Bonding Eastman Trēva™ Engineering Bioplastic Using Henkel Adhesives

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TopCon 2019

Who we are
Henkel at a glance 2019

Almost
50,000
employees worldwide

Around
€ 20 bn
sales,
+3.0% organic
sales growth

43%
of our sales generated
in emerging markets

€2.9 bn
adjusted[1] operating
profit (EBIT)

61%
of our sales generated
by our top 10 brands

140+ years
of brand success

[1] Adjusted for one-time charges/gains and restructuring charges.

Why Use Adhesives?

Benefits

- Join Dissimilar Substrates
- Distributes Stress Evenly
- Fill Large Gaps
- Seal, Bond and Protect
- Neat Appearance
- Easily Automated

Limitations

- Must be cured
- Fixture Time
- Can be Messy
- Another Chemical in the Plant
- Potentially Difficult to Disassemble
- Shelf Life

Agenda

1. Eastman Trēva™ Overview
2. Bonding Study Overview
3. Adhesive Technology Overview
4. A Medical Focus
5. Results
6. Acknowledgements

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Eastman Trēva™
Eco-Friendly Bioplastic Material

- Cellulose-based thermoplastic that offers both high performance and reduced environmental impact
- Cellulose derived from sustainably harvested trees
- BPA-free
- USDA Certified at 42% bio-based material content

Eastman Trēva™
Properties and Benefits

- Excellent chemical resistance to the harshest chemicals, including skin oils, popular sunscreens, and household cleaners.
- Excellent flow characteristics allow it to be used with complicated parts, including filling thin walls, allowing designers to innovate with confidence when molding or extruding.
- Low birefringence eliminates the rainbow effect some plastics experience with polarized light.
- Expect great optical performance in electronic devices or retail displays.

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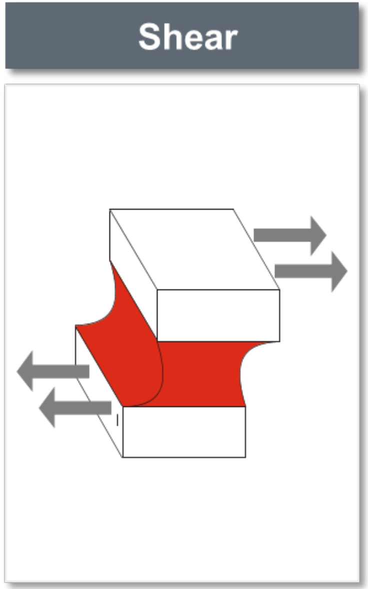
Bonding Study
Why and How?

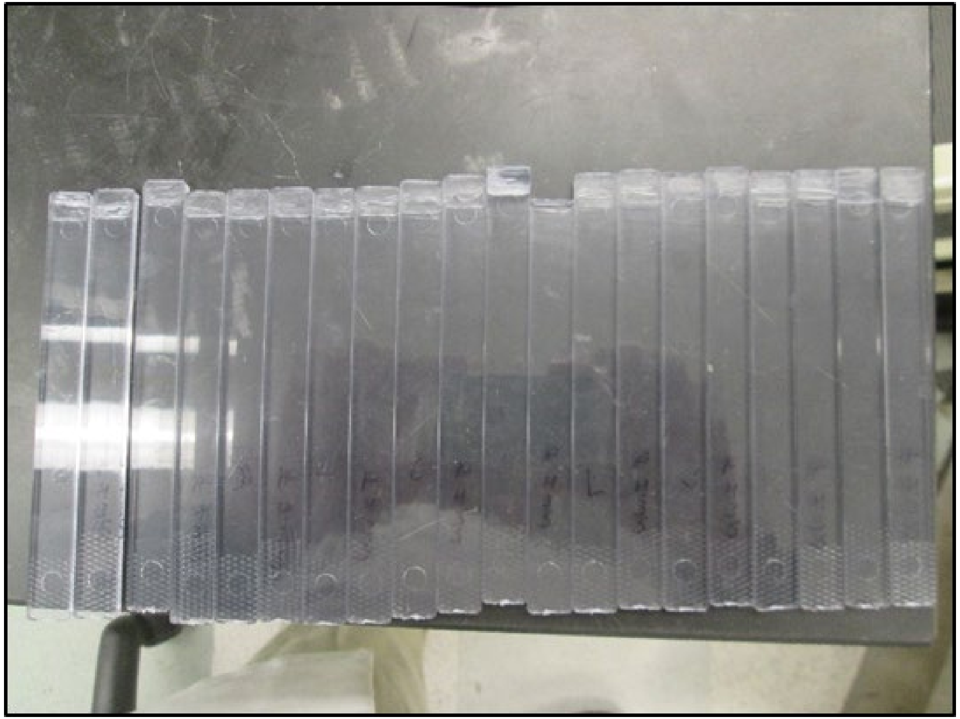
- Shear strength data
- Variety of key plastic bonder technologies
- Explore which adhesive assembly methods work well
- Explore potential for new applications

