LOCTITE®


# LOCTITE® 3D IND249™

## High Temperature
## Black

**LOCTITE®**
Henkel Corporation
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# IND249 BK™

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## LOCTITE 3D IND249 BK™

LOCTITE 3D IND249 BK is a high-temperature, high-strength material that prints challenging geometries with fine feature resolution. This low-viscosity material features exceptionally high green strength to enable ease of processing.

Stiffness and thermal durability make LOCTITE 3D IND249 BK ideal for production applications, including mold tooling, manufacturing aids, and other complex geometries. In addition, LOCTITE 3D IND249 BK provides an exceptional chemical resistance.

LOCTITE 3D IND249 BK has validated workflows for printing on various DLP platforms.

### Benefits:

- Exceptionally high stiffness
- Low viscosity
- High accuracy
- Good temperature resistance
- Very high chemical resistance

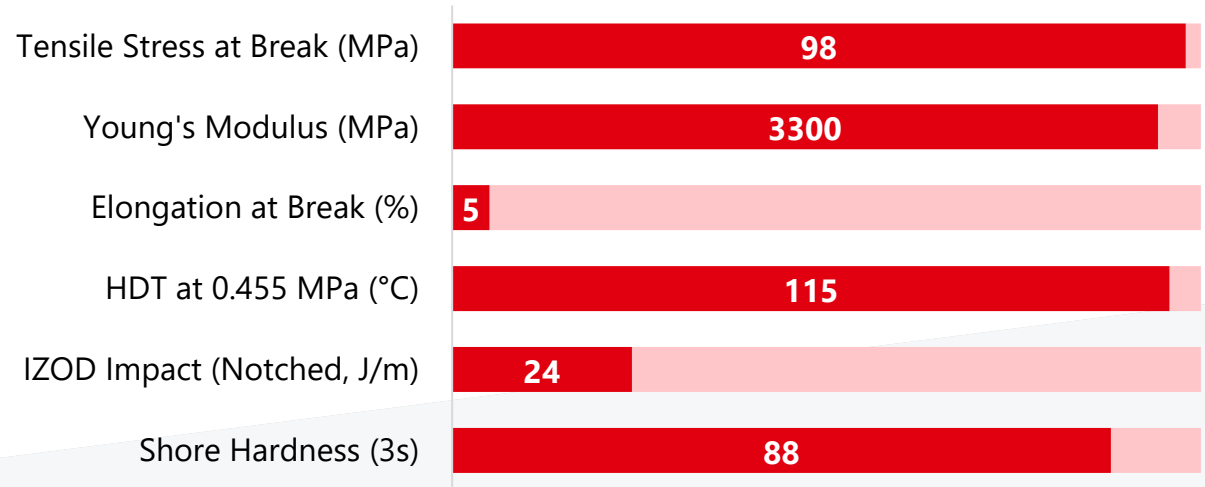
### Ideal for:

- Challenge geometries
- Mold tooling
- Manufacturing aids

### Markets:

Industry

Consumer Goods




**Values shown are linked to LOCTITE IND249 BK as reference, please refer to the specific mechanical properties for each of the colors shown in this document*

