Abrasion Resistant VueGuard® Coatings for Tritan

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Introduction

- Dr. Paul Fenelon of Cailis LLC is evaluating Tritan® for scratch resistant beer glass applications.
- It is a requirement for Tritan® to be modified with a scratch resistant, dishwasher safe coating on the outside. FDA approval is not a requirement for the coating.
- VueGuard® 801 and VueGuard® 901 coatings from PCI Labs were selected as candidates to imprve the scratch resistance of Tritan.
- The VueGuard coatings were manually sprayed onto 2”x2”plaques of Tritan® TX1001 and TX2001.
- Coated plaques were tested for instrumented drop impact, abrasion, and dishwasher resistance.
- Contact information for Cailis:

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VueGuard Coatings

- VueGuard 801® and VueGuard 901® coating treatments offer superior resistance to scratching and abrasion for plastic sheets and molded articles,. VueGuard 801® has originally been designed primarily for acrylic (polymethylmethacrylate) and polycarbonate substrates.
- Links to VueGuard® Coatings from PCI Labs:
  - VueGuard 801®
  - VueGuard 901®
- Contact information:

Performance Coatings International Labs, LLC
600 S Murray St.
Bangor, PA 18013
610 588 7900 x 24
610 588 7901 fax
www.pcilabsllc.com

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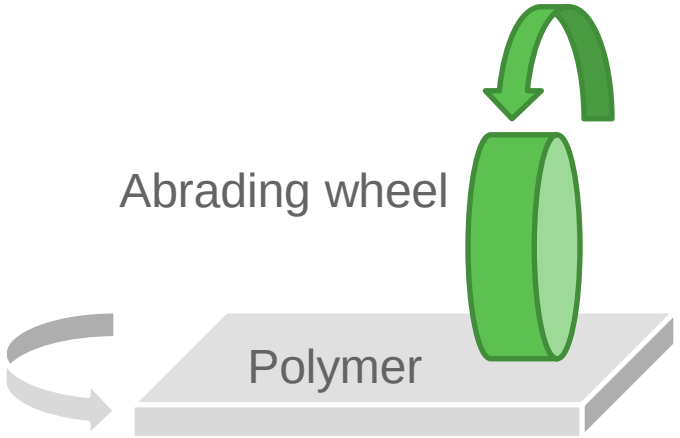
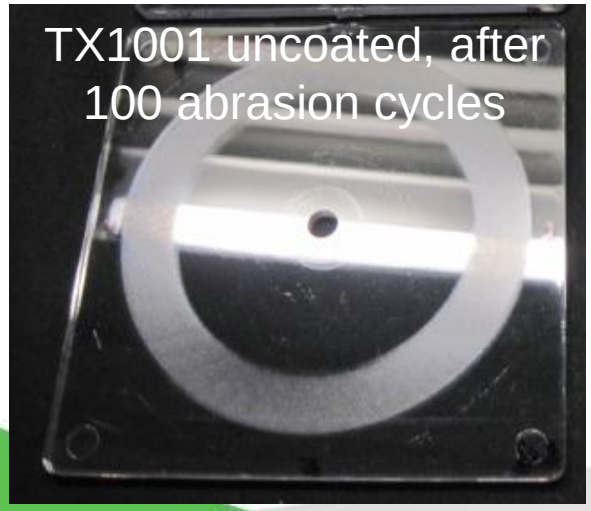
Coating Application

- Both VueGuard® 801 and 901 are solvent based, UV cured acrylic coatings.
- VueGuard 801 commonly has better pencil hardness and steel wool rating, but can appear inferior to VueGuard 901 in the taber abrasion testing.
- Samples reside in a convection oven held at 40-50^{o}C for 2-3 minutes before being sprayed by the coating, and are UV cured with a medium pressure mercury lap at 1200 mJ/cm^2 (300 W/in) energy density for 2-3 seconds.
- Coatings were manually sprayed on the Tritan substrates at 5 μm thickness in this trial. Coatings were observed to have good adhesion to Tritan, and would not be expected to give brittle failure in drop impact due to the coating thickness used, which is sufficient for this application.
- Industrial coating process adapted by PCI Labs employs a conveyor belt which directs flat parts through a convection oven, spray coating process, and the UV cure cycle.
- For cylindrical part geometry, the part would need to be rotated by a robotic arm during spraying and curing stage, which could potentially be handled at an externally contracted facility.

Taber Abrasion Testing





4” x 4” x 0.150” Tritan plaques were used with CS-10F wheels.

