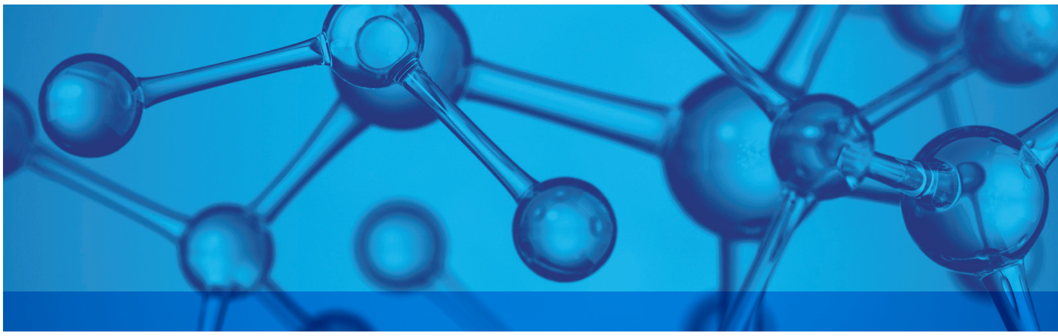

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Chemical Resistance of Specialty Polymers for Medical Equipment Housings

The Healthcare industry constantly strives to reduce hospital acquired infections by using stronger disinfectants and using them more aggressively. Only a handful of polymers have the chemical resistance to stand up to these new procedures, and they are quickly replacing lower performing polymers no longer able to perform as needed.

Solvay's broad portfolio of specialty polymers gives design engineers a range of performance capabilities for medical equipment components, including housings. They range from unfilled resins for toughness and glass-filled compounds for strength and stiffness. These higher performing materials make equipment components more durable and longer lasting, which translates to less downtime and reduced cost.

Solvay conducted a study comparing the chemical resistance of select specialty polymers to two incumbent polymers often used for equipment housings. An overview of these materials is presented in Table 1. Six commonly used disinfectants used in the study are listed in Table 2. Test methods for chemical exposure include immersion and Environmental Stress Crack Resistance (ESCR) similar to ASTM D543.

Test plaques, flex bars and tensile bars molded from each polymer were exposed to the various disinfectants at room temperature for 7 days. During the exposure period, in the case of ESCR testing, external stresses were applied to samples in tension mode by using bended jigs. After 7 days, the samples were visually inspected and evaluated for tensile strength, tensile modulus and impact resistance to determine the effect of chemical exposure and stress.

Table 1: Polymers selected for chemical resistance testing

Product Name	Polymer	Classification	Tensile Strength	Tensile Modulus	Impact Resistance
Incumbent-1	PC/PBT	Amorphous, unfilled	Medium	Medium	High
Incumbent-2	PC/ABS	Amorphous, unfilled	Medium	Medium	High
Udel® P-1700	PSU	Amorphous, unfilled	Medium	Medium	High
Radel® R-5800	PPSU	Amorphous, unfilled	Medium	Medium	High
Ixef® 1022	PARA	Semi-crystalline, glass filled	High	High	Low
Kalix® 5950	HPPA	Semi-crystalline, glass filled	High	High	Low
Amodel® A-1145	PPA	Semi-crystalline, glass filled	High	High	Low

Table 2: Disinfectants selected for chemical resistance testing

Type	Disinfectant
IPA	IPA 70 %
Aldehyde	Cidex® (2.4 % gluteraldehyde)
Hypochlorite	Clorox® Bleach (8.25 % sodium hypochlorite)
Phenolic	Vesphene® II SE
Quaternary ammonium chloride	Virex® TB
Quaternary ammonium chloride	3M™ Quat

Impact Performance after Chemical Immersion

Molded test samples were immersed in chemical disinfectants for 7 days at room temperature. Then, they were visually inspected and tested for Dynatup impact, which measures the material's toughness by vertically dropping a tup at a calculated distance onto the plaque sample. The energy to max load was obtained from a load-deflection curve, and then used to compare impact performance before and after immersion. Glass-filled grades were not included in Table 3 as they have inherently lower impact characteristics due to the glass fibers, making them unsuitable for high impact use.