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## PROPERTIES

| Mechanical Properties | Measure | Method | Green | Post Processed |
|---|---|---|---|---|
| Young's Modulus | MPa | ASTM D638 | 1700 - 1880 [1] | 2980 - 3350 [1] |
| Tensile Stress at Yield | MPa | ASTM D638 | 43 - 53 [1] | - |
| Elongation at Yield | MPa | ASTM D638 | 4.2 – 4.8 [1] | - |
| Tensile Stress at Break | MPa | ASTM D638 | 37 - 46 [1] | 83 - 98 [1] |
| Elongation at Break | % | ASTM D638 | 16 - 24 [1] | 4 - 7 [1] |
| Flexural Modulus | MPa | ASTM D790 | 2340 – 3330 [2,3] | 3170 - 3600 [3,4] |
| Flexural Stress at Break | MPa | ASTM D790 | 94 - 130 [2,3] | 127 - 153 [3,4] |
| Flexural Elongation at Break | % | ASTM D790 | >5 [2,3] | 4 - 5 [3,4] |
| IZOD Impact (Notched) | J/m | ASTM D256 | 11 – 24 [8,9] | 13 - 24 [10,8] |
| Shore Hardness (3s) | D | ASTM D2240 | 74 - 87 [13,14] | 81 - 88 [13,15] |
| **Other Properties** | | | | |
| HDT at 0.455 MPa | °C | ASTM D648 | - | 113 - 117 [5,6] |
| HDT at 1.82 MPa | °C | ASTM D648 | - | 96 - 101 [7,6] |
| Water Absorption (24hr) | % | ASTM D570 | - | 0.5 - 0.7 [11,12] |
| Water Absorption (48hr) | % | ASTM D570 | - | 0.6 - 0.7 [25] |
| Water Absorption (72hr) | % | ASTM D570 | - | 0.7 - 0.9 [11,12] |
| Solid Density | $g/cm^3$ | ASTM D792 | 1.16 - 1.19 [16,17] | 1.17- 1.20 [16,17] |
| Thermal Conductivity | W/(m·K) | ASTM D5930 | - | 0.2 – 0.21 [21] |
| Heat Capacity | J/(g·K) | ASTM D5930 | - | 1.4 – 1.5 [21] |
| CTE (< 55°C) | µm/(m·K) | ASTM E831 | - | 60.4 – 66.6 [22] |

**Test parameters:**
"All specimen are printed unless otherwise noted. All specimen were in ambient lab conditions at 19-23°C / 40-60% RH for at least 24 hours." ASTM Methods: D638 Type IV, 5mm/min; D790-B 1.3 mm/min; D256 Notched IZOD (Machine Notched) 6 mm x 12 mm; D2240 Type "D" (3, 5 seconds); D648 127 mm x 13 mm x 6,8 mm; D570 3.2 mm x 51 mm Disc 24hr@ 25°C; D792 solid 8 mm x 10 mm Disc; D5930 80 mm x 40 mm x 10 mm; E831 80 mm x 40 mm x 10 mm; D7867@ 25°C (77°F); D1475; D149 50 mm x 3 mm disc; D257 110 mm x 110 mm x 5 mm; D150 70 mm x 70 mm x 1.2 mm.
*The biological assessment has been performed based on the in vitro method according to ISO10993-23

**Internal Data Sources:**
[1] GEN329696, [2] FOR317892, [3] FOR317854, [4] FOR317895, [5] FOR338673, [6] FOR338726, [7] FOR332911, [8] FOR332913, [9] FOR331481, [10] FOR317866, [11] FOR332975, [12] FOR316403, [13] FOR332977,[14] FOR317904, [15] FOR317906, [21] FOR377534, [22] FOR377524, [25] FOR539856

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## PROPERTIES

### Liquid Properties

| | | | | |
|---|---|---|---|---|
| Viscosity at 25°C (77°F) | cP | ASTM D7867 | | 444 - 461 [18,19] |
| Liquid Density | g/cm³ | ASTM D1475 | | 1.09 – 1.10 [17,16] |
| **Electrical Properties** | **Measure** | **Method** | **Green** | **Post Processed** |
| Volume Resistivity | Ω·cm | ASTM D257 | - | $0.9 \cdot 10^{16}$ - $1.4 \cdot 10^{16}$ [23] |
| Surface Resistivity | Ω | ASTM D257 | - | $2.0 \cdot 10^{16}$ - $4.6 \cdot 10^{16}$ [23] |
| Dielectric Strength | kV/mm | ASTM D149 | - | 24.00 – 26.4 [24] |
| AC Relative Permittivity (Dielectric Constant)[25] | | | | |
| at 50 Hz (XY) | none | ASTM D150 | - | 3.2 - 3.8 |
| at 1 kHz (XY) | none | ASTM D150 | - | 3.4 - 3.8 |
| at 1 MHz (XY) | none | ASTM D150 | - | 2.5 - 3.3 |
| AC Loss Characteristic (Dissipation Factor)[25] | | | | |
| at 50 Hz (XY) | none | ASTM D150 | - | 0.107 - 0.147 |
| at 1 kHz (XY) | none | ASTM D150 | - | 0.054 - 0.094 |
| at 1 MHz (XY) | none | ASTM D150 | - | 0.208 - 0.348 |

