SUBSTRATE COMPATIBILITY USING CIP 100® ALKALINE PROCESS & RESEARCH CLEANER

OBJECTIVE

The objective of this study was to evaluate the effect of full immersion exposure to 1, 2 and 4% solutions of CIP 100 Process & Research Cleaner at 80°C (176°F) for one week using a variety of plastics, elastomers and metals.

BACKGROUND

Substrate compatibility is an important issue in the pharmaceutical and biotech industries. This study evaluated possible effects of CIP 100 cleaner on materials used in the pharmaceutical and biotech industries.

This study was designed to evaluate substrate compatibility in a systematic and quantitative manner through gravimetric, thickness and hardness evaluations before and after exposure to CIP 100 cleaner. A visual observation was also completed to assess the appearance of the coupons. In all instances, the results were compared with results from coupons exposed to Milli-Q® Water Purification System[1] at the same temperature (as a control).

PROTOCOL

Materials

The following elastomer, plastic and metal substances were used:

- Acrylonitrile-Butadiene-Styrene (ABS)
- Buna-N Rubber
- Chlorinated Polyvinyl Chloride (CPVC)
- Ethylene-propylene-diene 70 (EPDM 70)
- Neoprene
- Nylon 101
- High Density Polyethylene (HDPE)
- Polymethyl methacrylate (Plexiglas®[5])
- Polycarbonate (Lexan®[2])
- Polypropylene (PP)
- Polyvinyl Chloride (PVC)
- Polyvinylidene Fluoride (Kynar®[3])
- Silicon Rubber
- Polytetrafluoro-ethylene (Teflon®[4])
- Fluoroelastomer (Viton®[4])

The following metals were used:

- Aluminum 1100 (AL 1100)
- Anodized Aluminum (ANN)
- Brass (CDA 443)
- Cast Iron
- Copper (CDA 110)
- 1010 Mild Steel
- 304 Stainless Steel
- 316 Stainless Steel
- 316L Stainless Steel with Orbital Weld

All of the coupons used in the study were 3 x 1/2 x 1/16" and were either solid or had a hole punched in one end. The surface areas of the coupons were 22.20 cm^2 (solid) or 22.06 cm^2 (with hole). The orbital-welded 316L coupons were larger because they came from a different source.

The CIP 100 cleaner used in this study was lot number 218168.

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1. *Milli-Q® is a registered trademark of Merck KGAA.*
2. *Lexan® is a registered trademark of SABIC Innovative Plastics IPBV.*
3. *Kynar® is a registered trademark of Arkema, Inc.*
4. *Teflon® and Viton® are registered trademarks of E.I. duPont de Nemours and Company.*
5. *Plexiglas® is a registered trademark of Arkema France Corporation.*

Coupon Cleaning (pre-exposure)

All coupons used in the study were precleaned to remove contaminants. A solution of a neutral detergent, Manu-Klenz® Instrument Detergent (STERIS Corporation) composed of 8 mL of detergent per 100 mL of tap water, was used to clean the plastics and elastomer coupons. All materials were rinsed with water from the Milli-Q Water Purification System and allowed to air-dry overnight before studies commenced. Acetone was used to clean the metal coupons before the studies began. Two cleaned coupons of each type of metal, plastic and elastomer were used as unexposed controls for comparison purposes.

Coupon Cleaning (post-exposure)

After exposure to the test solutions, all materials were rinsed with tap water then rinsed with water from the Milli-Q Water Purification System. The plastic coupons were dried for an hour and then weighed. The metal coupons were further cleaned in acidic solutions in a sonicator. This was done to ensure that any oxide deposits would be removed before reweighing the coupons. The copper and brass coupons were cleaned in 10% sulfuric acid. The stainless steels, mild steel and cast iron were cleaned in 10% nitric acid. The aluminum 1100 and the anodized aluminum were cleaned in 100% nitric acid. The metal coupons that were cleaned with an acidic solution were rinsed with tap water, water from the Milli-Q Water Purification System and finally with acetone. Following drying, the coupons were weighed.

Measurement

The thickness of the plastic and elastomeric coupons was determined using a micrometer, and the hardness was found by using Shore® Instrument durometers[1]. A sharp-ended durometer (Type D) and a blunt-ended durometer (Type A) were used depending on the hardness of the material.

