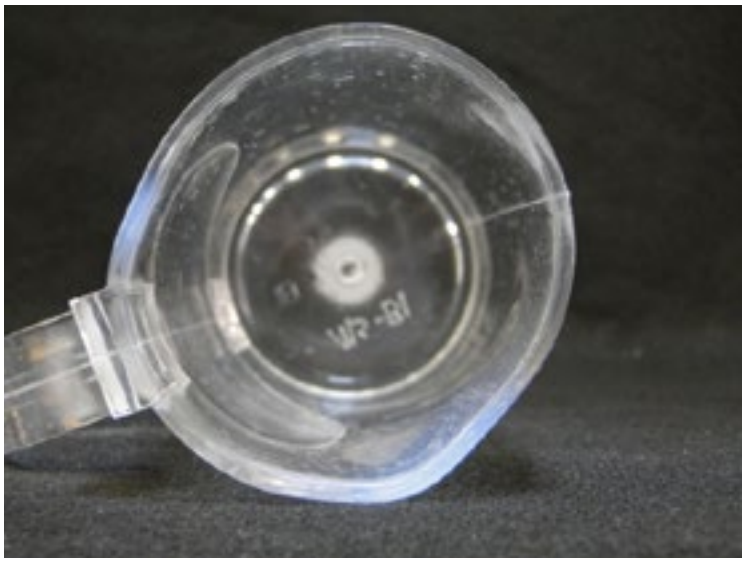
## Acrylic

Typical progression of crazing after 125 cycles.

## Methyl Methacrylate Styrene (MS)

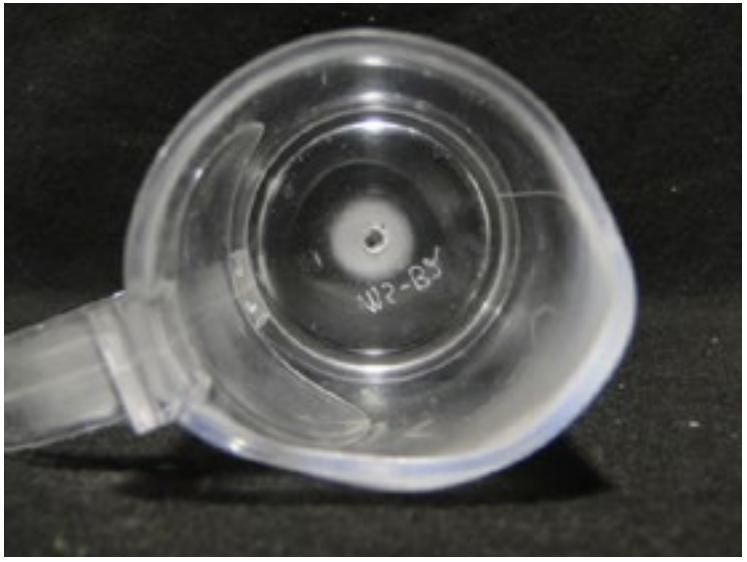


Hazing was observed in three of six samples after 10 cycles.



Hazing in four of six samples and deformation observed in a bottom-rack sample after 25 cycles.

Hazing and deformation worsened in many samples after 50 cycles



Increased deformation observed in many samples after 75 cycles.

*continued from previous page*

## Methyl Methacrylate Styrene (MS)

Increased deformation observed in all samples
after 100 and 125 cycles.

## Transparent Acrylonitrile Butadiene Styrene (TABS)

No damage or deformities observed through 75 cycles.