**Test parameters:**
"All specimen are printed unless otherwise noted. All specimen were in ambient lab conditions at 19-23°C / 40-60% RH for at least 24 hours." ASTM Methods: D638 Type IV, 5mm/min; D790-B 1.3 mm/min; D256 Notched IZOD (Machine Notched) 6 mm x 12 mm; D2240 Type "D" (3, 5 seconds); D648 127 mm x 13 mm x 6,8 mm; D570 3.2 mm x 51 mm Disc 24hr@ 25°C; D792 solid 8 mm x 10 mm Disc; D5930 80 mm x 40 mm x 10 mm; E831 80 mm x 40 mm x 10 mm; D7867@ 25°C (77°F); D1475; D149 50 mm x 3 mm disc; D257 110 mm x 110 mm x 5 mm; D150 70 mm x 70 mm x 1.2 mm.
*The biological assessment has been performed based on the in vitro method according to ISO10993-23

**Internal Data Sources:**
[16] FOR332976, [17] FOR316402, [18] FOR323025, [19] FOR316377, [23] FOR402775, [24] FOR402788, [25] FOR402809

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## WORKFLOW

Validated workflows need to be followed to achieve properties as provided in the TDS. Examples of validated workflow steps are listed below. Users should defer to the most current workflow information for best results which can be found at https://www.loctiteam.com/printer-validation-settings

### PRINTER SETTINGS

LOCTITE 3D IND249 BK is formulated to print optimally on industrial DLP printer. Read the safety data sheet carefully to get details about health and safety instructions. Recommended print parameters:

- Shake resin bottle well before usage
- Temperature: 20°C to 35°C
- Intensity: 3 mW/cm² to 7 mW/cm²

| Settings: 385 nm at 5 mW/cm² | Measure | Method | Value |
|---|---|---|---|
| Layer Thickness (µm): | µm | Internal | 100 |
| Burn-in Region (s) | s | Internal | 30 |
| Transition Region (s): | s | Internal | 20 |
| Model Region (s): | s | Internal | 7 |

| Settings: 385 nm at 5 mW/cm² | Measure | Method | Value |
|---|---|---|---|
| $E_C$ | mJ/cm2 | Internal | 11.37 [1, 20] |
| $D_P$ | mm | Internal | 0.28 [1, 20] |

| Settings: 385 nm at 5 mW/cm² | Measure | Method | Exposure time |
|---|---|---|---|
| $D_C$ =100um | s | Internal | 1.82 [1, 20, *] |
| $D_C$ =50um | s | Internal | 1.30 [1, 20, *] |

**Test parameters:**
" Exposure times are calculated without a safety factor.

**Internal Data Sources:**
[1] GEN329696, [20] FOR328621

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### CLEANING

LOCTITE 3D IND249 BK requires post processing to achieve specified properties. Prior to post curing, support structures should be removed from the printed part, and the part should then be washed. Use compressed air to remove residual solvent from the surface of the material between intervals.

| Post Process Step | Agent | Method | Duration | Intervals | Additional Info |
|---|---|---|---|---|---|
| Cleaning Step #1 | IPA | Ultrasonic | 1 min | 1 | Dry after each interval |
| Cleaning Step #2 | IPA | Ultrasonic | 1 min | 1 | Dry after each interval |
| Dry | n.a. | Compressed air | 10 to 60 s | 1 | Air pressure (50psi) |
| Wait before post curing | n.a. | Ambient condition | 60 min | 1 | Room temperature |

### POST CURING

LOCTITE 3D IND249 BK requires post curing to achieve specified properties. It is recommended that either an LED or wide spectrum lamp be used to post cure parts.