To take measurements, the durometer was grasped between the thumb and middle finger, with the index finger resting on the mounting knob. The durometer was then applied to the test article with an even and steady pressure until there was firm contact of the pressure foot with the test article. Application pressure was about two to three pounds on the test article. The test article was on a clean, hard surface so firm contact could be made. Hardness measurements of the test articles were taken approximately one to three seconds after the pressure foot was in firm contact with the test article.

Gravimetric studies were conducted using an analytical balance with readability to 0.1 mg. To conduct gravimetric studies, the coupons were weighed. A weigh boat was used on the balance so the coupon would not touch the balance or be contaminated by the balance in any way. Between different coupon types, the balance was re-zeroed and the measurements were taken to as many significant figures as the balance allowed. Weights of the plastic, elastomeric and metal coupons were taken before and after being exposed to the test solutions. Metal degradation rates were calculated in mils per year (mpy), per the following formula:

$$\text{mpy} = \frac{(\text{weight loss, g}) \times (3.45 \times 10^6)}{(\text{metal density, g/cm}^3) \times (\text{metal area, cm}^2) \times (\text{exposure time, hour})}$$

A micrometer was used to measure the thickness of all of the coupons. The micrometer was tightened on the coupon until the slightest bit of tension was felt. At that point, a measurement was taken. The measurements for thickness were made at each end of the coupon and at the center. An average was then taken of the three measurements.

Product Exposure

Eight-ounce glass jars were used to house the samples while they were exposed. Four conditions were used for the exposure:

Control: Water from the Milli-Q Water Purification System at 80°C (176°F)

Test Solution: Solution of 1% (v/v) CIP 100 cleaner at 80°C (176°F) – soft metals only

Test Solution: Solution of 2% (v/v) CIP 100 cleaner at 80°C (176°F)

Test Solution: Solution of 4% (v/v) CIP 100 cleaner at 80°C (176°F)

The conditions were labeled on the jar. For the orbital-welded 316L, there was only one coupon per jar for exposure. For all the other substrate types, three coupons were placed in each jar. Initially, the 1% solution of CIP 100 cleaner was used to submerge the soft metal (such as brass, copper, aluminum) coupons, and the 2% solution of CIP 100 cleaner was used to submerge all of the other coupons. All jars were then placed in a laboratory oven at 80°C (176°F) for one week. After this period, the coupons were removed from their respective solutions and cleaned as described above. Observations were made concerning the color of the coupons, cracking, crazing and pitting.

If the coupon was judged compatible with 2% CIP 100 cleaner, further testing was performed at 4% CIP 100 cleaner. The soft metals were deemed incompatible at 1%; therefore, no further testing was conducted. Three new coupons were obtained for each material compatible in 2% CIP 100 cleaner. The coupons were then submerged in 4% CIP 100 cleaner and placed in the oven at 80°C (176°F) for one week. After this period, the coupons were removed from their respective solutions and cleaned as described above. Observations were made concerning the color of the coupons, cracking, crazing and pitting.

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1. *Shore® Instrument is a registered trademark of Illinois Tool Works, Inc.*

RESULTS

Visual Observations (Tables 1 and 2)

The coupons were examined by visual observation. The observation tables show the corresponding differences observed. The changes in the appearance of the coupon indicated the compatibility of the coupon in each corresponding solution. The results are shown in **Tables 1 and 2**.

Weight Changes of Plastics and Elastomers (Table 3)

All of the percent weight changes for the elastomers and polymers were similar to the water control. In cases where there were very slight differences, in general the solutions of CIP 100 cleaner caused less weight increase than the water control.

Hardness Changes (Table 4)

In no cases did the change in hardness vary by more than a 10% absolute from the hardness of the water control.

Thickness Changes (Table 5)

In no cases did the change in thickness of any plastic or elastomeric coupon vary by more than a 5% absolute from the thickness change of the water control except in the case of Nylon 101 exposed to 4% CIP 100 cleaner.

Corrosion Rates of Metals (Table 6)

Significant increases in corrosion rates (as compared to the water control) were seen with the 1010 mild steel, the aluminum and the anodized aluminum.

CONCLUSIONS

This data is intended to provide assistance in terms of evaluating CIP 100 cleaner for compatibility with various substrates. Consideration should be given to the absolute changes following exposure, as well as to the changes relative to the water control. In addition, the relevance of this data should be considered in light of the actual application procedures used at a given facility, which typically involves much less rigorous (time, temperature, dilution rate) exposure conditions.

