ThreeBond
TECHNICAL NEWS

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Single-Component Low-Heat High-Speed Curing Elastomeric Adhesive

Introduction

At ThreeBond, we have been offering single-component elastomeric adhesives that cure at room temperature through our ThreeBond 1530 Series since 2000. Since its release, this series has been utilized in a wide variety of applications.

In recent years, there has been growing demand for higher energy efficiency, cost reduction and shortened takt time at manufacturing sites, as well as product development that takes overall CO_2 emission reduction and other environmental concerns into consideration. This kind of product development is beneficial to both production and to users.

We developed ThreeBond 1539 with these concerns in mind, utilizing plant-based materials to create a single-component elastomeric adhesive that cures quickly at low temperature, unlike other conventional single-component adhesives.

Here, we will introduce both the development history and special features of this product.

Hereafter, ThreeBond is abbreviated as TB.

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1. Background

1-1 Recent Environmental Issues

Reducing CO_2 emissions that causes the greenhouse effect has become a major concern as global warming issues continue to take hold across the world. Industrial waste disposal of plastic products has also continued to become a greater and greater issue with every passing year.

In light of these circumstances, "Carbon Neutral" has become a buzzword in the environmental science community, bringing focus on plant-based materials and other components that place very little burden on the environment. These materials neither increase nor decrease atmospheric CO_2, even when incinerated, so products made of such materials are regarded as environmentally conscious.

1-2 Biomass Resources

Biomass is the general name for bioresources that come from animals and plants. Unlike finite fossil resources, such as coal and petroleum, biomass resources are renewable as long as there is sun, water and plant life. These resources are being aggressively pursued as the above-mentioned global warming issues face more and more scrutiny as the 21st century progresses. In recent years, research has been underway to develop general-use petroleum-based polymers from materials such as biomass ethanol. However, while biomass ethanol itself is carbon neutral, additional CO_2 may be released through its production and consumption (i.e. energy when ethanol is produced from raw materials), so it is necessary to consider whether production is appropriate from the prospective of energy balance.

Against such a backdrop, ThreeBond has conducted product development focused on castor oil, a biomass resources that is relatively easier to produce and obtain than petroleum-based polymers.

2. Castor Oil

Castor oil is a non-edible oil made of pressed and refined castor beans that has long been utilized as a lubricant, laxative, etc. Castor bean can be grown in relatively nutrient-light soil, so it is produced in many countries, from India and China to Brazil. Additionally, there have been findings that suggest that castor bean plants absorb more CO_2 than rice and other agricultural crops, making it an environmentally friendly resource.

Because ricinoleic acid is the main component of castor oil, it also boasts properties such as flexibility, low temperature performance, stability, electrical properties and biological inactivity traits that make it extremely useful as a main adhesive component (Fig. 1).