If a lower energy LED or other post cure unit is used, an additional heat cure at 130°C for 2 hours may be required to realize highest HDT performance. Allow the parts to rest one hour between UV cure and heat cure. To minimize risk of warpage place parts in cold oven before ramping up temperature to target value and cool down parts slowly in switched off oven after reaching the heat curing conditions.

| UV Curing Unit | UV Source | Intensity | Cure time per side | Additional Settings (Shelf, Output Energy) | Heat Cure |
|---|---|---|---|---|---|
| Dymax 5000 EC Flood | Mercury Arc Bulb (broad spectrum) | 148 mW/cm² at 380 nm | 10 min | 400W, Shelf K | - |
| Loctite CL36 | 405nm LED | 80 mW/cm² at 405 nm | 30 min | 100% top & side | 2 hours at 130°C |
| PCU 90 | Metal halide | 100% | 20 min | Rotary Table | 2 hours at 130°C |

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Validated workflows need to be followed to achieve properties as provided in the TDS. Examples of validated workflow steps are listed below. Users should defer to the most current workflow information for best results which can be found at https://www.loctiteam.com/printer-validation-settings

### STORAGE

Store LOCTITE 3D IND249 BK in the unopened container in a dry location. Optimal Storage: 8°C to 30°. Storage below 8°C or above 30°C can adversely affect product properties. Material removed from containers may be contaminated during use. For this reason, filter used resin with 190µm mesh filter before placing back into proper storage container.

## TIPS & TRICKS

This section is a collection of useful advices, guides, and recommendations designed to help users of the LOCTITE 3D IND249 BK deal with specific process tasks more efficiently.

### RESIN USE

Use LOCTITE 3D IND249 BK within two weeks after having opened the bottle to assure stable mechanical properties.

Please make sure to do the Heat Curing at the same day as the post UV cuing step when using an LED based 405nm post curing device to get best mechanical properties in combination with an HDT of over 113 °C at 0.455 MPa.

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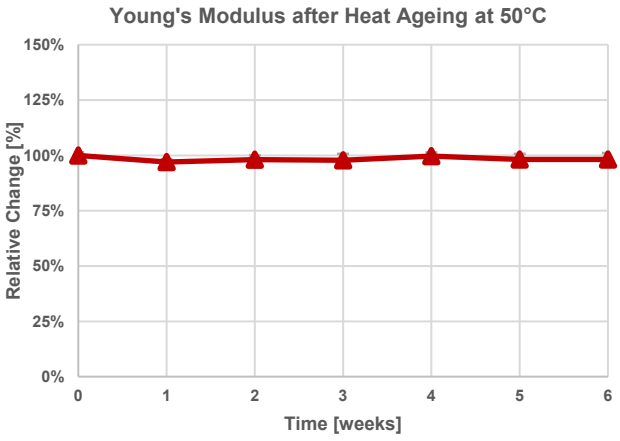
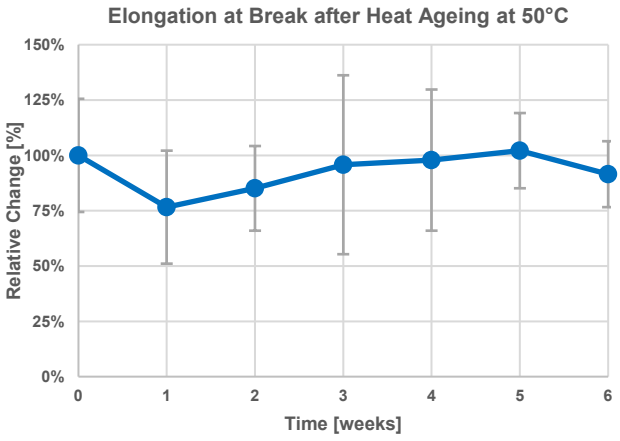
## AGEING AND ENVIRONMENTAL EFFECTS – HEAT AGEING