Table 1: Plastic Observations

Coupon Type	Control Visual Observations	Visual Observations of 2% CIP 100 Cleaner	Visual Observations of 4% CIP 100 Cleaner
ABS	Coupons slightly brown	Coupons unchanged	Coupons unchanged
Buna-N	Coupons unchanged	Coupons unchanged	Coupons unchanged
CPVA	Coupons unchanged	Coupons unchanged	Coupons unchanged
EPDM 70	Coupons unchanged	Coupons unchanged	Coupons unchanged
Polycarbonate (Lexan)	Coupons unchanged	Coupons are cracked on ends and sides	Coupons are cracked along edges and at identification number
Neoprene	Coupons have white pittings	Coupons unchanged	Coupons unchanged
Nylon 101	Coupons unchanged	Coupons unchanged	Coupons unchanged
HDPE	Coupons unchanged	Coupons unchanged	Coupons unchanged
Polymethyl methacrylate (Plexiglas)	Coupons unchanged	Coupons unchanged	Coupons unchanged
Polyvinylidene Fluoride (Kynar)	Coupons cloudy with brown edges	Coupons unchanged	Coupons darker along edges and light brown on surfaces
Polypropylene	Coupons unchanged	Coupons unchanged	Coupons unchanged
Polyvinyl Chloride (PVC)	Coupons unchanged	Coupons unchanged	Coupons unchanged
Silicone Rubber	Coupons unchanged	Coupons unchanged	Coupons unchanged
Polytetrafluoro-ethylene (Teflon)	Coupons unchanged	Coupons unchanged	Coupons unchanged
Fluoroelastomer (Viton)	Coupons unchanged	Coupons unchanged	Coupons unchanged except for removal of yellow mark on the back of the coupon

Table 2: Metal Observations

Coupon Type	Control Visual Observations	Visual Observations of 1% CIP 100 Cleaner	Visual Observations of 2% CIP 100 Cleaner	Visual Observations of 4% CIP 100 Cleaner
1100 Aluminum	Coupons are dull, dark gray around edges	Coupons unchanged	Coupons unchanged	Not applicable
Anodized Aluminum	Coupons are a dull gray color	Coupons unchanged	Not applicable	Not applicable
Brass (CDA 443)	Coupons are black with traces of gold color	Coupons are black/ brown	Not applicable	Not applicable
Cast Iron	Coupons are dark gray with gold speckles, edges are swollen and colored dark gray and gold	Not applicable	Coupons unchanged	Coupons are green and dark pink
Copper (CDA 110)	Coupons are dark brown with traces of copper color	Coupons are darker in color	Not applicable	Not applicable
1010 Mild Steel	Coupon surfaces and edges contain rusty spots	Not applicable	Coupons unchanged	Coupons unchanged
304 Stainless Steel	Coupons unchanged	Not applicable	Coupons unchanged	Coupons unchanged
316 Stainless Steel	Coupons unchanged	Not applicable	Coupons unchanged	Coupons unchanged
316L Stainless Steel w/Orbital Weld	Jar was cracked while in oven; no data collected	Not applicable	Coupons unchanged	Coupons unchanged

Table 3: Weight Change of Plastics

Coupon Type	Test Solution	Initial Average Weight	Final Average Weight	Average Weight Change*	Average Percent Change*
ABS	Control 2% CIP 100 Cleaner 4% CIP 100 Cleaner	1.5016 1.4920 1.4729	1.5285 1.5130 1.4804	0.0269 0.0210 0.0075	1.8 1.4 0.5
Buna-N	Control 2% CIP 100 Cleaner 4% CIP 100 Cleaner	2.3701 2.3971 2.3940	2.4636 2.4022 2.3680	0.0935 0.0050 (0.0260)	3.9 0.21 (1.1)
CPVC	Control 2% CIP 100 Cleaner 4% CIP 100 Cleaner	4.6695 4.6707 4.6634	4.6830 4.6840 4.6743	0.0135 0.0133 0.0108	0.3 0.3 0.2

