



STERRAD[®] Testing of Color Anodized Finishes

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Introduction

- ▶ Increased popularity of color anodized aluminum for medical devices
- ▶ At issue is fade resistance for multi-use devices
 - ▶ STERRAD®
 - ▶ During the sterilization cycle, hydrogen peroxide is injected into the chamber and then irradiated to form a highly reactive and penetrating plasma that destroys organic substances it comes into contact with.
- ▶ Many anodizers have asked for advise



Purpose

- ▶ To determine best practices to produce STERRAD compatible parts by investigating:
 - ▶ Coloring technologies
 - ▶ Organic dyes
 - ▶ Inorganic pigments
 - ▶ Sealing technologies
 - ▶ Boiling
 - ▶ Mid-temperature
 - ▶ Cold
 - ▶ Duplex
 - ▶ Hi-Barrier Dual
 - ▶ Modified Hi-Barrier Dual



Procedure

- ▶ AA6061 flat sheet
- ▶ Alkaline soak cleaned
- ▶ Flash etched
- ▶ Anodized
 - ▶ 15 A/ft²
 - ▶ 45 minutes
 - ▶ 0.7- 0.8 mil
- ▶ Colored (details follow)
- ▶ Sealed (details follow)



Coloring Procedure

► Organic Dye

<u>Chemistry</u>	<u>Conc.</u>	<u>pH</u>	<u>Temp.</u>	<u>Immersion Time</u>	<u>Color</u>
Sanodal Red B3LW	5 g/l	5.6	140 F	20 min.	Red
Sanodye* Blue G	3 g/l	5.6	140 F	20 min.	Blue
Sanodal Green 3LW	3 g/l	5.6	140 F	20 min.	Green
Sanodal Deep Black HBL	10 g/l	5.6	140 F	20 min.	Black
Sanodye* Yellow 3GL	3 g/l	5.6	140 F	20 min.	Yellow
Sanodal Turquoise PLW	5 g/l	5.6	140 F	20 min.	Turquoise

**Also a Sanodal product*



Coloring Procedure

▶ Inorganic pigment (precipitation)

<u>Chemistry</u>	<u>Conc.</u>	<u>pH</u>	<u>Temp.</u>	<u>Time</u>	<u>Color</u>
Sanodal Gold 4N	20 g/l	5	140 F	10 min.	Gold
Step 1: $K_2Fe(CN)_6 \cdot 3H_2O$	10 g/l		70 F	2	
Step 2: $FeNO_3$	10 g/l		70 F	2	Blue



Coloring Procedure

▶ Inorganic pigment (electro-deposition)

<u>Chemistry</u>	<u>Voltage</u>	<u>Time</u>	<u>Color</u>
30 g/l CuSO4.5H2O 10 g/l MgSO4.7H2O 6 g/l H2SO4	18V AC	5 min.	Maroon
20 g/l Anodal Color TS-2 20 g/l H2SO4	18V AC	3 min.	Bronze
	18V AC	12 min.	Black



Sealing Procedure

► High temperature (boiling)

<u>ID</u>	<u>Type</u>	<u>Additive</u>	<u>Time</u>	<u>Temp.</u>	<u>pH</u>
1	Boiling water	3 g/l Anodal SH-1	45 min.	>205 F	5.7
2	Boiling nickel	7 g/l Anodal ASL	45 min.	>205 F	5.5





Sealing Procedure

▶ Mid-Temperature

<u>ID</u> <u>Type</u>	<u>Additive</u>	<u>Time</u>	<u>Temp.</u>	<u>pH</u>
3 Mid nickel	20 ml/l Anodal MS-1 New	20 min.	180 F	5.8