Test Method: ASTM D3163
An Overview

- Determining Shear Strength of Bond
- Stressing a single adhesive overlap joint with the application of a tensile force parallel to the bond area
- Specimens were pulled to failure at a speed of 0.08"/min
- A force transducer measured load at failure



Specimens



Light Cure Methods

- Acrylics and CAs: 405nm LED Flood @ 1W/cm2, 10 Seconds,
- Silicones: D Bulb (Fusion Chamber) @ 1.00W/cm2, 90 Seconds

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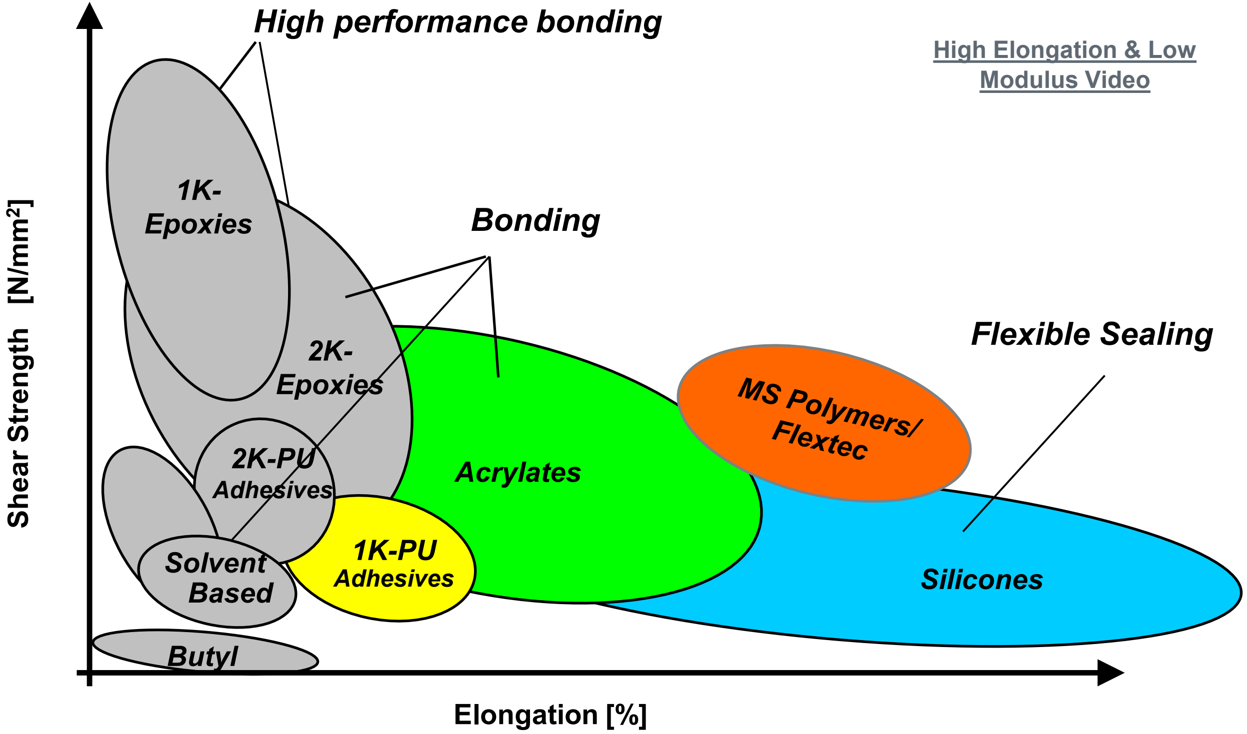
Henkel Adhesives: Across the Spectrum

How do they fit?



[High Elongation & Low Modulus Video]