Table 3: Weight Change of Plastics

Coupon Type	Test Solution	Initial Average Weight	Final Average Weight	Average Weight Change*	Average Percent Change*
EPDM 70	Control 2% CIP 100 Cleaner 4% CIP 100 Cleaner	3.5399 3.5416 3.5306	3.6021 3.5430 3.5195	0.0623 0.0014 (0.0112)	1.8 0.0 (0.3)
HDPE	Control 2% CIP 100 Cleaner 4% CIP 100 Cleaner	1.3504 1.3280 1.3588	1.3507 1.3278 1.3580	0.0003 (0.0001) (0.0008)	0.0 0.0 (0.1)
Neoprene	Control 2% CIP 100 Cleaner 4% CIP 100 Cleaner	2.1633 2.1561 2.1546	2.2359 2.1943 2.1475	0.0727 0.0382 (0.0071)	3.4 1.8 (0.3)
Nylon 101	Control 2% CIP 100 Cleaner 4% CIP 100 Cleaner	1.7769 1.7803 1.7829	1.8532 1.8594 1.8462	0.0763 0.0791 0.0632	4.3 4.4 3.5
Polymethyl methacrylate (Plexiglas)	Control 2% CIP 100 Cleaner 4% CIP 100 Cleaner	6.1974 6.2068 6.1947	6.2868 6.2945 6.2760	0.0894 0.0878 0.0813	1.4 1.4 1.3
Polycarbonate (Lexan)	Control 2% CIP 100 Cleaner 4% CIP 100 Cleaner	1.8789 1.8613 1.8713	1.8791 1.8588 1.8660	0.0002 (0.0025) (0.0052)	0.0 (0.1) (0.3)
Polypropylene (PP)	Control 2% CIP 100 Cleaner 4% CIP 100 Cleaner	1.3461 1.3462 1.3640	1.3464 1.3461 1.3637	0.0003 (0.0001) (0.0003)	0.0 0.0 0.0
Polyvinyl Chloride (PVC)	Control 2% CIP 100 Cleaner 4% CIP 100 Cleaner	2.1126 2.1064 2.1046	2.1537 2.1436 2.1387	0.0411 0.0372 0.0341	1.9 1.8 1.6
Polyvinylidene Fluoride (Kynar)	Control 2% CIP 100 Cleaner 4% CIP 100 Cleaner	2.5429 2.5158 2.5472	2.5453 2.5179 2.5479	0.0024 0.0021 0.0007	0.1 0.1 0.0
Silicone Rubber	Control 2% CIP 100 Cleaner 4% CIP 100 Cleaner	1.9984 1.9906 1.9892	1.9943 1.9836 1.9827	(0.0041) (0.0071) (0.0065)	(0.2) (0.4) (0.3)
Polytetrafluoro-ethylene (Teflon)	Control 2% CIP 100 Cleaner 4% CIP 100 Cleaner	3.3608 3.3715 3.3671	3.3605 3.3713 3.3672	(0.0003) (0.0003) 0.0001	0.0 0.0 0.0
Fluoroelastomer (Viton)	Control 2% CIP 100 Cleaner 4% CIP 100 Cleaner	2.6922 2.6909 2.9740	2.7857 2.7536 2.9772	0.0935 0.0627 0.0031	3.5 2.3 0.1