## Glass

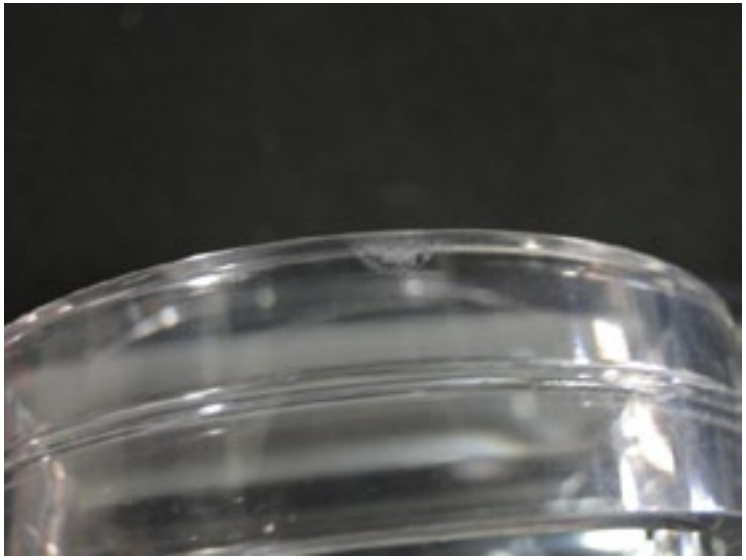
No damage or deformities observed through 125 cycles.

# Staining (microwavability)

| Material | Average Rating (1 to 5; 5=best) | Before/After |
|---|---|---|
| Eastman Tritan™ copolyester TX1001 | 4 | (51140770001r, Fig E3 and E7) |
| Eastman Tritan copolyester TX1501HF | 4 | (51140770001r, Fig E7 and E8) |
| Eastman Tritan copolyester TX2001 | 4 | (51140770001r, Fig E11 and E12) |
| Polycarbonate | 5 | (51140770001r, Fig E15 and E16) |
| Clarified Polypropylene | 2 | (51141040039r, Fig E15 and E16) |
| Styrene Acrylonitrile (SAN) | 5 | (51141040043r, Fig E3 and E14 or E15 and E16) |
| Methyl Methacrylate Butadiene Styrene (MBS) | 1 | (51141040047r, Fig E13 and E14 or E15 and E16) |
| Acrylic | 5 | (51141040046r Part 1, Fig E11 and E12) |
| Methyl Methacrylaate Styrene (MS) | 1.7 | (51141040047r;,Fig E15 and E16) |
| Transparent Acrylonitrile Butadiene Styrene (TABS) | 3.7 | (51141040049r, Figures not available in source received) |
| Glass | 5 | (51141040050r, Figures E3 and E4) |

# Drop impact test (toughness)

## Eastman Tritan™ copolyester TX1001

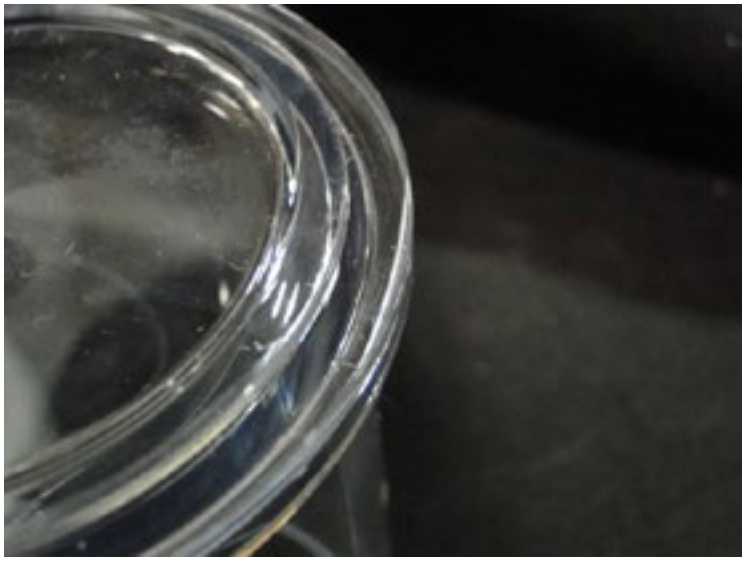


Mark on handle observed on one sample after eighth drop onto its rim.