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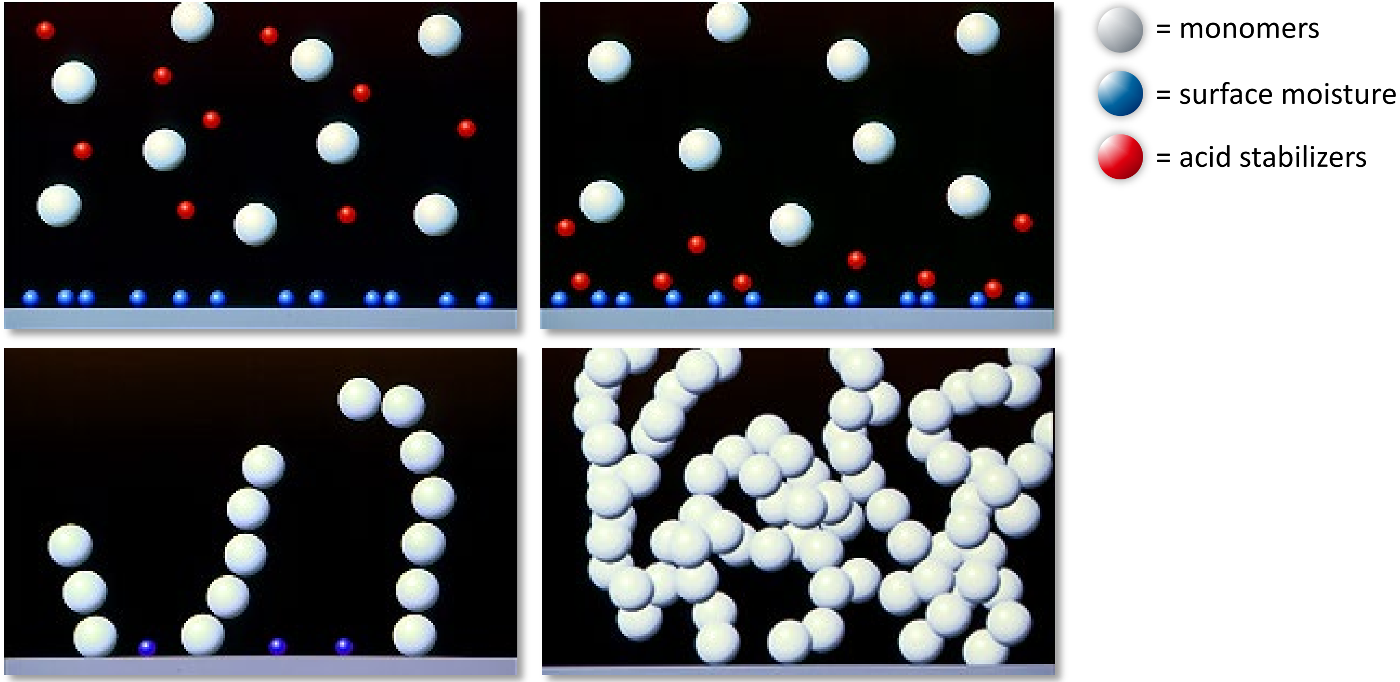
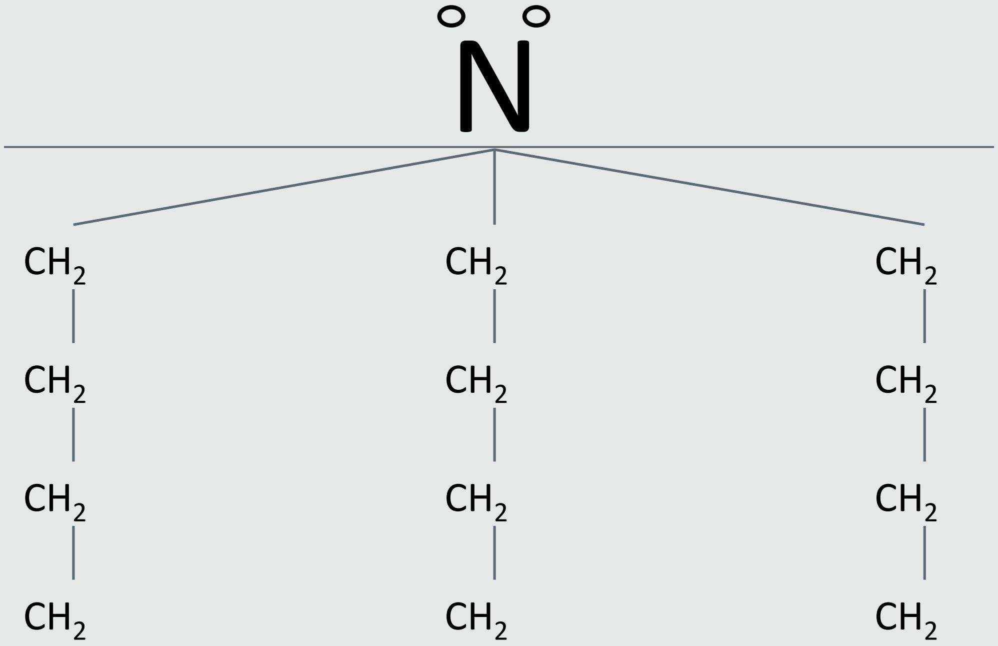
Cyanoacrylates
Cure Mechanism



Cyanoacrylates
Unique Factors

- Basic Chemical Species in Solvent
- Anchoring Site for Cyanoacrylate



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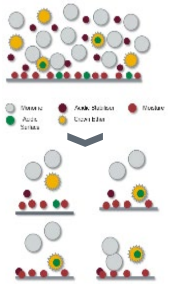
Cyanoacrylates
Unique Factors