** NOTE: In this table, a weight decrease is noted in parentheses.*

Table 4: Hardness Change of Plastics

Coupon Type	Test Solution	Initial Average Hardness	Final Average Hardness	Average Change in Hardness*	Average Percent Change*
ABS	Control	62.6	66.6	4.0	6.4
	2% CIP 100 Cleaner	64.2	67.8	3.6	5.5
	4% CIP 100 Cleaner	63.3	68.9	5.6	8.8
Buna-N	Control	59.3	63.1	3.8	6.4
	2% CIP 100 Cleaner	63.9	65.6	1.7	2.6
	4% CIP 100 Cleaner	66.1	72.3	6.2	9.4
CPVC	Control	77.2	81.8	4.6	5.9
	2% CIP 100 Cleaner	77.0	81.3	4.3	5.6
	4% CIP 100 Cleaner	73.6	82.8	9.2	12.5
EPDM 70	Control	71.1	75.6	4.4	6.2
	2% CIP 100 Cleaner	73.1	77.3	4.2	5.8
	4% CIP 100 Cleaner	73.1	77.8	4.7	6.4
HDPE	Control	56.0	57.8	1.8	3.2
	2% CIP 100 Cleaner	53.4	60.3	6.9	12.9
	4% CIP 100 Cleaner	59.1	62.7	3.6	6.0
Neoprene	Control	62.9	67.1	4.2	6.7
	2% CIP 100 Cleaner	66.3	68.2	1.9	2.8
	4% CIP 100 Cleaner	68.0	71.2	3.2	4.7
Nylon 101	Control	70.0	68.4	(1.6)	(2.2)
	2% CIP 100 Cleaner	71.8	68.6	(3.2)	(4.5)
	4% CIP 100 Cleaner	70.9	71.0	0.1	0.2
Polymethyl methacrylate (Plexiglas)	Control	78.8	88.6	9.8	12.4
	2% CIP 100 Cleaner	79.9	88.7	8.8	11.0
	4% CIP 100 Cleaner	81.4	90.1	8.7	10.6
Polycarbonate (Lexan)	Control	78.6	81.9	3.3	4.2
	2% CIP 100 Cleaner	79.2	82.4	3.2	4.1
	4% CIP 100 Cleaner	81.4	81.4	0.0	0.0
Polypropylene (PP)	Control	55.4	61.3	5.9	10.6
	2% CIP 100 Cleaner	59.9	62.4	2.6	4.3
	4% CIP 100 Cleaner	60.1	62.3	2.2	3.7
Polyvinyl Chloride (PVC)	Control	75.7	76.0	0.3	0.4
	2% CIP 100 Cleaner	73.3	79.4	6.1	8.3
	4% CIP 100 Cleaner	79.6	78.6	(1.0)	(1.3)
Polyvinylidene Fluoride (Kynar)	Control	68.6	74.8	6.2	9.1
	2% CIP 100 Cleaner	71.8	74.1	2.3	3.2
	4% CIP 100 Cleaner	74.1	74.4	0.3	0.4
Silicone Rubber	Control	54.6	56.0	1.4	2.6
	2% CIP 100 Cleaner	56.2	58.3	2.1	3.8
	4% CIP 100 Cleaner	58.3	59.2	0.9	1.5
Polytetrafluoro-ethylene (Teflon)	Control	54.3	58.0	3.7	6.7
	2% CIP 100 Cleaner	55.7	59.3	3.7	6.6
	4% CIP 100 Cleaner	57.6	58.3	0.8	1.3
Fluoroelastomer (Viton)	Control	74.1	75.2	1.1	1.5
	2% CIP 100 Cleaner	75.8	75.9	0.1	0.1
	4% CIP 100 Cleaner	78.3	80.4	2.1	2.7

** NOTE: In this table, a decrease in Durometer reading is noted in parentheses.*

Table 5: Thickness Changes in Plastics

Coupon Type	Test Solution	Initial Average Thickness	Final Average Thickness	Average Change in Thickness*	Average Percent Change*
ABS	Control 2% CIP 100 Cleaner 4% CIP 100 Cleaner	1.537 1.537 1.520	1.603 1.607 1.577	0.067 0.070 0.057	4.3 4.6 3.7
Buna-N	Control 2% CIP 100 Cleaner 4% CIP 100 Cleaner	1.707 1.767 1.727	1.800 1.773 1.747	0.093 0.007 0.020	5.5 0.4 1.2
CPVC	Control 2% CIP 100 Cleaner 4% CIP 100 Cleaner	3.203 3.213 3.213	3.217 3.223 3.217	0.013 0.010 0.003	0.4 0.3 0.1
EPDM 70	Control 2% CIP 100 Cleaner 4% CIP 100 Cleaner	3.087 3.090 3.063	3.117 3.103 3.077	0.030 0.013 0.013	1.0 0.4 0.4
HDPE	Control 2% CIP 100 Cleaner 4% CIP 100 Cleaner	1.560 1.551 1.521	1.552 1.552 1.516	(0.008) 0.001 (0.005)	(0.5) 0.1 (0.3)
Neoprene	Control 2% CIP 100 Cleaner 4% CIP 100 Cleaner	1.600 1.600 1.610	1.663 1.640 1.623	0.063 0.040 0.013	4.0 2.5 0.8
Nylon 101	Control 2% CIP 100 Cleaner 4% CIP 100 Cleaner	1.607 1.593 1.600	1.630 1.617 1.624	0.023 0.023 0.026	1.5 1.5 1.6
Polymethyl methacrylate (Plexiglas)	Control 2% CIP 100 Cleaner 4% CIP 100 Cleaner	5.697 5.693 5.677	5.470 5.490 5.483	(0.227) (0.203) (0.193)	(4.0) (3.6) (3.4)
Polycarbonate (Lexan)	Control 2% CIP 100 Cleaner 4% CIP 100 Cleaner	1.613 1.600 1.613	1.617 1.607 1.607	0.003 0.007 (0.007)	0.2 0.4 (0.4)
Polypropylene (PP)	Control 2% CIP 100 Cleaner 4% CIP 100 Cleaner	1.530 1.520 1.563	1.547 1.553 1.570	0.017 0.033 0.007	1.1 2.2 0.4
Polyvinyl Chloride (PVC)	Control 2% CIP 100 Cleaner 4% CIP 100 Cleaner	1.592 1.581 1.606	1.718 1.688 1.684	0.126 0.107 0.079	7.7 7.0 4.9
Polyvinylidene Fluoride (Kynar)	Control 2% CIP 100 Cleaner 4% CIP 100 Cleaner	1.540 1.530 1.560	1.550 1.533 1.560	0.010 0.003 0.000	0.6 0.2 0.0
Silicone Rubber	Control 2% CIP 100 Cleaner 4% CIP 100 Cleaner	1.620 1.600 1.657	1.633 1.640 1.647	0.013 0.040 (0.010)	0.8 2.5 (0.6)
Polytetrafluoro-ethylene (Teflon)	Control 2% CIP 100 Cleaner 4% CIP 100 Cleaner	1.583 1.587 1.580	1.580 1.580 1.590	(0.003) (0.007) 0.010	(0.2) (0.4) 0.6
Fluoroelastomer (Viton)	Control 2% CIP 100 Cleaner 4% CIP 100 Cleaner	1.498 1.487 1.690	1.568 1.559 1.683	0.070 0.072 (0.007)	5.8 4.3 (0.4)