## Eastman Tritan™ copolyester TX1501HF

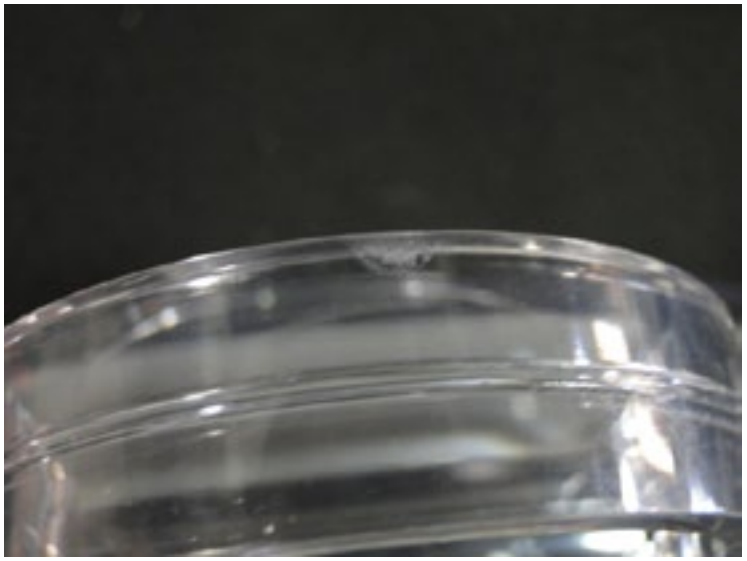
Mark on corner of handle observed after third drop onto its rim.

## Eastman Tritan™ copolyester TX2001



Mark on corner of handle observed after sixth drop onto its base.

## Polycarbonate

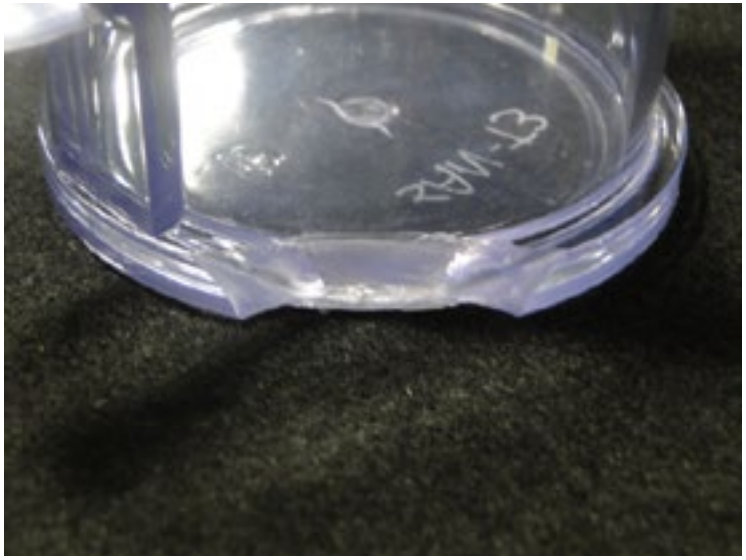


Mark on bottom observed after third drop onto its base.