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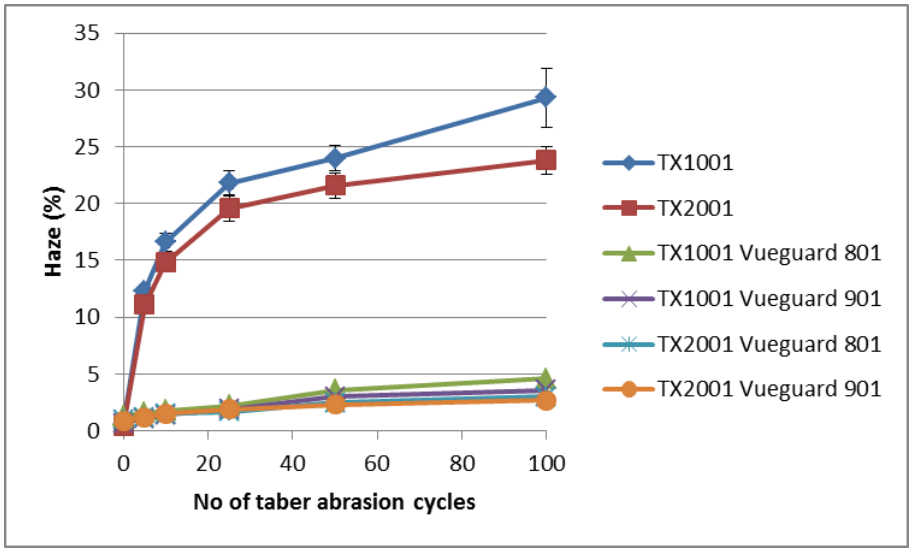
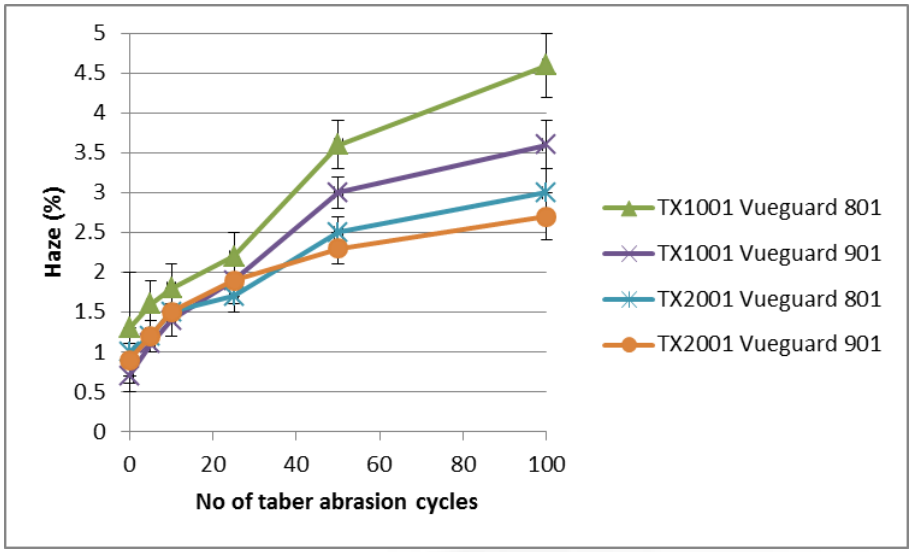
Abrasion Resistance with and without coating

- TX2001 is slightly more resistant to abrasion than TX1001.
- VueGuard ® coatings significantly improve the abrasion resistance of both TX1001 and TX2001.
- VueGuard ® 901 coating appeared to be slightly more effective than VueGuard ® 801 in improving the abrasion resistance of Tritan.





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Pencil Hardness Testing

- Pencil hardness test was performed according to ASTM D-3363 by PCI Labs. Molded plaques were tested with Mitsubishi Hi-Uni graphite pencils at 750 g load and 45 degree angle. Hardness of the lead that just fails to scratch the surface was reported.

Pencil Hardness Scale

6B 5B 4B 3B 2B B HB F H 2H 3H 4h 5H 6H 7H 8H 9H

Softer ← → Harder

Material	Coating	Pencil Hardness
Tritan® TX1001	Uncoated	B
Tritan® TX1001	VueGuard 801	F
Tritan® TX1001	VueGuard 901	HB
Tritan® TX1001	Uncoated	B
Tritan® TX2001	VueGuard 801	F
Tritan® TX2001	VueGuard 901	HB
PC 9034	Uncoated	B

Wolf Wilburn Pencil Hardness Tester

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Steel Wool Scratch Testing

- A fixed steel wool pad (#0000) was mounted at the bottom of a shaft, while carrying a variable load from 1 lb to 50 lbs per square inch, to induce deformation on molded plaques. The resistance to scratching was observed, and the least pressure to cause visible scratching was recorded.