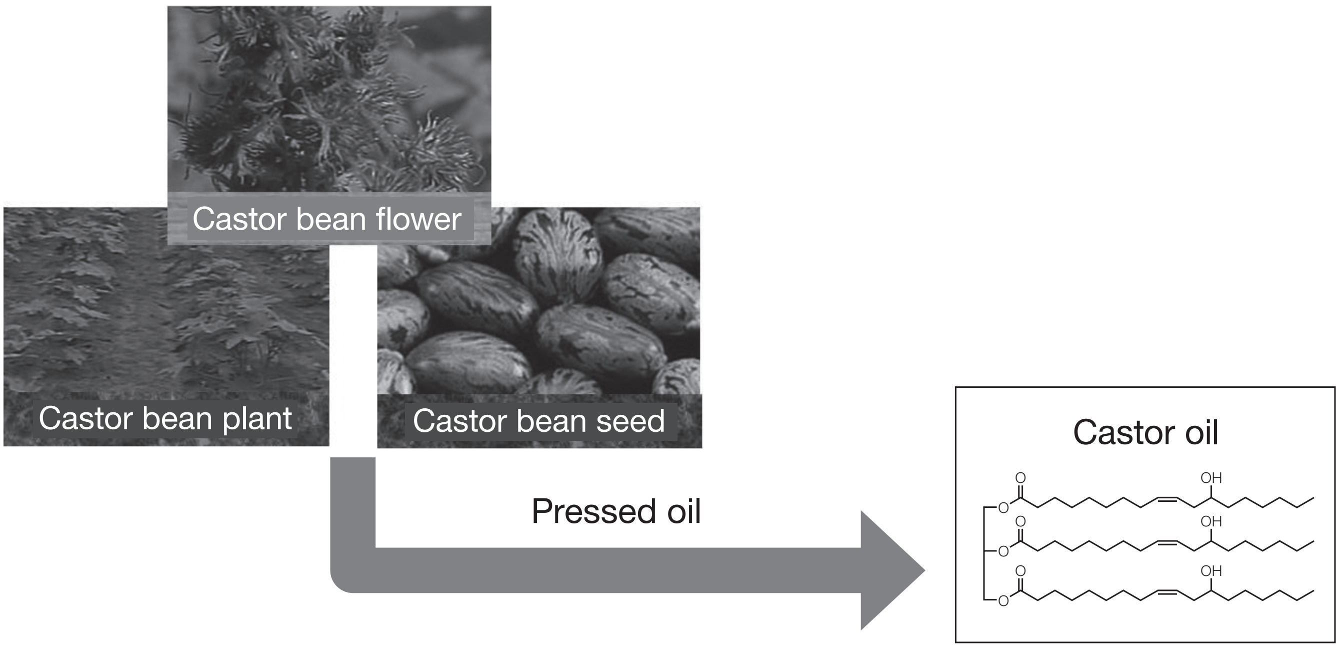


Fig. 1 Castor Oil and its Raw Materials (ricinus)

Table 1 ThreeBond Elastomeric Adhesive (Representative Grades)

Category	Silicone-based	Modified silicone-based	Acrylic-based
Product grade	TB1220 series	TB1530 series	TB3955
	Single component moisture-curing	Single component moisture-curing	Two-component mixing
Curing speed	△	△	○
Adhesive strength	△	○	◎
Flexibility	◎	◎	○
Heat resistance	◎	○	◎
Low molecular mass siloxane	△	None	None

◎: Excellent ○: Good △: Moderate

Table 2 TB1530 Physical Characteristics (Representative Grades)

	Unit	TB1530	TB1530B	TB1530C	Testing method
Appearance	-	White	Black	Semi-transparent	3TS-2100-002
Viscosity	Pa·s	100	110	100	3TS-2F00-002
Specific gravity	-	1.39	1.31	1.31	3TS-2500-002
Tack-free time	min	7	7	7	3TS-3130-006
Hardness	Durometer A	44	48	55	3TS-2B00-004
Tensile shear bond strength (A1/A1)	MPa	6.6	4.4	4.3	3TS-4100-013
Tensile strength	MPa	5.9	3.0	4.1	3TS-4190-001
Elongation rate	%	280	380	200	3TS-4190-001

3. Elastomeric Adhesives

In recent years, silicone, modified silicone, polysulfide, urethane and other elastomeric adhesives are increasingly used because they easily bond to a wide range of adherends.

At ThreeBond, we have broadly classified three product grades based upon main component (Table 1).

Base resins have different characteristics and properties, so selection is based on the intended use. The TB1530 series is mainly composed of modified silicone. It is a single-component elastomeric adhesive that cures through moisture at room-temperature and features excellent adhesion to a relatively wide range of materials, so it has been adopted by many markets for a wide variety of applications (Table 2).

However, while the single-component moisture-curing adhesives typified by the TB1530 series are easy to handle, they also require around an entire week to cure at room temperature. This necessitates a switch to two-component types to speed up the curing process, making application of temperatures of 100°C or more required. This makes handling at production sites difficult while also posing danger to the environment.

To remedy these issues, we developed a single-component elastomeric adhesive that quickly cures at low temperature while maintaining excellent adhesiveness, shortening takt time at manufacturing sites while also enabling use of elastomeric adhesives in applications where it had previously been impossible due to manufacturing processes and heat-resistance of materials. We are certain this range of application will only further expand moving forward.

4. Single-Component Low-Heat High-Speed Curing Elastomeric Adhesive TB1539

4-1 Development Background

As mentioned above, single-component elastomeric adhesive that cures at room temperature requires a long time to cure, and because it cures through moisture in the air, it is not suitable for large adherends, potting, etc. As a solution to this, we set our sights on research and development of an all-new single-component elastomeric adhesive that would cure quickly (from about 1 min.) at a relatively low temperature of 60°C.