Sealing Procedure

▶ Room Temperature

<u>ID</u>	<u>Type</u>	<u>Additive</u>	<u>Time</u>	<u>Temp.</u>	<u>pH</u>
4	Step 1: Cold seal	3 g/l Anodal CS-3	15 min.	85 F	6
	Step 2: Hot water	3 g/l Anodal SH-1	15 min.	160 F	5.7
5	Step 1: Cold seal	3 g/l Anodal CS-3	15 min.	85 F	6
	Step 2: Hot nickel	7 g/l Anodal ASL	30 min.	160 F	5.5





Sealing Procedure

▶ Duplex

<u>ID</u>	<u>Type</u>	<u>Additive</u>	<u>Time</u>	<u>Temp.</u>	<u>pH</u>
6	Step 1: Hot nickel	7 g/l Anodal ASL	10 min.	160 F	5.5
	Step 2: Boiling water	3 g/l Anodal SH-1	45 min.	>205 F	5.7





Sealing Procedure

▶ Reference

<u>ID</u>	<u>Type</u>	<u>Additive</u>	<u>Time</u>	<u>Temp.</u>	<u>pH</u>
7	No seal - reference	n/a	n/a	n/a	n/a



Sealing Procedure

▶ Hi-Barrier Dual

<u>ID</u>	<u>Type</u>	<u>Additive</u>	<u>Time</u>	<u>Temp.</u>	<u>pH</u>
8	Step 1: Hot nickel	7 g/l Anodal ASL	15 min.	160 F	5.5
	Step 2: Boiling silicate	20 ml/l Anodal Si1000	15 min.	> 205 F	11



Sealing Procedure

▶ Modified Hi Barrier Dual

<u>ID</u>	<u>Type</u>	<u>Additive</u>	<u>Time</u>	<u>Temp.</u>	<u>pH</u>
9	Step 1: Cold seal	3 g/l Anodal CS-3	15 min.	85 F	6
	Step 2: Boiling silicate	20 ml/l Anodal Si1000	15 min.	> 205 F	11
10	Step 1: Cold seal	3 g/l Anodal CS-3	15 min.	85 F	6
	Step 2: Hot nickel	7 g/l Anodal ASL	15 min.	180 F	5.5
	Step 3: Boiling silicate	20 ml/l Anodal Si1000	15 min.	> 205 F	11



Application Testing

- ▶ **STERRAD**
 - ▶ Performed by Advance Sterilization Products
 - ▶ 100 cycles
 - ▶ Washed every 10 cycles



Test Results

▶ Organic Dyes

	<u>Seal</u> <u>1</u>	<u>Seal</u> <u>2</u>	<u>Seal</u> <u>3</u>	<u>Seal</u> <u>4</u>	<u>Seal</u> <u>5</u>	<u>Seal</u> <u>6</u>	<u>Seal</u> <u>7</u>	<u>Seal</u> <u>8</u>	<u>Seal</u> <u>9</u>	<u>Seal</u> <u>10</u>
<u>Sanodal Red B3LW</u>	Red	Red	Red	Light Red	Light Red	Red	Red	Light Red	Photo	Light Green
<u>Sanodye Blue G</u>	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red
<u>Sanodal Green 3LW</u>	Red	Red	Red	Light Red	Light Red	Red	Red	Light Green	Photo	Light Green
<u>Sanodal Deep Black</u>	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red
<u>HBL</u>	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red
<u>Sanodye Yellow 3GL</u>	Red	Red	Red	Light Green	Light Green	Red	Red	Light Green	Photo	Dark Green
<u>Sanodal Turquoise PLW</u>	Red	Red	Red	Light Red	Light Red	Red	Red	Light Red	Light Red	Light Red
Degree of Fading:	None	Dark Green	Some	Light Green	Most	Light Red	Complete	Red		



Review



► Modified Hi Barrier Dual

<u>ID</u>	<u>Type</u>	<u>Additive</u>	<u>Time</u>	<u>Temp.</u>	<u>pH</u>
9	Step 1: Cold seal	3 g/l Anodal CS-3	15 min.	85 F	6
	Step 2: Boiling silicate	20 ml/l Anodal Si1000	15 min.	> 205 F	11
10	Step 1: Cold seal	3 g/l Anodal CS-3	15 min.	85 F	6
	Step 2: Hot nickel	7 g/l Anodal ASL	15 min.	180 F	5.5
	Step 3: Boiling silicate	20 ml/l Anodal Si1000	15 min.	> 205 F	11