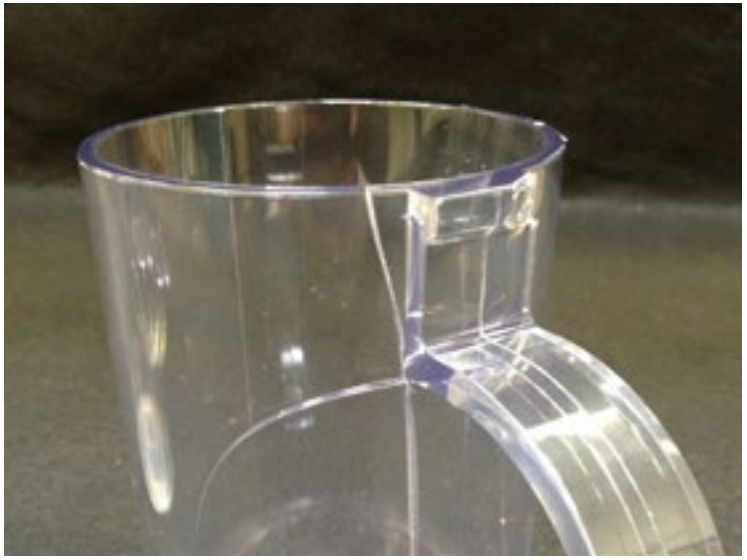
## Clarified Polypropylene

No drop impact photos presented

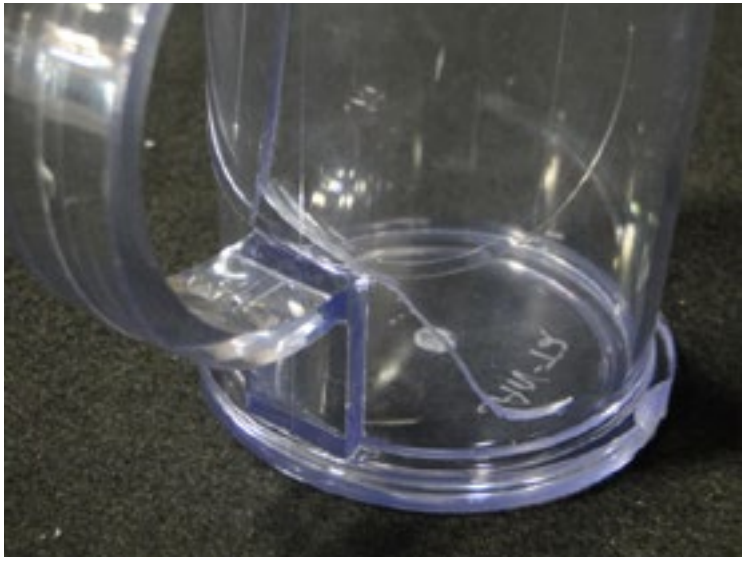
## Styrene Acrylonitrile (SAN)



Chipping observed after tenth drop onto its base.



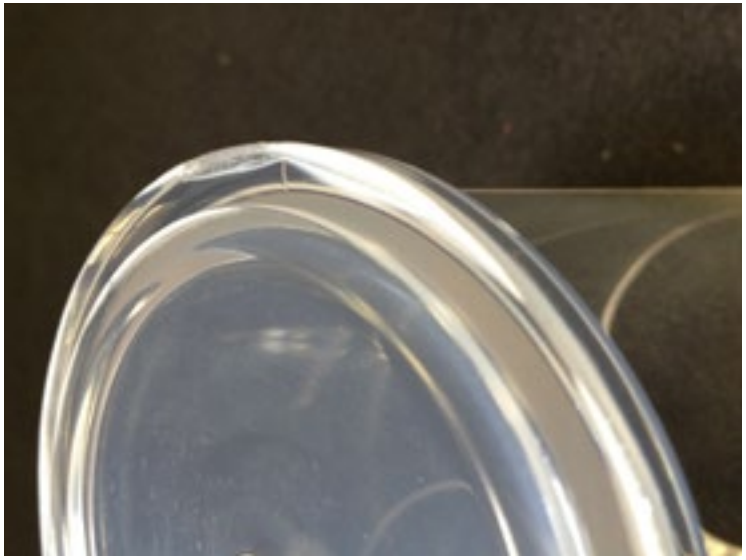
Typical large crack after third drop onto its rim.



Crack observed after tenth drop onto its rim.

Fracture observed in bottom-rack sample
after ninth drop onto its rim.