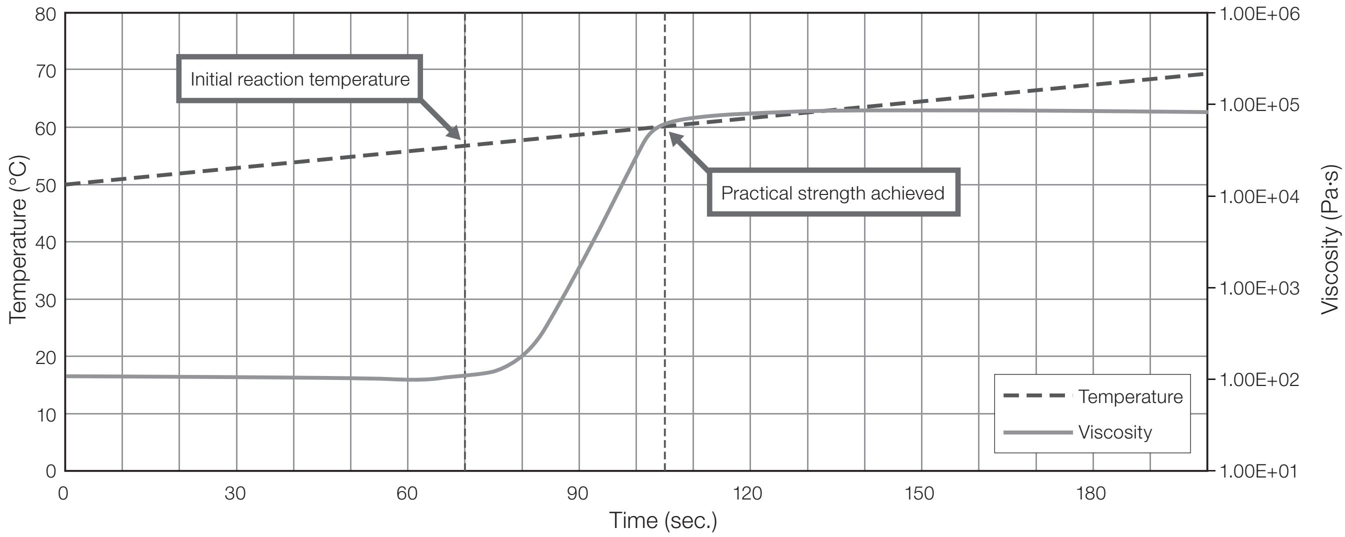


Fig. 4 TB1539 Fluid Flow Characteristics when Heat is Applied (Quick, Low-Temperature Curing)

Combining polymer modified castor oil mainly composed of plant-based components with a thermally latent curing agent that activates at the relatively low temperature of 60°C enabled the development of the TB1539 elastomeric adhesive, which has the following properties (Fig. 2 and 3).

Organotin compounds are widely used as a catalyst in moisture-curing elastomeric adhesives, but such compounds are not contained within TB1539, making it compliant with EU directives applied from 2015.

TB1539 maintains a rubber-like elasticity after curing for bonding and sealing where impact, vibration and stress resistance are required. The adhesive bonds well to a wide variety of adherends, from metal to plastic and glass, which enables use in a broad range of fields, such as electronics and transportation equipment, with expansion into many more expected in the future.

Fig. 2 TB1539 (Product Specifications)

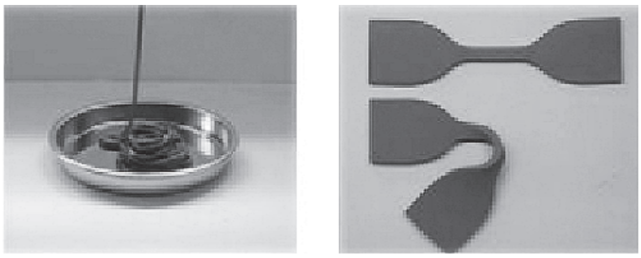


Fig. 3 TB1539 (Left: Pre-Cured, Right: Cured)

4-2 Fluid Flow Characteristics when Heat is Applied (Quick, Low Temperature Curing)

Fig. 4 shows changes in viscosity as captured by a thermal rheometer when TB1539 is heated at a rate of 5°C/min.