Surface Insensitive



- Ability to cure on dry or acidic surfaces
- Fastest cure & highest bond strengths on most plastics

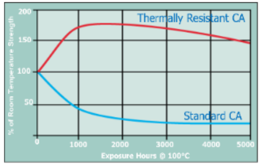
Low Odor / Low Bloom

- Higher molecular weight
- Lower Odor
- Less Likely to Bloom
- Slower Curing
- Lower Strength

CA / Epoxy Hybrid

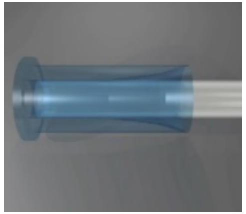
- Speed of CA
- Strength of Epoxy

Thermally Resistant



- Higher temperature rating

Flexible



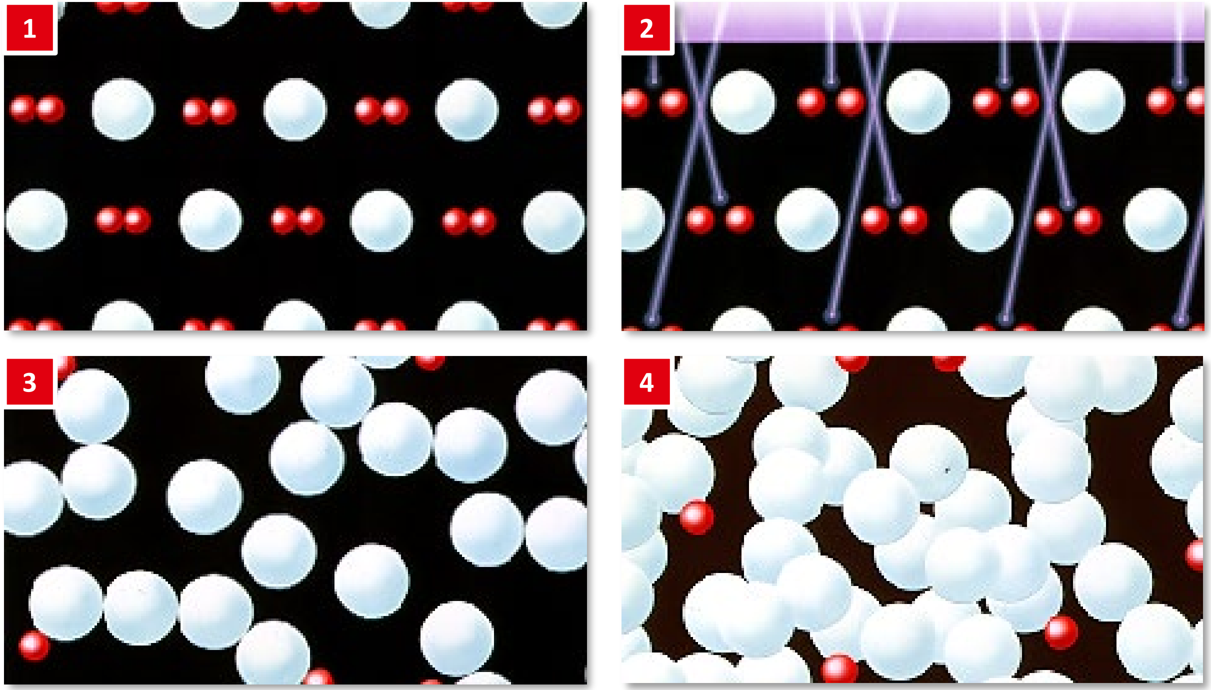
- Standard CA (D 27-80)
- Flexible CA (A 85)

Light Cure

- Cured by light
- Cures fillets & deep sections

Light Cure Acrylics

Cure Mechanism



= photoinitiators

= free radicals

= monomers

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Conventional Light Cure Acrylics
Evaluation Criteria

Benefits

- Cure on demand
- One-part, RT Cure
- Fast Cure, seconds
- Rapid throughput, high productivity
- Long Open Time
- Excellent Bond Strength to most substrates
- Op. temp. to 150oC (300oF)
- Quick ability to QC test
- Easily automated
- Very low VOC

Considerations

- Substrate Transmission
- Oxygen inhibition
- Ozone Emission
- Light cure equipment required
- Cure Thru Depth
- Safety

Silicones: Light Cure

Benefits

- Excellent Thermal Resistance
- Superior Flexibility
- Secondary Shadow Cure
- Excellent Weatherability – UV, Moisture, etc.
- Good Adhesion to Metals and Plastics
- Complete cure on demand by light

Considerations

- Low Cohesive/Tensile Strength
- Poor Resistance to Non-polar solvents
- Poor adhesion to elastomers
- Volatiles Can Contaminate Paint Processes
- Corrosivity (some types)
- No cure in shadowed areas (some)
- Requires capital investment in light source
- Surface Tackiness common with lower cost light sources