## Methyl Methacrylate Butadiene Styrene (MBS)

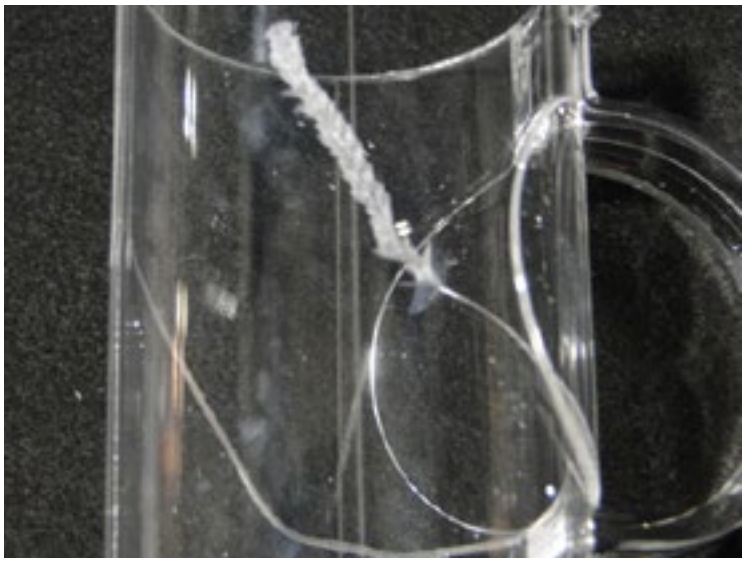


Example of mark on bottom observed on one sample after fourth drop onto its base.

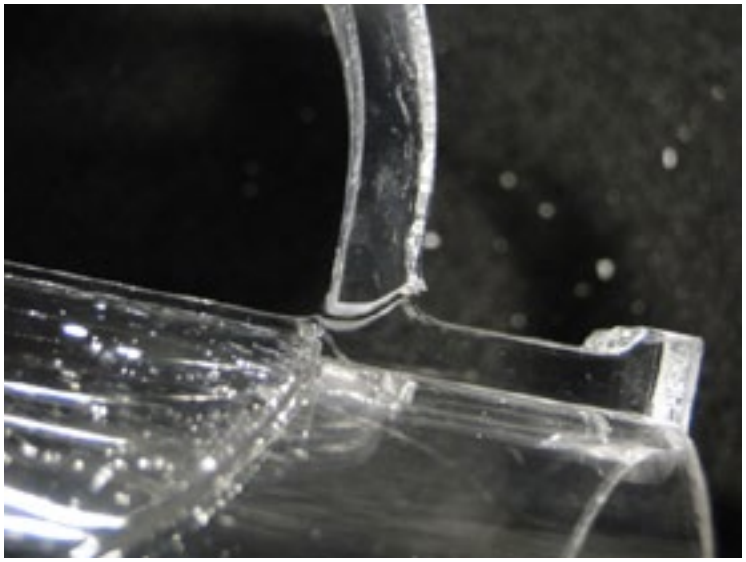
Damage on rim observed on one sample after being dropped onto its base.

## Acrylic

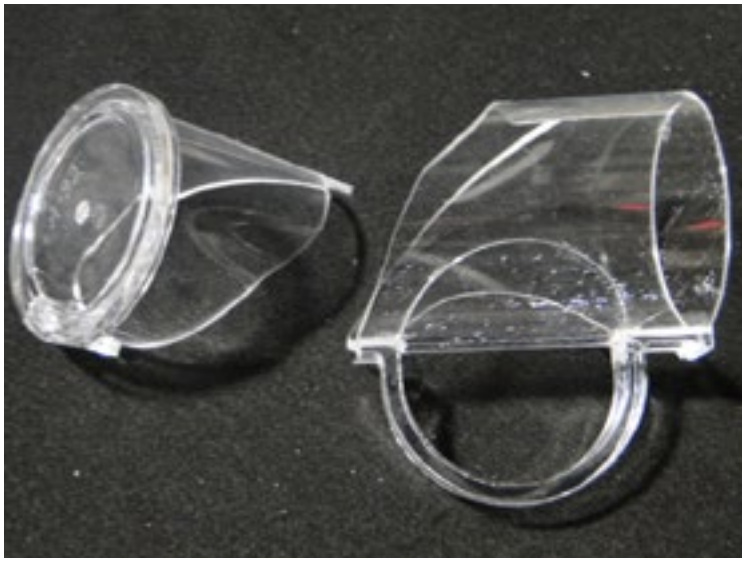
Example of chipping after tenth drop onto its base.