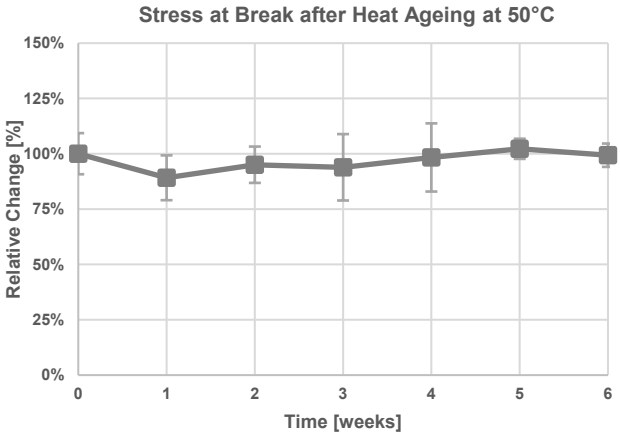
LOCTITE 3D IND249 BK was heat aged without load according to ASTM D3045. Test samples were exposed for a defined time at 50°C and conditioned for 24 hours at 22°C before mechanical testing. Control samples were stored at a constant 22°C. All samples were printed in the same print job using a validated workflow. Mechanical testing was conducted according to ASTM D638 at standard lab conditions (22°C).

"0 weeks" represents non-aged samples stored at 22°C and tested 24 hours after post-processing.

Based on temperature dependence of reaction rates a test time of 6 weeks at 50°C can be interpreted as approximately 12 months at ambient temperature.




**Test parameters:**
ASTM D638: Type IV, Pull speed: 5 mm/min, Young's modulus measured at 0.1-1.0% (regression), 22°C

**Internal Data Sources:**
FOR382546, FOR382551

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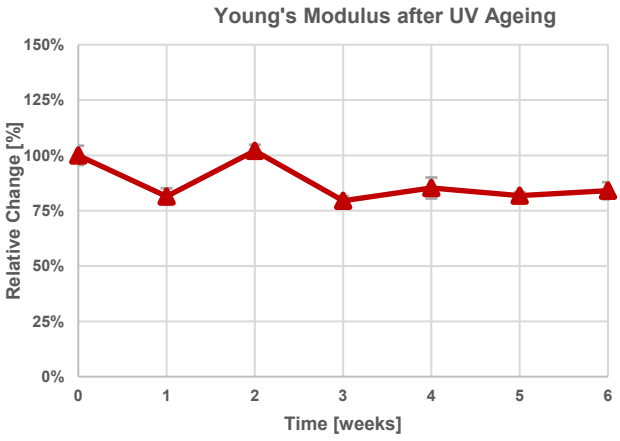
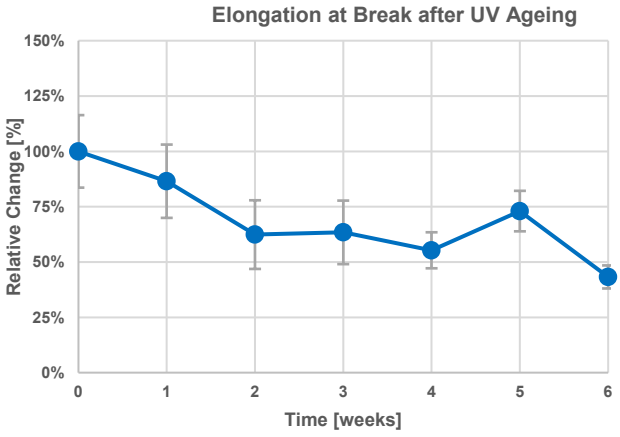
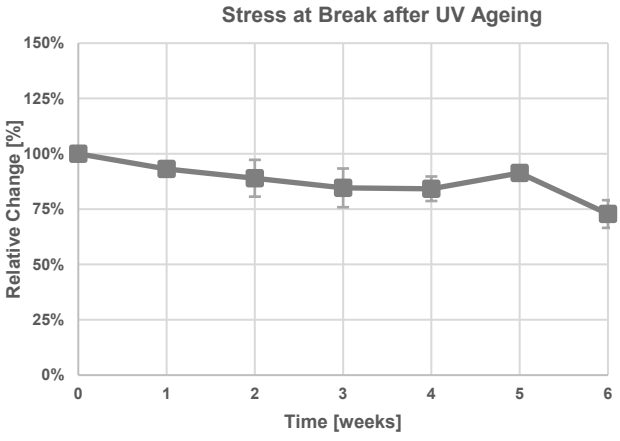
## AGEING AND ENVIRONMENTAL EFFECTS – ACCELERATED WEATHERING (UV AGEING)