Structural Bonding: MMAs, Epoxies, and Urethanes

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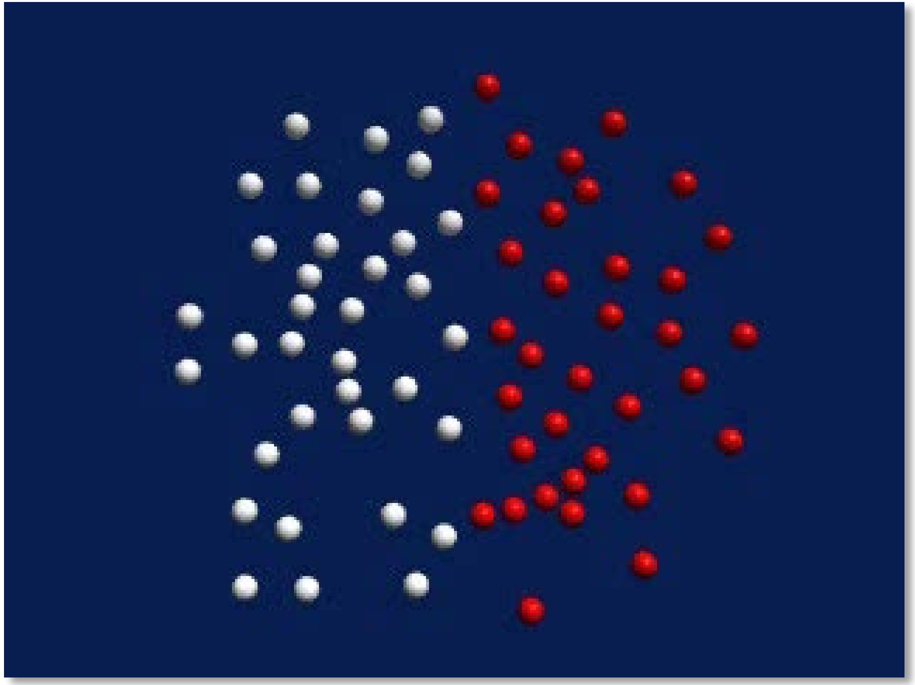
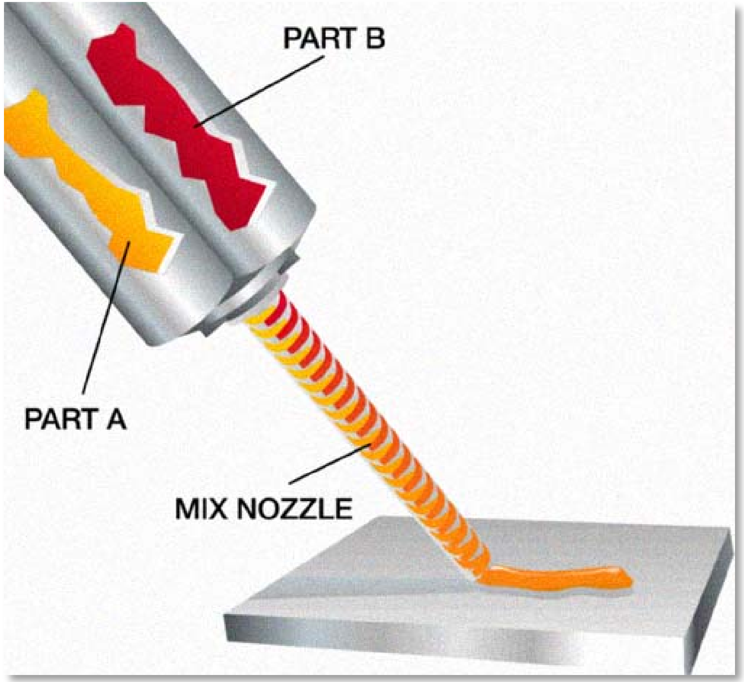
Structurals
Cure Mechanism





From Instant Bonding to Structural Bonding
What is a Hybrid?

Opportunities:

1. New universal structural bonder
2. Shift more of traditional structural to faster, safer technology

Relative Performance

CAs
- 1K
- Fast cure
- High performance on plastics
- Safe to handle

Hybrids
- **Fast cure through high gap**
- **Universal adhesion**
- **Very good structural and environmental durability**
- **Safe to handle**

Structurals
- High gap fill
- Structural performance
- Environmental durability
- High performance on metals

Ease of Use — **Structural Durability**

Application Examples

- **Instant bonding applications where speed counts, e.g. Plastic Tube Bonding, Rubber mat fixation, Gasket Bonding, Instant Repair, etc.**
- **Applications that requires speed and structural integrity**
- **Structural bonding applications replacing mechanical fasteners, e.g. metal bonding, composite bonding, plastic bonding, magnet bonding, dissimilar substrates bonding**