Example of cracking of top-rack sample after second drop onto its base.



Example of broken handle of bottom-rack sample after fourth drop onto its base.



Example of broken handle of bottom-rack sample after ninth drop onto its base.

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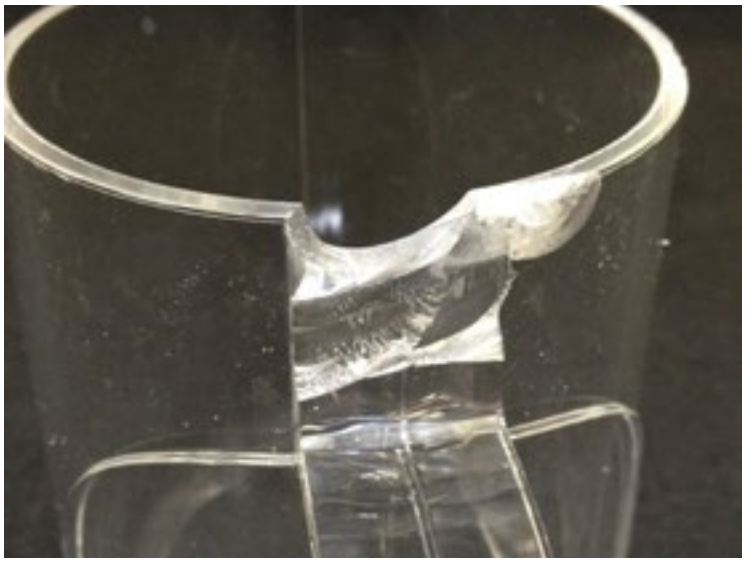
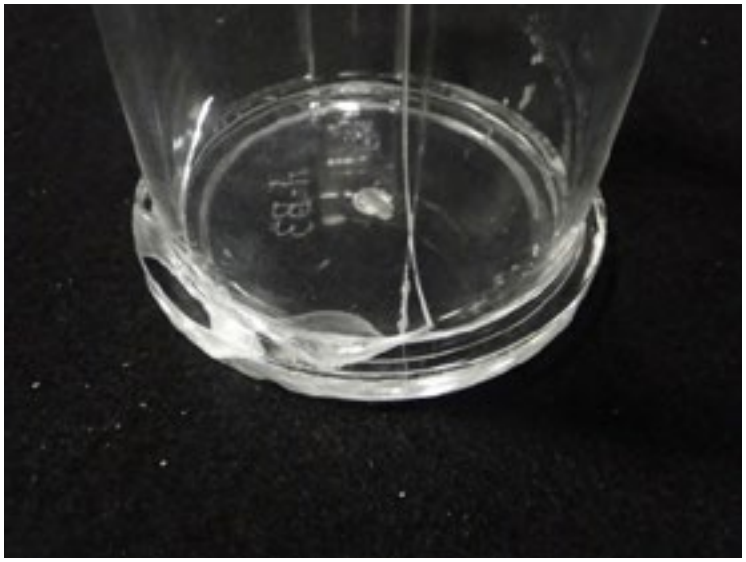
## Acrylic

Example of broken handle of bottom-rack sample after first drop onto its rim.