Material	Coating	Steel wool scratch resistance (psi)
Tritan® TX1001	Uncoated	< 1 psi
Tritan® TX1001	VueGuard 801	50 psi
Tritan® TX1001	VueGuard 901	24 psi
Tritan® TX1001	Uncoated	< 1 psi
Tritan® TX2001	VueGuard 801	50 psi
Tritan® TX2001	VueGuard 901	24 psi
PC 9034	Uncoated	< 1 psi

Steel Wool Scratch Tester

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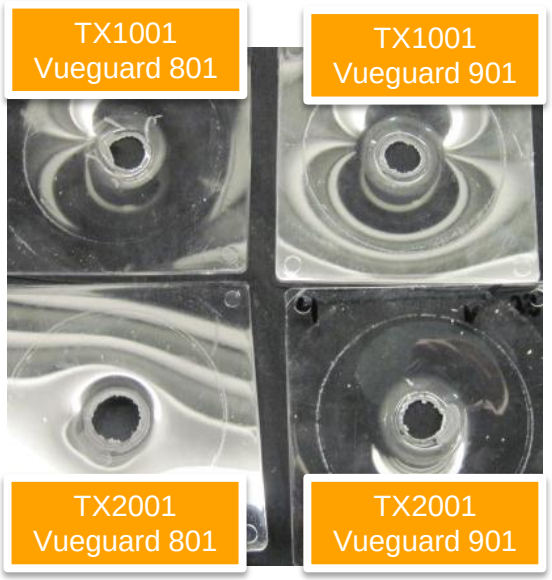
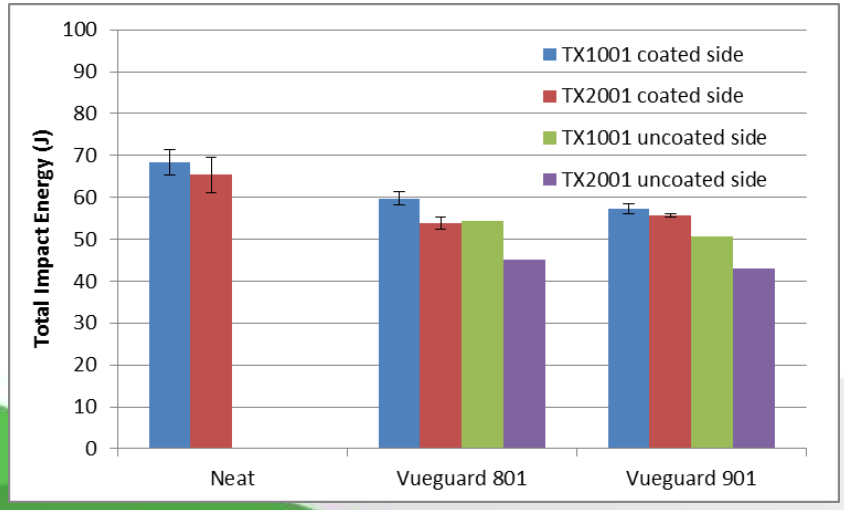
Instrumented Drop Impact

- Instrumented drop impact was performed on neat Tritan® plaques, and coated and reverse coated sides of plaques.
- A 28 kg load was dropped from 0.5 m at a temperature of 23°C.
- Compared to neat TX1001 and TX2001, impact energy of coated plaques exhibited was 12.5-17.5% lower with impact on the coated side (coating in compression), and 20.3-34.2% with impact opposite the coated side (coating in tension).
- Difference between impact energies of plaques coated with VueGuard® 801 and 901 were statistically insignificant.
- Drop impact fractures was ductile in both coating side and reverse coating side impact on coated Tritan® plaques.





Drop Impact	Coating	Reduction in Impact Energy (%) TX1001	TX2001
Coated side	VueGuard 801	12.5%	17.5%
Coated side	VueGuard 901	16.2%	14.9%
Uncoated side	VueGuard 801	20.3%	30.9%
Uncoated side	VueGuard 901	26.0%	34.2%