After reaching the initial reaction temperature (about 60°C), viscosity rises sharply then stabilizes after a short time (under 1 min.), at which point practical strength is realized.

Fig. 4 is an example of curing behavior, so curing time may vary depending on the heat capacity (heat transference characteristics) of the adherend.

4-3 Characteristics/Curing Properties

TB1539 characteristics and curing properties are indicated in Table 3. The elastomeric adhesive demonstrates appropriate viscosity to enable excellent workability and is rubbery.

4-3-1 Tensile Shear Bond Strength

TB1539 tensile shear bond strength is indicated by curing time in Figure 5. High adhesive strength can be achieved simply through 1.5 hours of 60°C heat. Strength is then further improved through curing at 23°C, 50% RH.

Table 3 TB1539 Characteristics/Curing Properties

	Unit	TB1539	Testing method
Appearance	-	Black	3TS-2100-002
Viscosity	Pa·s	100	3TS-2F00-002
Specific gravity	-	1.34	3TS-2500-002
Hardness	Durometer A	70	3TS-2B00-004
Tensile strength	MPa	3.5	3TS-4190-001
Elongation rate	%	120	3TS-4190-001
Volume resistivity	Ω·m	2.4×10^{11}	3TS-5200-001

Curing conditions: 60°C × 1.5 hrs + 23°C, 50% RH × 3 days

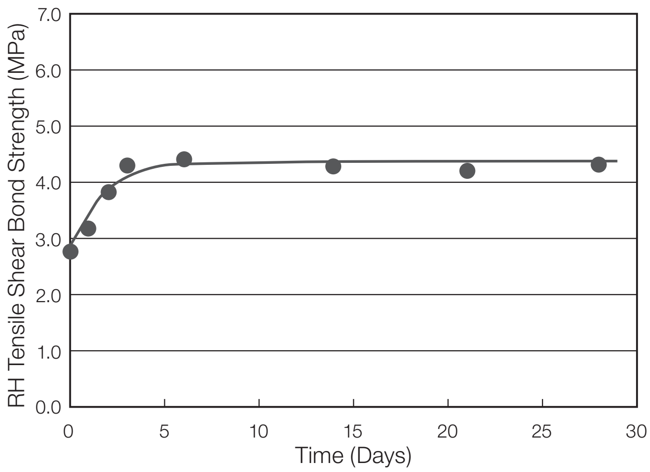


Fig. 5 TB1539 Tensile Shear Bond Strength by Curing Time

Hardening conditions: 60°C × 1.5 hrs
Curing conditions: 23°C, 50%
Testing method: 3TS-4100-013, bonded aluminum materials (A1050P) together after applying to adherends

4-3-2 Tensile Strength, Elongation Rate and Hardness

TB1539 tensile strength, elongation rate and hardness are indicated by curing time in Figures 6 and 7. In the same way as for tensile shear strength, rubber-like characteristics are obtained simply by applying 60°C heat for 1.5 hours. Properties then stabilize by curing in 23°C, 50% RH.

5. Characteristics

5-1 Tensile Shear Bond Strength

TB1539 tensile shear bonding strength is indicated by adherend material in Figure 8. Excellent adhesion strength is demonstrated for metal, various plastics and other materials.

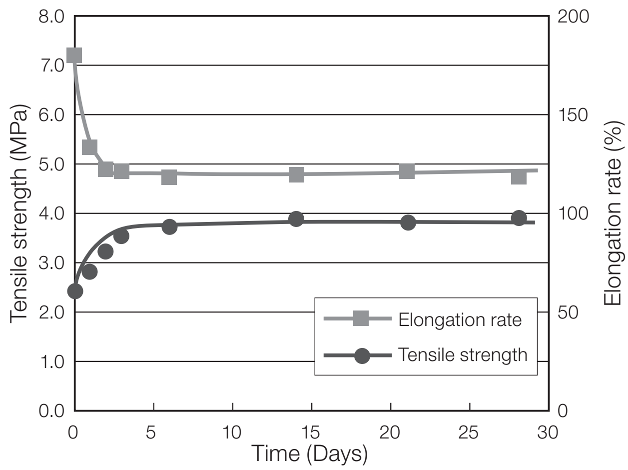


Fig. 6 TB1539 Tensile Strength by Curing Time

Hardening conditions: 60°C × 1.5 hrs
Curing conditions: 23°C, 50% RH
Testing method: 3TS-4190-001