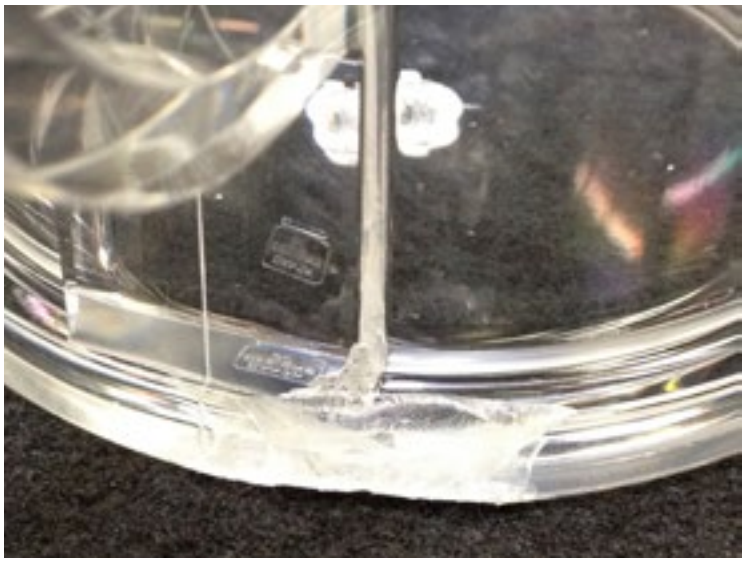


Example of large chip/broken handle after eighth drop onto its rim.

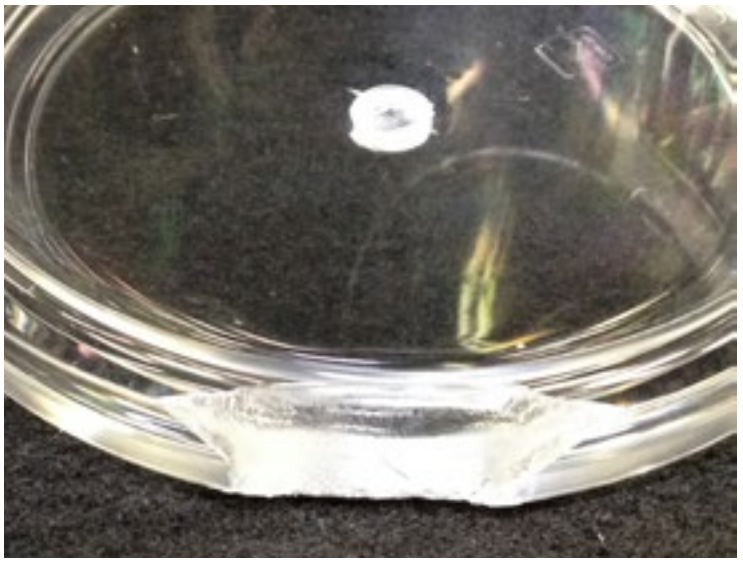


Example of large crack after fifth drop onto its rim.

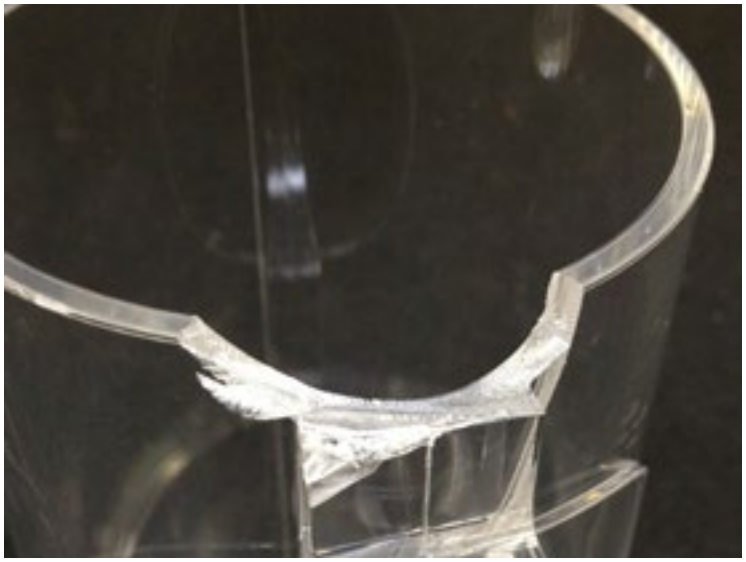
# Methyl Methacrylate Styrene (MS)