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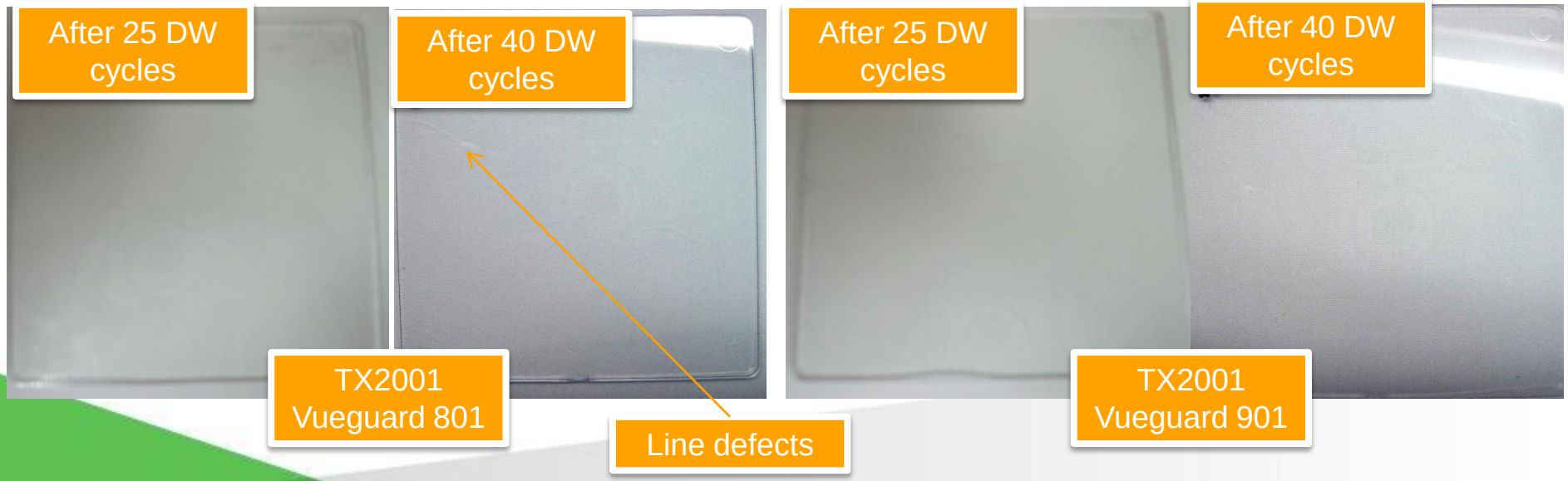
Dishwasher Durability

- Coated plaques of TX2001 were washed on the top rack of a residential dishwasher for 25 and 40 cycles.
- While only localized surface blemishes were observed on the coated surfaces after 25 dishwasher cycles, line defects were observed on TX2001 coated with VueGuard® 801 after 40 cycles.
- The localized surface defects following dishwashing are suspected to be due to the manual spray application of coatings, and uniform coating application could potentially resolve issues with surface blemishes.



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Conclusions

- VueGuard® 801 and 901 coatings effectively improve the abrasion and scratch resistance of Tritan® TX1001 and TX2001.
- VueGuard® 801 coating was more effective in improving the steel wool scratch resistance and pencil hardness of Tritan, while VueGuard® 901 coating appeared to be more affective in improving taber abrasion resistance.
- The drop impact energy of TX1001 and TX2001 plaques were reduced up to 35% on reverse coating side impact by application of coatings, however all coated plaques retained their ductility to impact.
- Both VueGuard® 801 and 901 coated TX2001 plaques had slight surface blemishes after 25 dishwasher cycles, while VueGuard® 801 coated TX2001 plaques exhibited line defects after 40 cycles. More conclusive dishwasher testing would require defect free coating application.
- Both VueGuard ® 801 and 901 coatings are effective in improving the scratch resistance of TX1001 and TX2001, without embrittling the materials.

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Update 2/29/2011

- Call with Aneta Bogdonova to discuss results
  - Coating thickness is 5 μm, which should be sufficient for this application, is not expected to give brittle failure in drop impact. Conversely, brittle failure could be expected if a coating of 1 mil thickness was applied. Both 801 and 901 coating are expected to behave similarly.
  - Coating is a solvent based acrylic. Samples reside in a convection oven held at 40-50^{o}C for 2-3 minutes before being sprayed by the coating, and UV cured with a medium pressure mercury lap at 1200 mJ/cm^2 (300 W/in) energy density for 2-3 seconds.
  - Industrial coating process is on conveyor belt with oven, spray coating and cure cycle on flat geometry. For cylindrical part geometry, the part would need to be rotated by a robotic arm during spraying and curing stage, which could be handled at an externally contracted facility by Cailis,
  - Taber abrasion is not a very accurate test method. While Vueguard 801commonyl has better pencil hardness and steel wool rating, it appeared to be inferior to Vueguard 901 in the taber abrasion testing. CS10F test is harsher compared to CS10 and can give misleading results. Weighing of samples before and after abrasion is not an option for these coatings due to low weight of coating relative to Tritan substrate.
  - Uncoated and coated plaques of Tritan will be tested for scratch with pencil hardness and steel wool testing. For the pencil hardness, Mitsubishi Uni tips are used with a 750 g load. How the tips is sharped and placed has a large influence on the test results.
  - One coated part will be returned by Aneta for drop impact with the uncoated sides on top.

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