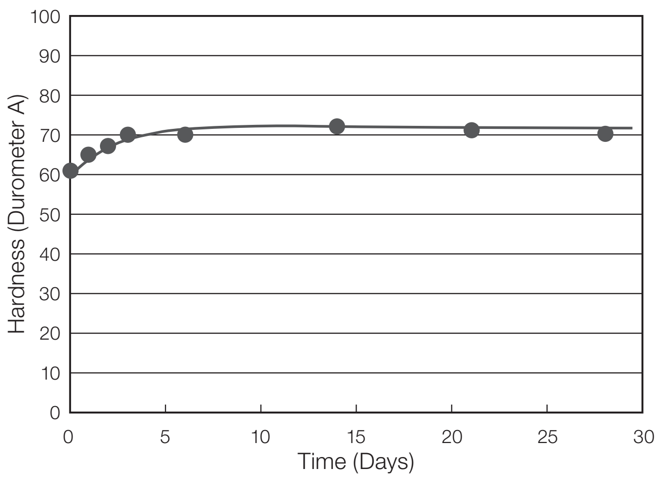


Fig. 7 TB1539 Hardness by Curing Time

Hardening conditions: 60°C × 1.5 hrs
Curing conditions: 23°C, 50% RH
Testing method: 3TS-2B00-004

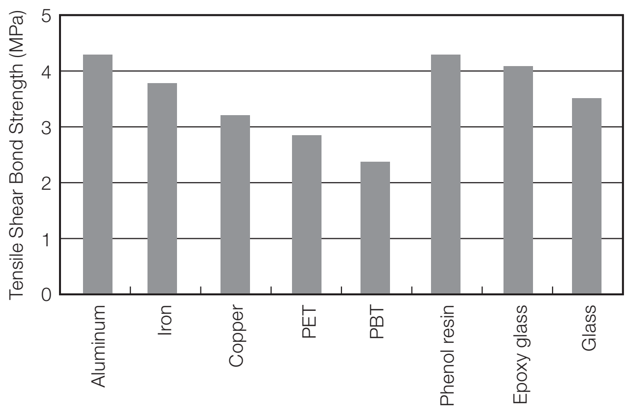


Fig. 8 TB1539 Tensile Shear Bond Strength by Material

Curing conditions: 60°C × 1.5 hrs + 23°C, 50% RH × 3 days

Testing method: 3TS-4100-013, bonded together after applying to adherends

5-2 Viscoelasticity (DMA)

Measurements of TB1539 dynamic viscoelasticity when cured are indicated in Figure 9. TB1539 maintains a rubber-like elasticity in a wide temperature range (-35 to 100°C).

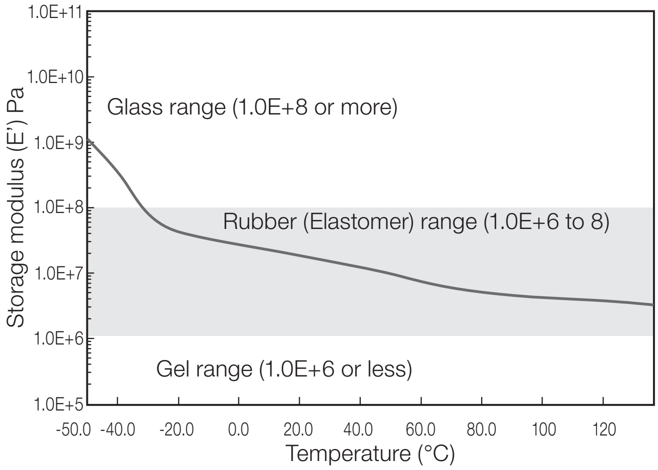


Fig. 9 TB1539 Viscoelasticity

Curing conditions: 60°C × 1.5 hrs + 23°C, 50% RH × 3 days
Testing method: 3TS-4730-001