If the retention of energy to max load for the sample was greater than 90 %, it was ranked as *Good*; less than 90 % was considered *Poor*. As shown in Table 3, PC/ABS samples exposed to Vesphene® IISE and Virex® TB lost their physical integrity and could not be tested. PC/PBT samples showed poor chemical resistance to three of the five disinfectants. Udel® PSU and Radel® PPSU exhibited better chemical resistance than the other polymers tested, which can be attributed to their molecular structures.

Table 3: Retention of Dynatup impact energy to max load after 7-day chemical immersion

Disinfectant	PC/ABS	PC/PBT	Udel® PSU	Radel® PPSU
IPA 70 %	Good	Good	Good	Good
Cidex® (2.4 % gluteraldehyde)	Good	Good	Good	Good
Clorox® Bleach (8.25 % sodium hypochlorite)	Good	Poor	Good	Good
Vesphene® II SE	Poor	Poor	NA	NA
Virex® TB	Poor	Poor	Poor	Good

Criteria: Good > 90 % retention; Poor < 90 % retention (lost integrity, could not be tested); NA = not available

ESCR After Chemical Exposure Under Constant Bending Stress

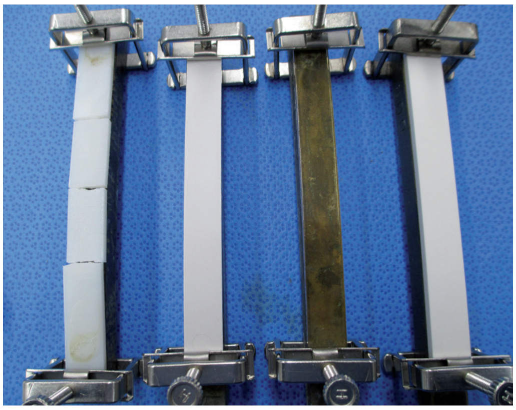
Molded flex bars were clamped onto bended jigs. Disinfectant soaked patches were applied onto the top surface of the flex bars for 7 days at room temperature. In order to accommodate for the varying modulus of the various base resins, the jigs were allowed different bending radii (or strain) in order to generate the same level of tension stress at top surface of the flex bars.

As chemicals weaken the material, the applied stress accelerates the formation of crazes and cracks and leads to breakage of the sample bars (Figures 1 and 2). After exposure, the sample surface was visually inspected for defects such as crazes and cracks. If no defects were observed, it was ranked as *Good*; otherwise, it was considered *Poor*.

After exposure to Virex® TB under low stress (7 MPa), only the PC/ABS sample broke (Figure 1). After exposure to Virex® TB under high stress (30 MPa), both PC/ABS and PC/PBT sample bars were broken (Figure 2). With the exception of Udel® PSU exhibiting some crazing, Solvay's polymers showed no defects or breakage, which demonstrates their superior chemical resistance to both incumbent materials (Table 4).

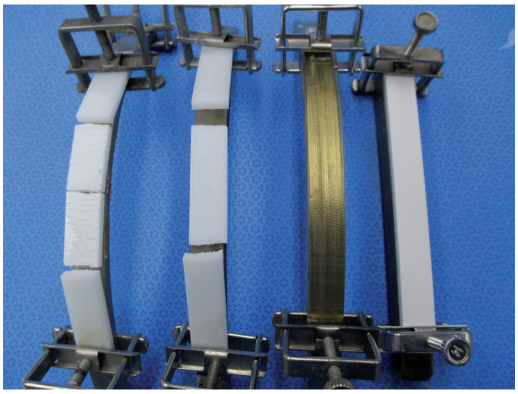
Solvay's polymers were also ESCR tested using six stronger chemical disinfectants. No cracking or crazing was observed with the exception of Udel® PSU, indicating that these materials demonstrate excellent chemical resistance (Table 5).