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Eastman-Henkel Study: A Medical Focus

Biocompatibility

USP Class VI:

Standard of United States Pharmacopeia requiring testing for:

- Systemic toxicity
- Muscle Implantation
- Intracutaneous toxicity

USP Class VI is an older and US specific test protocol with slightly different test procedures versus ISO

ISO 10993:

Global compatibility test standards for:

- Systemic toxicity
- Muscle Implantation
- Intracutaneous toxicity
- Cytotoxicity
- Hemolysis/Hemocompatibility
- Physicochemical
- Genotoxicity
- Sensitization
- Sub-chronic toxicity

General Topics
Biocompatibility

Henkel's ISO-10993 Test Protocol Includes five (5) Tests.

Note: All Henkel biocompatibility testing is completed by an outside, 3rd party laboratory.

ISO 10993:

Global compatibility test standards for:

- Systemic toxicity
- Muscle Implantation
- Intracutaneous toxicity
- Cytotoxicity
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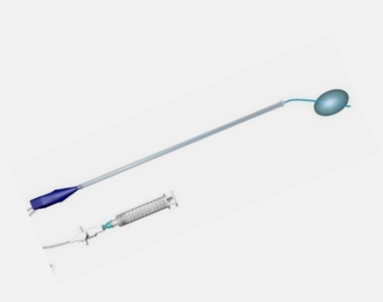
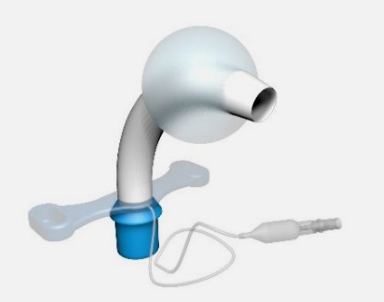
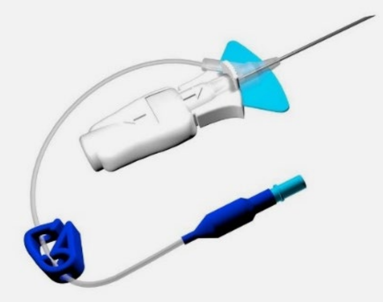
Flexible Medical Devices

Tube Sets	Catheters	Respiratory	General
			
Tubing to fittings, connectors, adaptors, ports & Y-connectors, IV sets, blood collection sets, drug infusion sets, feeding tubes	Balloon to multi-lumen tubing, strain relief or transition of balloon to tube urological catheter balloon bonding, angioplasty catheters, marker band bonding	Oxygen & anesthesia masks, resuscitator bags, breathing circuits and componentry	Drug delivery devices, fluid suctioning devices, suture and anchor devices

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Rigid / Tough Medical Devices

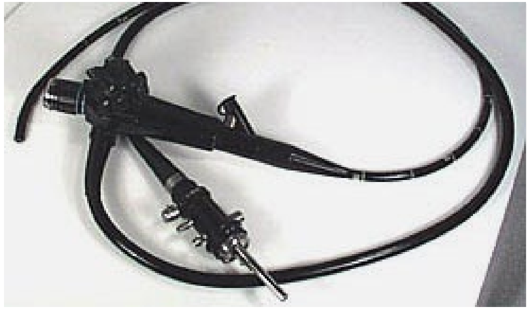
Needle & Syringe

Cannula to hubs in needle and syringe assemblies.

Reservoir & Housing

Press fits to looser tongue & groove bond joints of lid to housing. Fluid devices for transport or dispense liquids such as drugs or bodily fluids or serve as storage devices.

Endoscopic Devices



Tough and chemical resistant bonding of assemblies.