5-3 Heat Resistance

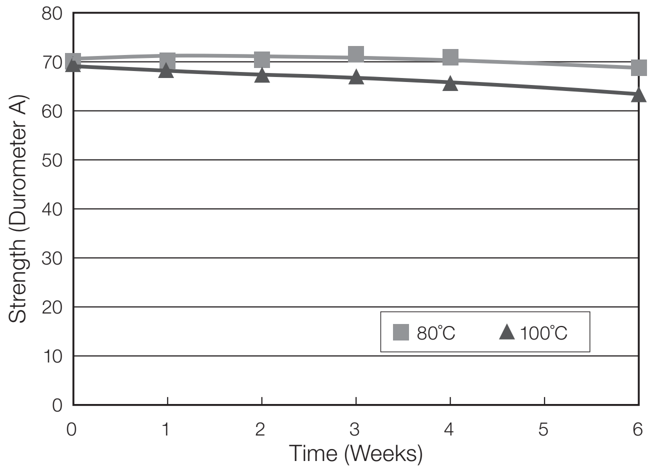
Cured TB1539 characteristics after exposure to 80 and 100°C environments are indicated in Figure 10.

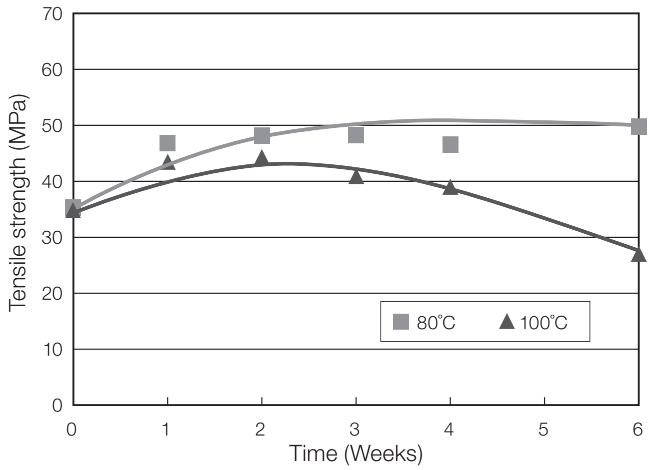
After six weeks of exposure in each temperature, characteristics equal to that of their initial levels were maintained and sufficient rubber characteristics were demonstrated.

5-4 Water-Resistance

Cured TB1539 characteristics after immersion in 40°C water are indicated in Figure 11.

Water resistance and sufficient rubber characteristics were demonstrated after six weeks of immersion, just as in heat resistance.





