Analyzing the Photostability of Artist Adhesives Using CIELAB Color Measurements

Ashleigh Ferguson-Schieszer, Aaron N. Shugar and Judith C. Walsh
SUNY – Buffalo State Art Conservation Department

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Introduction

A comparative, qualitative study was conducted on nine artist adhesives to test their photochemical and thermal stability. Adhesives selected for testing are notably used in the field of printmaking. To estimate whether the adhesives would yellow over time, specimens from the nine samples were exposed to heat, or light and heat.

In this investigation, the change in lightness ΔL*, the change in red to greenness Δa*, the change in blue to yellowness Δb*, and the overall change in color ΔE* are reported.

Accelerated Aging Methodology

Each adhesive was brush applied to the reverse side of a Sekishu Japanese tissue, with the exception of Scotch Repositionable and 3M Super 77, which were spray applied, and Dura Mount film, which was applied by pressure. Once coated with adhesive, the Sekishu tissue was adhered to an Arches Rives BFK cotton printmaking paper. The two papers were run through a galley press and printed with a photomechanical image using a stiff carbon black lithography printing ink. Printed Laminates cured for seven days.

After constructed, the samples were divided into thirds. One third, located along the right side of each sample, was retained as an un-aged control. The top left third of each sample was artificially aged in a Q-sun Xenon Test Chamber with irradiance 0.35 W/m² at 340 nm and temperature set to 63° C (145°F). The bottom left thirds were subjected to prolonged heat exposure of 63° C (145°F) in a dark oven. Tests were set in accordance to *ASTM D4303 Standard Test Methods for Lightfastness of Colorants Used in Artists' Materials.*

Each sample was divided into thirds before testing:

Right sides: retained as un-aged controls

Top lefts: artificially light aged for 411 hours

Bottom lefts: exposed to heat for 450 hours

Samples After Accelerated Aging:

Photographed under halogen BR-40 flood lights with a D70 Nikon camera in RAW format (f/10, ISO 200) with the AIC PhotoDocumentation target.

CIELAB Color Measurements

CIELAB color measurements were calculated using two analytical techniques. A GretagMacbeth ColorEye® XTH spectrophotometer was used as the primary method to measure the change in intensity of electromagnetic radiation reflected from the aged and un-aged portions of each sample (Stratis. 2002).

As a comparative, alternative method for color measurement, L*a*b* measurement readings were recorded for all of the specimens from digital photographic documentation in Adobe Photoshop® with the Color Sampler Tool.

Data was collected for L* (lightness (black to white)), a* (red (+) or green (-)), and b* (yellow (+) or blue (-)). Total difference in color change, ΔE*, was calculated to asses the results.

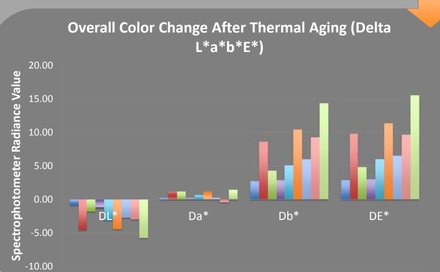
Due to inconsistencies in paper fiber color, measurements were based on an average of three readings, as shown below in measurement tables for Jade 403 PVA.

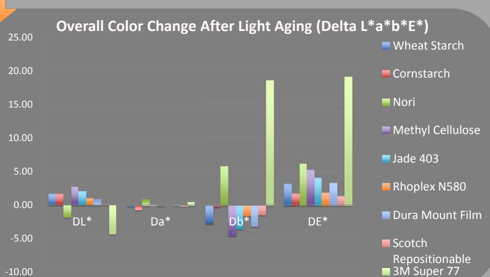
Adobe Photoshop® CIELAB Color Picker Measurements for Jade 403