LOCTITE 3D IND249 BK has been tested after accelerated outdoor weathering according to ASTM D4329 (Cycle A). Test samples were exposed to defined conditions of heat, water condensation and UV light. Exposed samples were conditioned for 24 hours at 22°C before mechanical testing. Control samples were stored at a constant 22°C. All samples were printed in the same print job using a validated workflow. Mechanical testing was conducted according to ASTM D638 at standard lab conditions (22°C). "0 weeks" represents non-aged samples stored at 22°C and tested 24 hours after post-processing.

Please note, accelerated weathering testing can never fully represent real outdoor conditions and complexity. It is therefore recommended to conduct additional (outdoor) testing relevant for your specific application needs.




**Test parameters:**
ASTM D638: Type IV, Pull speed: 5 mm/min, Young's modulus measured at 0.1-1% (regression), 22 °C
ASTM D4329: Cycle A for general applications, QUV/se, UVA 340 nm, 0.89 W/m²·nm, 8 hours UV light at 60°C followed by 4 hours at 50°C condensation in the dark. To reduce any sample warpage during test time samples were placed in tailor-made holders without any fixation clamps or mechanical load. Exposed samples were always removed from QUV before next condensation cycle to avoid samples that are soaked excessively with water before testing.

**Internal Data Sources:**
FOR390777, FOR390768

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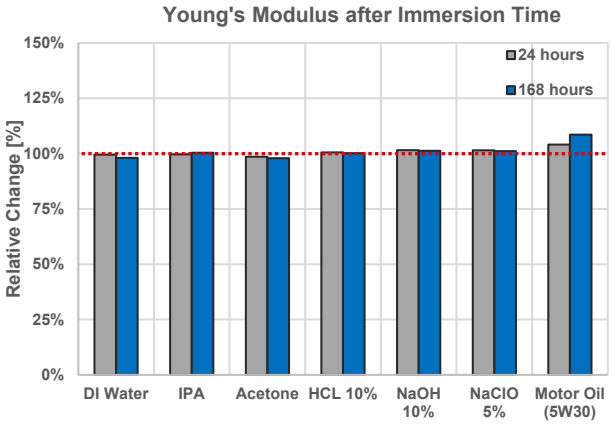
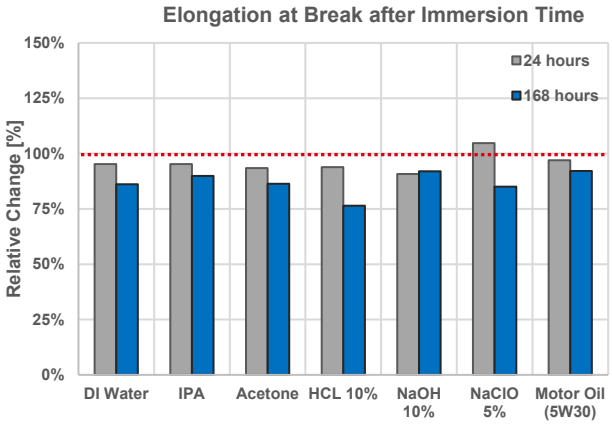
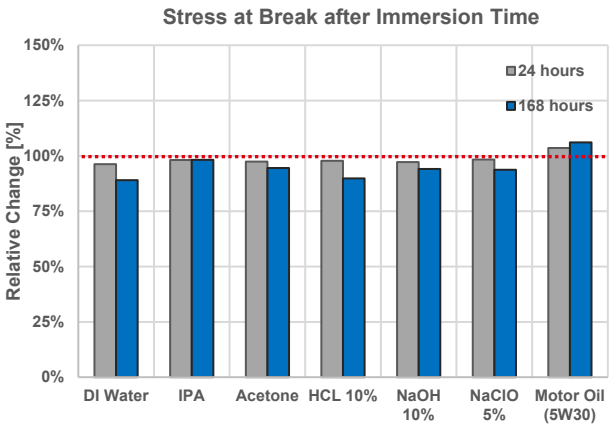
## AGEING AND ENVIRONMENTAL EFFECTS – CHEMICAL RESISTANCE (1/2)