** NOTE: In this table, a thickness decrease is noted in parentheses.*

Table 6: Corrosion Rates of Metals

Coupon Type	Concentration	Initial Weight	Final Weight	Average Weight Change	Average Corrosion Rate, mpy*
1100 Aluminum	Control 1% CIP 100 Cleaner	3.6070 3.7082	3.6199 3.6204	0.0129 (0.0878)	(4.4) 30.1
Anodized Aluminum	Control 1% CIP 100 Cleaner	4.0264 4.0387	4.0207 3.9224	(0.0057) (0.1163)	1.9 39.1
Brass	Control 1% CIP 100 Cleaner	13.7524 13.6902	13.7480 13.6782	(0.0044) (0.0120)	0.5 1.3
Cast Iron	Control 2% CIP 100 Cleaner 4% CIP 100 Cleaner	12.4996 12.2754 12.4970	12.1572 11.9770 12.0100	(0.3424) (0.2984) (0.4870)	42.8 37.3 60.9
Copper	Control 1% CIP 100 Cleaner	13.4556 13.4266	13.4499 13.4219	(0.0057) (0.0047)	0.6 1.3
1010 Mild Steel	Control 2% CIP 100 Cleaner 4% CIP 100 Cleaner	11.0161 11.0274 11.0192	10.9545 10.6314 10.4846	(0.0616) (0.3960) (0.5346)	7.1 45.9 62.5
304 Stainless Steel	Control 2% CIP 100 Cleaner 4% CIP 100 Cleaner	11.0190 11.0002 11.0436	11.0185 10.9997 11.0431	(0.0005) (0.0005) (0.0005)	0.1 0.2 0.2
316 Stainless Steel	Control 2% CIP 100 Cleaner 4% CIP 100 Cleaner	11.1078 11.0879 11.0921	11.1072 11.0873 11.0917	(0.0006) (0.0006) (0.0004)	0.1 0.2 0.2
316L SS with Orbital Weld	Control 2% CIP 100 Cleaner 4% CIP 100 Cleaner	38.7677 38.5758 38.8665	38.7669 38.5749 38.8654	(0.0008) (0.0009) (0.0011)	0.1 0.1 0.1

**NOTE: In this table, a negative corrosion rate (a number in parentheses) indicates that weight is being added to the coupon rather than being removed.*

For further information, please contact:

STERIS Life Sciences

STERIS Corporation
5960 Heisley Road
Mentor, OH 44060-1834 ▪ USA
440-354-2600 ▪ 800-444-9009
www.STERISLifeSciences.com