Figure 1: Test bars after 7-day exposure to Virex® TB under low constant bending stress (7 MPa)



PC/ABS PC/PBT Radel® PPSU Kalix® HPPA

Figure 2: Test bars after 7-day exposure to Virex® TB under high constant bending stress (30 MPa)



PC/ABS PC/PBT Radel® PPSU Kalix® HPPA

Table 4: ESCR results after 7-day exposure under high constant bending stress (30 MPa)

Disinfectant	PC/ABS	PC/PBT	Udel® PSU	Radel® PPSU	Kalix® HPPA	Ixef® PARA	Amodel® PPA
Virex® TB	Poor (broken)	Poor (broken)	Poor (crazes)	Good	Good	Good	Good

Criteria: Good = no surface defects; Poor = craze/crack

Table 5: ESCR results after 7-day exposure under high constant bending stress (30 MPa)

Disinfectant	Udel® PSU	Radel® PPSU	Kalix® HPPA	Ixef® PARA	Amodel® PPA
IPA 70 %	Good	Good	Good	Good	Good
Cidex® (2.4 % gluteraldehyde)	Good	Good	Good	Good	Good
Clorox® Bleach (8.25 % sodium hypochlorite)	Good	Good	Good	Good	Good
Vesphene® II SE	NA	NA	Good	NA	Good
3M™ Quat	Good	Good	NA	Good	NA
Virex® TB	Poor (crazes)	Good	Good	Good	Good

Criteria: Good = no surface defects; Poor = craze/crack; NA = not available

Tensile Properties After ESCR Chemical Exposure Under Constant Bending Stress

Tensile bars were exposed to the chemicals in a similar fashion as used for flex bars in ESCR testing. After 7 days of exposure under constant bending stress, tensile properties were evaluated using an Instron. Test data were compared to control samples (no exposure) in order to evaluate performance. If retention of tensile strength at break was greater than 90 %, it was ranked as *Good*; otherwise, it was considered *Poor*. Test results are provided in Table 7.

Table 6: Retention of tensile strength at break after 7-day ESCR chemical exposure under low constant bending stress (7 MPa)

Disinfectant	PC/ABS	PC/PBT	Udel® PSU	Radel® PPSU	Kalix® HPPA	Ixef® PARA	Amodel® PPA
IPA 70 %	Poor	Good	Good	Good	Good	Good	Good
Cidex® (2.4 % gluteraldehyde)	Poor	Good	Good	Good	Good	Good	Good
Clorox® Bleach (8.25 % sodium hypochlorite)	Poor	Good	Good	Good	Good	Good	Good
Vesphene® II SE	Poor (broken)	Good	Good	Good	Good	Good	Good
Virex® TB	Poor (broken)	Good	Good	Good	Good	Good	Good

Criteria: Good >90 % retention; Poor <90 % retention

Table 7: Retention of tensile strength at break after 7-day ESCR chemical exposure under high constant bending stress (30 MPa)

Disinfectant	PC/ABS	PC/PBT	Udel® PSU	Radel® PPSU	Kalix® HPPA	Ixef® PARA	Amodel® PPA
IPA 70 %	Poor	NA	Good	Good	Good	Good	Good
Cidex® (2.4 % gluteraldehyde)	Poor	NA	Good	Good	Good	Good	Good
Clorox® Bleach (8.25 % sodium hypochlorite)	Poor	NA	Good	Good	Good	Good	Good
Vesphene® II SE	Poor (broken)	NA	Good	Good	Good	Good	Good
Virex® TB	Poor (broken)	Poor (broken)	Good	Good	Good	Good	Good

Criteria: Good >90 % retention; Poor <90 % retention; NA = not available

Conclusion

Commonly used materials for medical housings, like PC/ABS and PC/PBT, can weaken and develop defects after repeated exposure to a variety of chemical disinfectants. When additional stress is added, it can accelerate the formation of defects, forming cracks and crazes.

Due to their intrinsic nature (molecular structure) Solvay's specialty polymers offer superior chemical resistance to PC/ABS and PC/PBT, and they exhibit little or no significant loss of mechanical properties when exposed to a variety of medical disinfectants under low and high stress conditions.

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