LOCTITE 3D IND249 BK has been tested after chemical ageing according to ASTM D543. The influence of chemicals was tested by measuring mechanical properties after different test times (Immersion test for 24 and 168 hours). Exposed samples were stored in containers and fully immersed in different chemicals. Samples were stirred every 24 hours using a shaker. After removal, exposed samples were washed and conditioned for 24 hours at 22°C before mechanical testing. All samples were printed using a validated workflow. Mechanical testing was conducted according to ASTM D638 at standard lab conditions (22°C). "100%" represents non-aged samples stored at 22°C and tested 24 hours after post-processing.




**Test parameters:**
ASTM D638: Type IV, Pull speed: 5 mm/min, Young's modulus measured at 0.1-1.0% (regression), 22°C
ASTM D543: Samples immersed in different chemicals were stored at 22°C. Samples immersed in Motor Oil were stored at 50°C.
Properties of media used: pH(HCl, 10%) = 1; pH(NaOH, 10%) = 14; pH(NaClO, 5%) = 13

**Internal Data Sources:**
DI water: FOR423057, IPA: FOR423062, Acetone: FOR423064, HCl 10 %: FOR423065, NaOH 10 %: FOR402572, NaClO 5 %: FOR402575, 5W30: FOR402578

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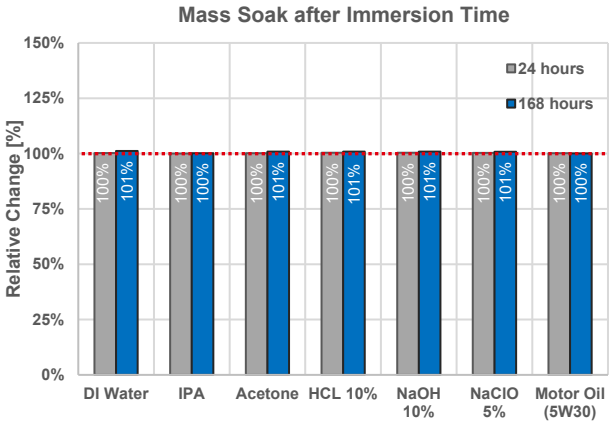
## AGEING AND ENVIRONMENTAL EFFECTS – CHEMICAL RESISTANCE (2/2)

LOCTITE 3D IND249 BK has been tested after chemical ageing according to ASTM D543. The influence of chemicals was tested by measuring the mass change after different test times (Immersion test for 24 and 168 hours). Exposed samples were stored in containers and fully immersed in different chemicals. Samples were stirred every 24 hours using a shaker. After removal exposed samples were washed, dried and immediately weighed. All samples were printed using a validated workflow. "100%" represents the initial weight 24 hours after post-processing.




**Test parameters:**
ASTM D543: Samples immersed in different chemicals were stored at 22°C. Samples immersed in Motor Oil were stored at 50°C.
Properties of media used: pH(HCl, 10%) = 1; pH(NaOH, 10%) = 14; pH(NaClO, 5%) = 13

**Internal Data Sources:**
DI water: FOR423067, IPA: FOR423069, Acetone: FOR423073, HCl 10 %: FOR423076, NaOH 10 %: FOR402584, NaClO 5 %: FOR402585, 5W30: FOR402586

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## NOTE

The information provided in this Technical Data Sheet (TDS) including the recommendations for use and application of the product are based on our knowledge and experience of the product as at the date of this TDS. The product can have a variety of different applications as well as differing application and working conditions in your environment that are beyond our control. Henkel is, therefore, not liable for the suitability of our product for the production processes and conditions in respect of which you use them, as well as the intended applications and results. We strongly recommend that you carry out your own prior trials to confirm such suitability of our product.

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