	Light Exposure in Xenon Arc chamber					(63°C) Thermal Exposure in oven				
Jade 403	Hours Aged	L	a*	b*	ΔE	Hours Aged	L	a*	b*	ΔE
Average	**0.00**	**78.67**	**1.00**	**6.33**		0.00	**78.67**	**1.00**	**6.33**	
STD		1.89	0.00	0.47			1.89	0.00	0.47	
Average	217	**80.67**	**0.00**	**4.00**	**3.23**	166	**73.67**	**1.00**	**8.67**	**5.52**
STD		0.47	0.00	0.00			0.47	0.00	0.47	
Δ L a* b*		**2.00**	**-1.00**	**-2.33**			**-5.00**	**0.00**	**2.33**	
Average	**411**	**81.33**	**0.00**	**2.00**	**5.19**	**450**	**74.67**	**1.67**	**8.67**	**4.68**
STD		0.47	0.00	0.00			2.62	0.47	1.25	
Δ L a* b*		**2.67**	**-1.00**	**-4.33**			**-4.00**	**0.67**	**2.33**	

GretagMacbeth ColorEye® XTH Spectrophotometer Measurements for Jade 403

	Light Exposure in Xenon Arc chamber					(63°C) Thermal Exposure in oven				
Jade 403	Hours Aged	L	a*	b*	ΔE	Hours Aged	L	a*	b*	ΔE
Average	0.00	**91.90**	**-0.51**	**8.75**		0.00	**91.90**	**-0.51**	**8.75**	
STD		0.32	0.04	0.28			0.32	0.04	0.28	
Average	217	**93.64**	**-0.40**	**4.69**	**4.41**	166	**89.27**	**0.18**	**12.74**	**4.83**
STD		0.35	0.03	0.08			0.68	0.35	0.13	
Δ L a* b*		**1.73**	**0.11**	**-4.05**			**-2.63**	**0.69**	**3.99**	
Average	411	**93.90**	**-0.61**	**5.17**	**4.09**	450	**88.85**	**0.20**	**13.85**	**5.99**
STD		0.20	0.01	0.05			0.60	0.15	0.84	
Δ L a* b*		**1.99**	**-0.10**	**-3.57**			**-3.05**	**0.71**	**5.11**	





Lightfastness and Color Change

All adhesives exhibited more yellowing following dark heat aging than following light heat aging. During light aging, the adhesives overall increase in L* and decrease in both a* and b* values with the exceptions of Nori and 3M Super. Both Nori and 3M Super 77 decreased in L* and increased in b* and a* values. The light aging ΔE* values reflect these changes, and do not indicate yellowing in any adhesives other than Nori and 3M Super 77 (see above photograph). The traditional adhesives, such as methylcellulose and wheat starch paste, proved to be significantly more resistant to yellowing than any of the adhesives evaluated in both light aging and thermal aging. Recently popularized adhesives such as Dura Mount pressure sensitive film and Scotch Repositionable aerosol spray proved resistant to yellowing during light aging, but yellowed significantly during thermal aging. The data is compiled below based in the ASTM-D4303 lightfastness categories.

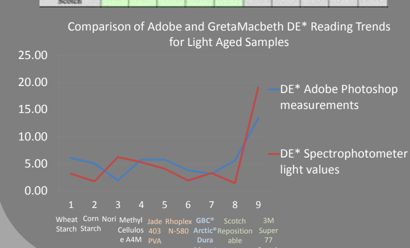
Adhesive	Average ΔE*	Light Aging ΔE*	ASTM Light-fastness category
Wheat starch paste	3.06	2.96	I
Corn starch	5.79	9.83	III
Nori paste	5.51	4.89	II
Methyl cellulose A4M	4.20	3.11	I
Jade 403 PVA	5.04	5.99	II
Rhoplex N-580	6.66	11.40	III
Dura Mount	4.96	6.61	II
Scotch Repositionable	5.59	9.73	III
3M Super 77 Scotch	17.03	15.50	III

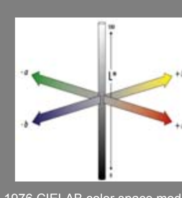
After 411 Hours of Light and Heat Exposure (63° C) in Xenon Arc Chamber