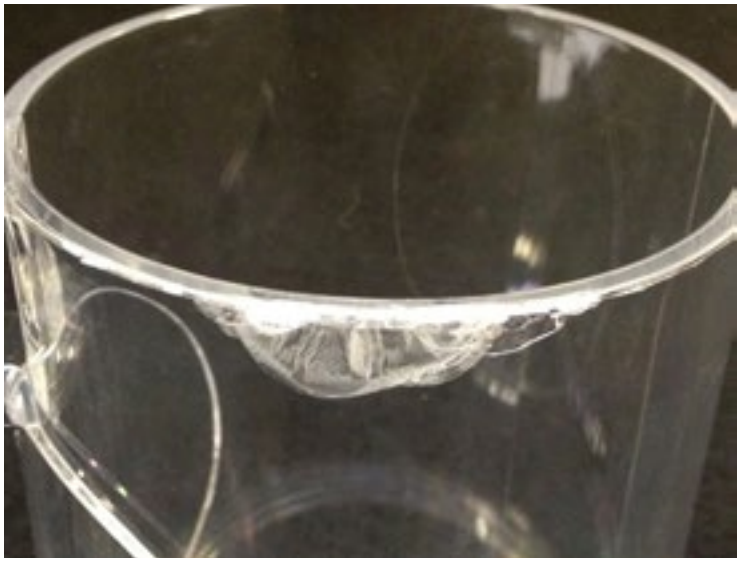
Example of chipping after first drop onto its base.



Example of chipping after eighth drop onto base.



Example of chipping after eighth drop onto its rim.

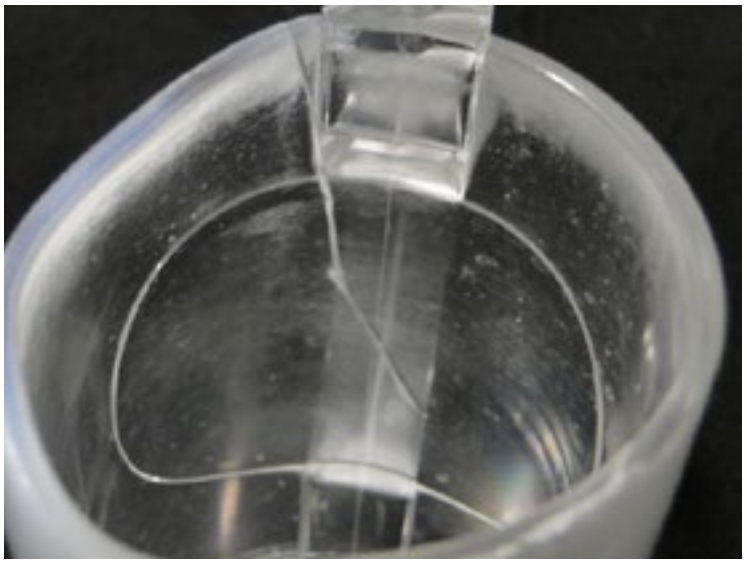


Example of cracking after eighth drop onto its rim.

*continued from previous page*

## Methyl Methacrylate Styrene (MS)

Example of deformed example after 125 dishwashing cycles and eight drops onto its rim.



Example of deformed example after 125 dishwashing cycles and five drops onto its rim.

## Transparent Acrylonitrile Butadiene Styrene (TABS)

No drop impact photos presented

## Glass

Three samples shattered after first drop onto its rim after 125 cycles.

Two more samples shattered after fourth and fifth drop onto its rim after 125 cycles.

For more information on any of these tests, please contact Karen Parsons at 1.423.229.3669.

For more information about how Eastman Tritan™ copolyester stands up to real-world testing, visit TritanTough.com.