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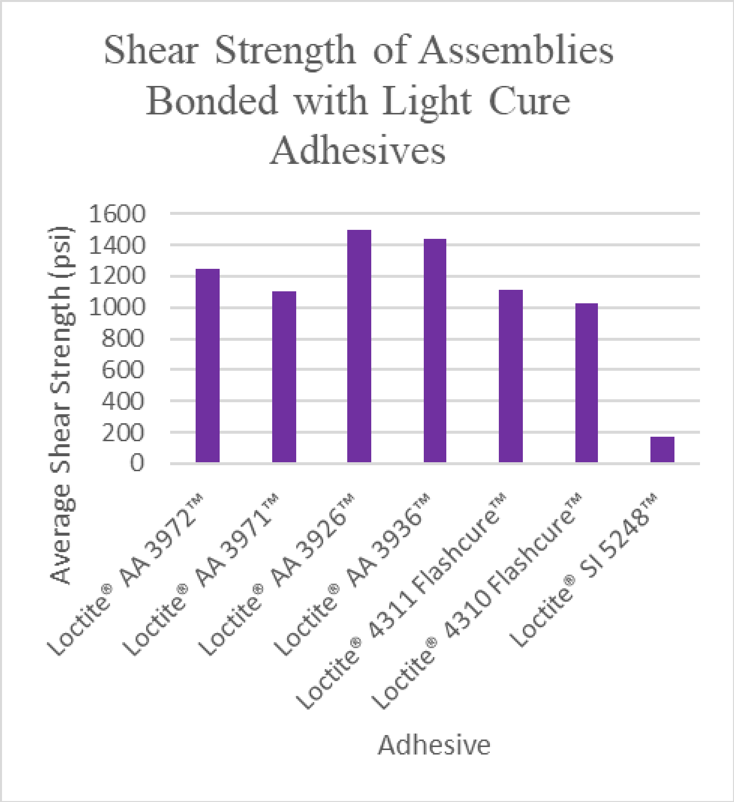
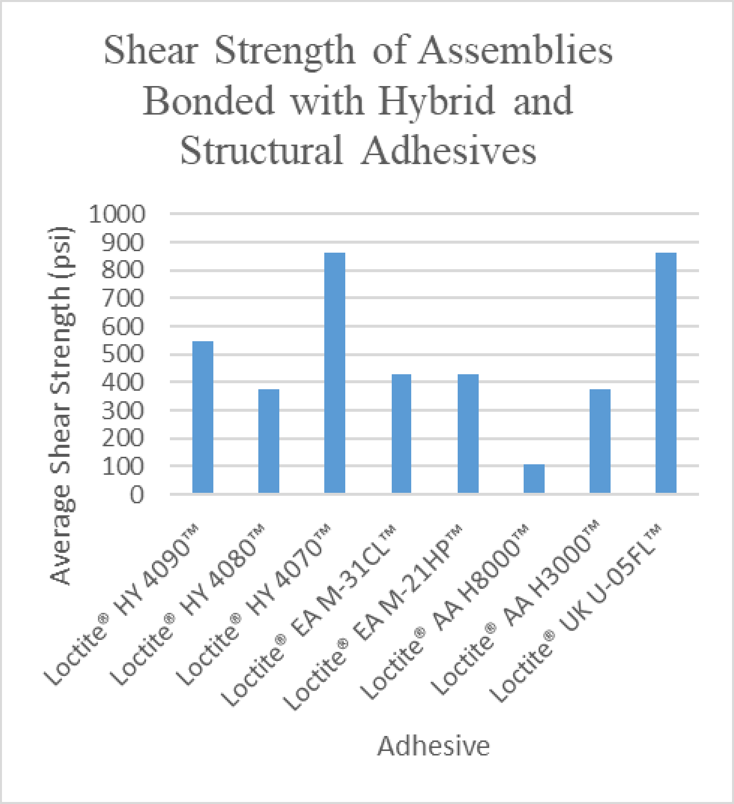
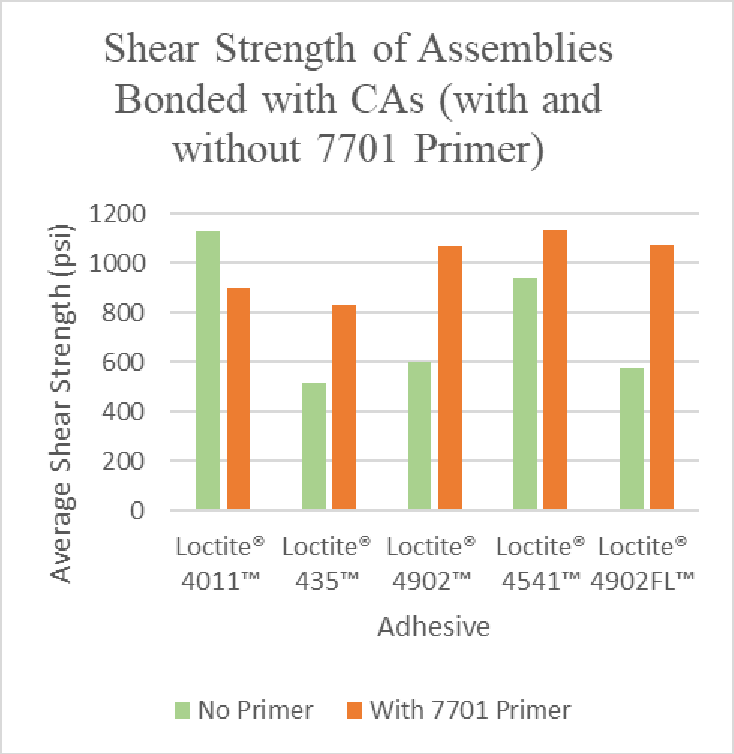
Results
Light Cure