Test Results

▶ Inorganic Pigments

	<u>Seal 1</u>	<u>Seal 2</u>	<u>Seal 3</u>	<u>Seal 4</u>	<u>Seal 5</u>	<u>Seal 6</u>	<u>Seal 7</u>
<u>Inorganic Gold</u>			Photo				
<u>Inorganic Blue</u>			Photo				
<u>Inorganic Maroon</u>			Photo				
<u>Inorganic Bronze</u>			Photo				
<u>Inorganic Black</u>			Photo				

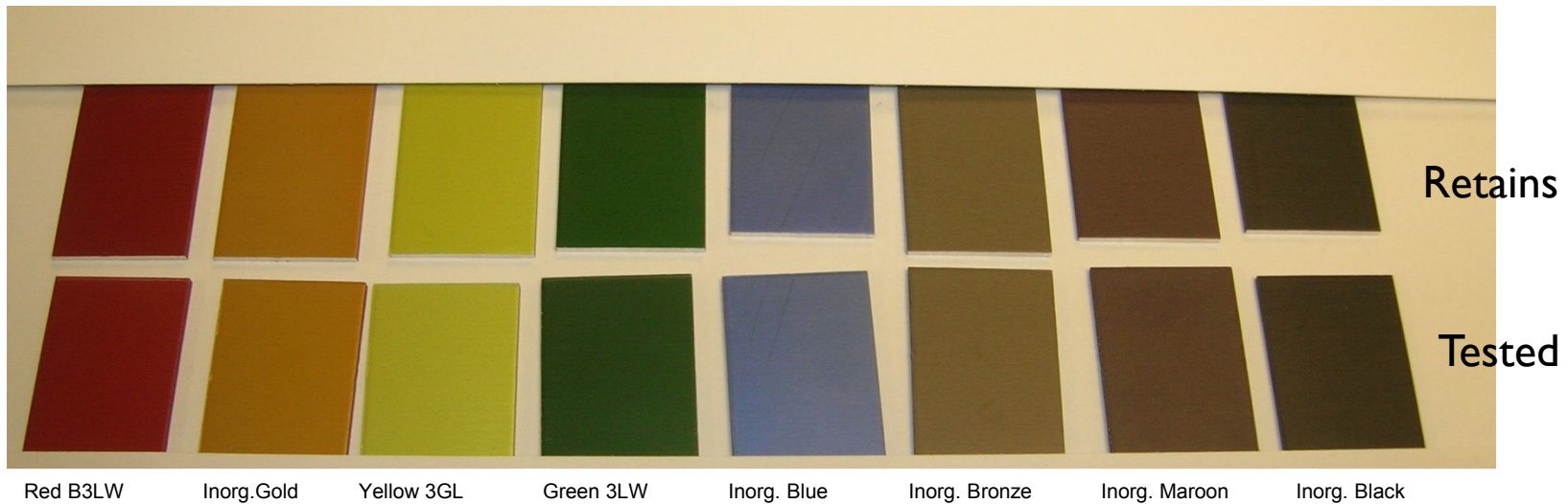
Degree of Fading: None  Some  Most  Complete 



Test Results



▶ Proven Color Range



Conclusions

- ▶ Conventional sealing methods will not protect dyes from fading – in most cases total color loss.
- ▶ Modified Hi-Barrier Dual (2-Step) seal will allow the use of some, (not all) dyestuffs for this application.
- ▶ Inorganic colors are unaffected by STERRAD sterilization and are therefore suitable for this application.
- ▶ A suitable range of color finishes include: Red, Gold, Yellow, Green, Blue, Bronze, Maroon and Black.



Acknowledgement



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