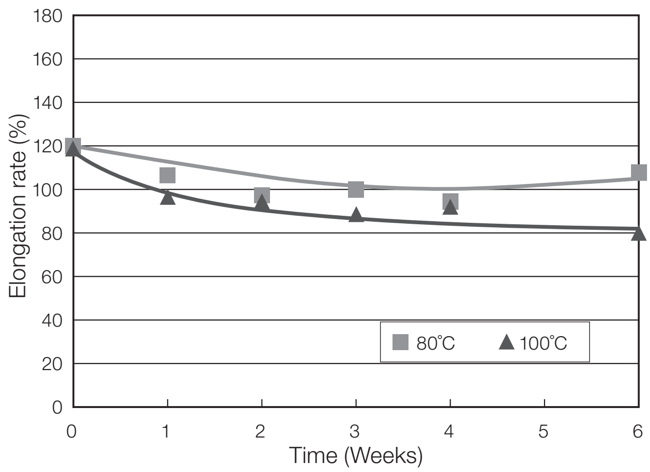


Fig. 10 Cured TB1539 Characteristics After Exposure to 80 and 100°C Environments

Curing conditions: 60°C × 1.5 hrs + 23°C, 50% RH × 3 days

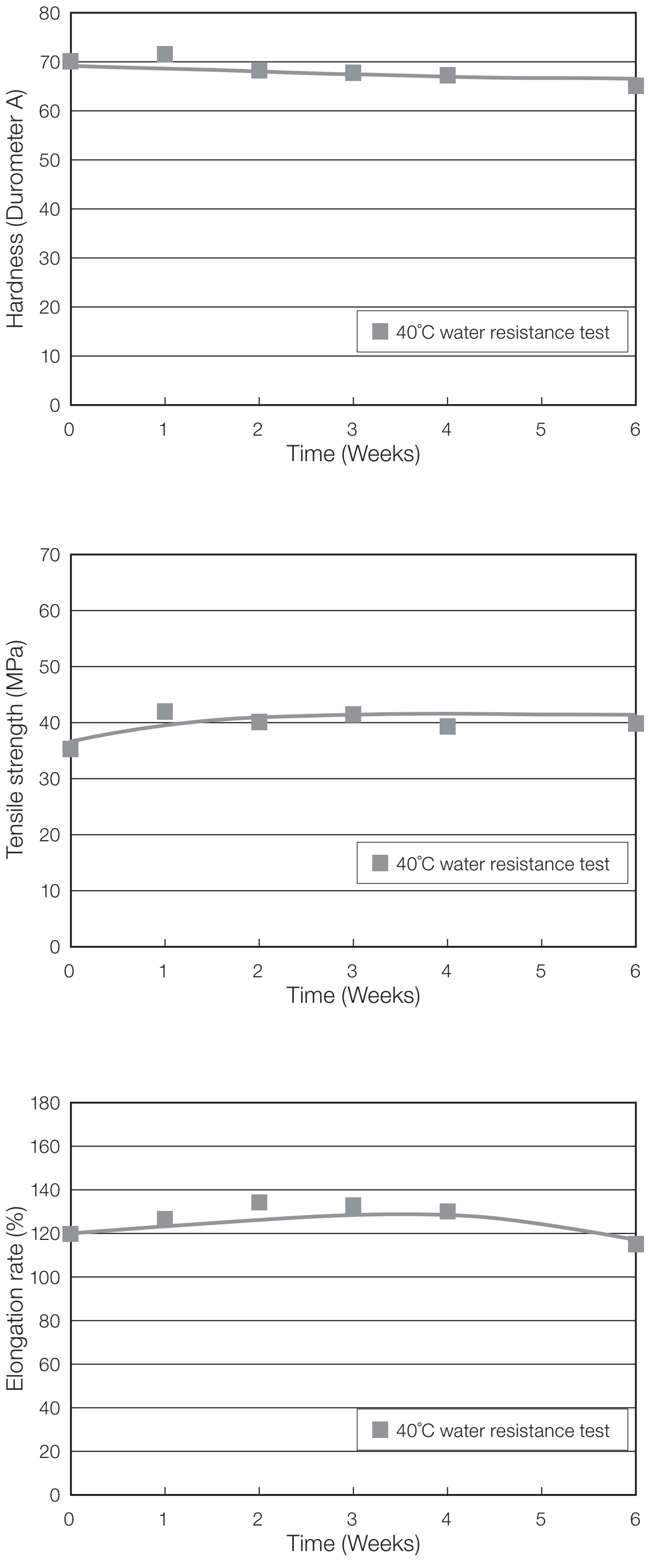


Fig. 11 Cured TB1539 Characteristics After Immersion in 40°C Water

Curing conditions: 60°C × 1.5 hrs + 23°C, 50% RH × 3 days

6. Applications Examples

- Affixing and bonding automotive parts
- Bonding and sealing electrical, electronic and medical equipment parts, etc.
- Bonding and sealing various household products
- Bonding various metals, plastics, rubber, etc.

Moisture-curing elastomeric adhesive cures by coming into contact with air, making it unsuitable for curing in the center or deep sections of an object, such as for large adherends or potting. Because TB1539 cures quickly at low heats, these issues are eliminated, and it is suitable for bonding and sealing of bonded parts and other applications. It also demonstrates excellent water resistance and electrical insulation, making it perfectly suitable for electronics and other applications where such characteristics are required.

While other adhesives are difficult to use with plastics due to softening that can occur during the heat curing process, TB1539 cures at the relatively low temperature of 60°C while also demonstrating excellent bonding to such adherents, making it excellent when used with a variety of such materials. It is traits like these that make us confident that TB1539 application will only continue to grow.

Closing

TB1539 was developed for the purpose of creating an all new, environmentally friendly single-component elastomeric adhesive that cures quickly at low temperatures.

Utilizing TB1539 is sure to realize improved energy efficiency at manufacturing sites, which will also reduce costs. This adhesive is perfect for a wide range of applications in a variety of markets thanks to the many materials to which it can be bonded as well as excellent heat and water resistance. We will continue to expand this lineup, using TB1539 as the center of this new series.

As market demand continues to grow for environmentally friendly products, we at ThreeBond promise to also make this kind of development a priority, not only for the sake of the elastomeric adhesive field, but in the hopes of contributing to industry-wide product development.

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