Results
Structurals

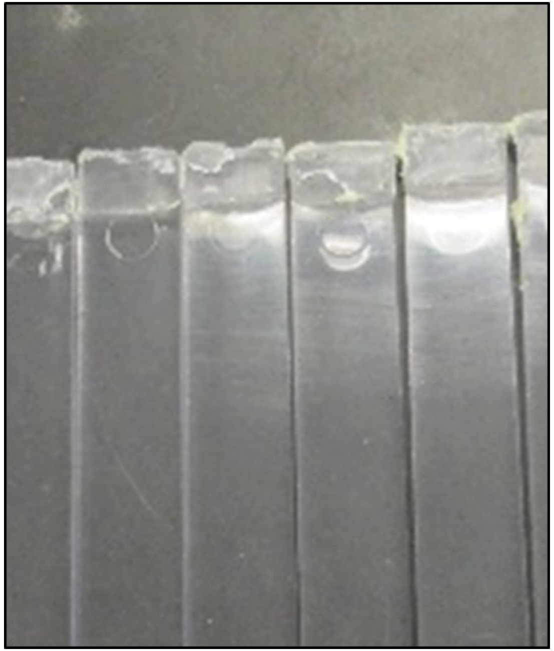


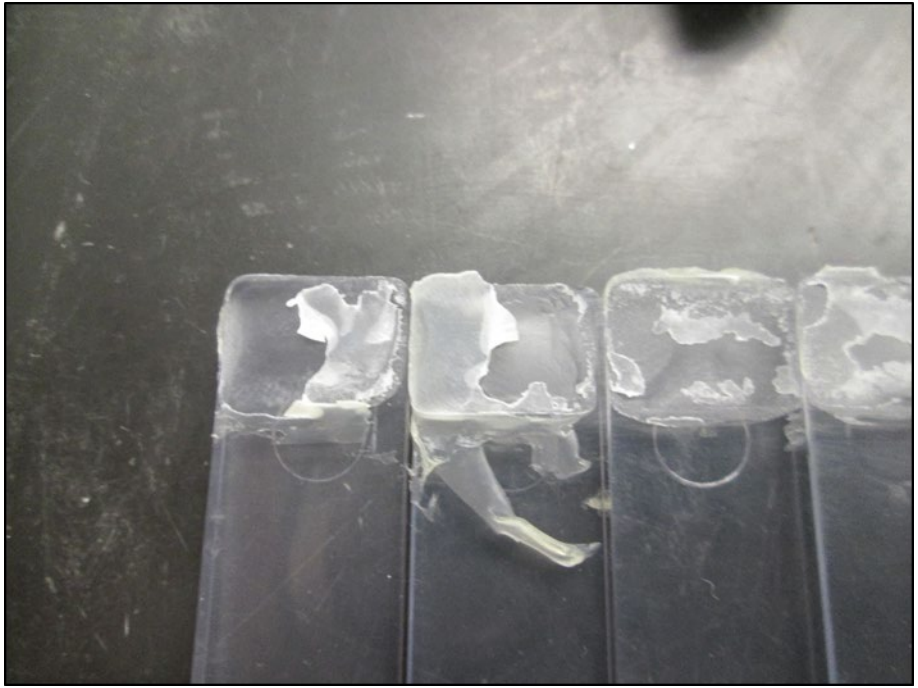
Results
CAs



Shear Strength of Assemblies Bonded with CAs (with and without 7701 Primer)
Average Shear Strength (psi)
1200
1000
800
600
400
200
0
Loctite® 4011™
Loctite® 435™
Loctite® 4902™
Loctite® 4541™
Loctite® 4902FL™
Adhesive
No Primer
With 7701 Primer

Failure Modes





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Moving Forward

- Chemical Resistance
- Peel, Tensile, etc
- Thermal Conditions (Hot Strength, Heat Aging)

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Acknowledgements and References

- [1] ASTM D3163-01, Standard Test Method for Determining Strength of Adhesively Bonded Rigid Plastic Lap-Shear Joints in Shear by Tension Loading. ASTM International, West Conshohocken, PA, 2014.
- [2] ASTM D907-15, Standard Terminology of Adhesives, ASTM International, West Conshohocken, PA, 2015.
- [3] ASTM F1241, Standard Terminology of Silicon Technology, ASTM International, West Conshohocken, PA, 2000.
- [4] Eastman Chemical Company, Eastman Trēva™ Engineering Bioplastic. Kingsport, TN, 2019. https://www.eastman.com/Brands/Treva/Pages/Overview.aspx
- [5] ISO 10993-1, Biological Evaluation of Medical Devices, International Organization for Standardization, Geneva, Switzerland, 2018.
- [6] USDA, Biopreferred® Catalog, United States Department of Agriculture, Washington, D.C. 2019.

- Special thanks to Ian Barron for producing the shear strength test data contributing to this study.
- Special thanks to Eastman Chemical for supplying substrates

Thank you!