Adhesive	Adobe Photoshop Measurements					Spectrophotometer Values				
	ΔL*	Δa*	Δb*	ΔE*	STD	ΔL*	Δa*	Δb*	ΔE*	STD
Wheat starch paste	2.67	1.00	-5.33	6.05	0.72	1.62	-0.12	-2.71	3.16	0.21
Corn starch	1.67	1.00	-4.67	5.06	0.72	1.59	-0.66	-0.30	1.75	0.17
Nori paste	1.00	0.00	1.67	1.94	0.43	-1.91	0.80	5.88	6.24	0.82
Methyl cellulose	2.67	-1.00	-5.00	5.75	0.42	2.65	0.02	-4.58	5.29	0.06
Jade 403 PVA	2.67	-1.00	-4.33	5.75	0.16	1.99	-0.10	-3.57	4.09	0.09
Rhoplex N580	2.33	0.00	-3.00	3.80	0.16	0.95	-0.08	-1.66	1.91	0.21
Dura Mount	1.00	0.00	-3.00	3.16	0.42	0.84	0.07	-3.19	3.30	0.23
Scotch Repositionable	5.33	0.00	-1.67	5.59	0.43	0.14	-0.17	-1.42	1.44	0.23
3M Super 77 Scotch	3.00	1.00	13.00	13.38	0.43	-4.39	0.53	18.55	19.07	0.29

After 450 Hours of Dark Thermal Exposure in Oven (63° C)

Adhesive	Adobe Photoshop Measurements					Spectrophotometer Values				
	ΔL*	Δa*	Δb*	ΔE	STD	ΔL*	Δa*	Δb*	ΔE*	STD
Wheat starch paste	-1.67	-1.00	-2.33	3.04	1.34	-0.83	0.27	2.83	2.96	0.26
Corn starch	-2.33	1.00	2.67	3.68	1.70	-4.54	1.19	8.64	9.83	0.17
Nori paste	-2.67	0.33	2.67	3.79	1.04	-1.81	1.25	4.37	4.89	0.53
Methyl cellulose	-3.33	0.00	0.33	3.35	1.66	-1.17	0.30	2.87	3.11	0.21
Jade 403 PVA	-4.00	0.67	2.33	4.68	1.45	-3.05	0.71	5.11	5.99	0.53
Rhoplex N580	-2.00	2.00	5.67	6.33	0.31	-4.39	1.20	10.45	11.40	0.23
Dura Mount	-3.00	1.00	1.00	3.32	1.94	-2.65	0.33	6.05	6.61	0.36
Scotch Repositionable	2.33	0.33	5.67	6.14	0.73	-2.90	-0.28	9.28	9.73	0.36
3M Super 77 Scotch	-5.33	1.33	7.33	9.17	2.60	-5.71	1.53	14.32	15.50	1.52





1976 CIELAB color space model, Image Copyright ©2000 Adobe Systems Incorporated

Example of L*a*b* Photoshop® Color Sampler Tool measurements

Conclusions

When measuring CIE L*a*b* values, a much greater sensitivity of color change is detected by a spectrophotometer radiance with a smaller standard of deviation than by digital photograph color space readings in Adobe Photoshop, however, both yield similar comparative ΔE* results. Photoshop measurements are also subject to variable lighting conditions, despite attempts at lighting a sample evenly.

While the type of aging was shown to play a factor into whether an adhesive yellows, 3M Super 77 aerosol spray exhibited the highest degree of yellowing in both light aging and thermal aging.

Wheat starch paste and methyl cellulose remain the most stable adhesives for printmaking. Some Category II adhesives, such as Dura Mount, Scotch Repositionable, Rhoplex N580, and Jade 403, appear to be stable in light aging but not in dark thermal aging. Most surprisingly, Nori paste is not recommended for use since it was found to unacceptably yellow in both light and dark thermal aging.

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