MICOM INC.
LABORATOIRES · LABORATORIES

January 2, 2020

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TEST REPORT # MI-19-11811

On November 21st 2019, Micom Laboratories Inc. received 2 samples to perform accelerated Light Aging.

SAMPLES DESCRIPTION:

- Sample 1 : Arizona Trail 310
- Sample 2 : Volcano Ash 310

Samples 1 & 2

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Phone : 514-633-0078, fax : 514-633-7188

REFERENCE TEST METHOD:

Samples were exposed as per ASTM G155 Cycle 1 - Standard Practice for Operating Xenon Arc Light Apparatus for Exposure of Non-Metallic Materials.
The cycle consists of 102 min Light followed by 18 min Light and water spray (Air temp. not controlled).
Conditions in the Xenon Light chamber:

- Irradiance: 0.35 ± 0.02 W/m^2 @ 340 nm
- Filters: Daylight Filter (Borosilicate Inner/Borosilicate Outer Filter)
- Black panel: 63 ± 2.5 °C

Exposure duration: 1000hrs.
Samples were exposed: ☒ As received ☐ Preparation: - - - -

Type of equipment used with Xenon Arc emission lamp

Samples were rated according to:

- ASTM D523 (Specular Gloss)
- ASTM D2244 (Calculation of Color Tolerances and Color Differences from Instrumentally Measured Color Coordinates)

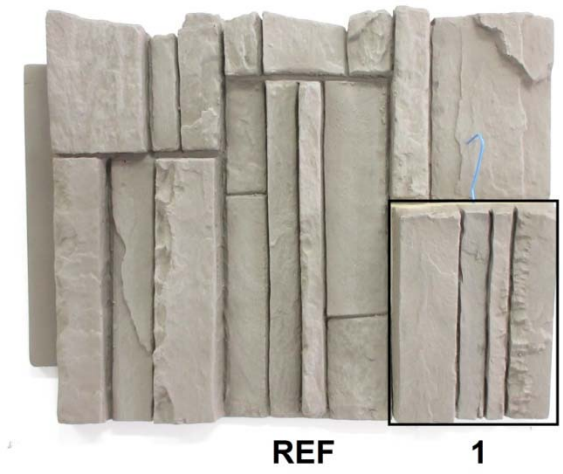
RESULTS:

Tests performed between 2019-11-21 and 2020-01-02.

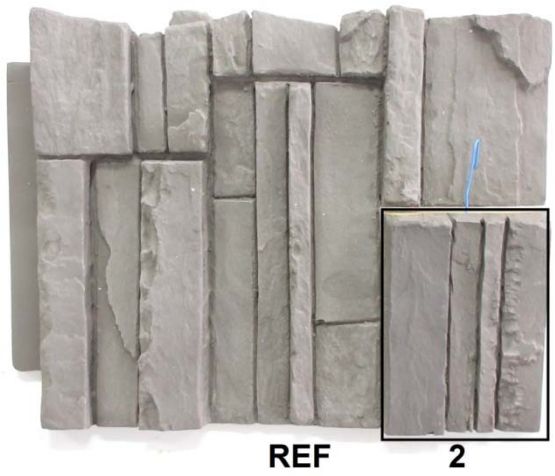
Sample	Exposition total hrs	Initials values			ASTM G155
		L*	a*	b*	Gloss 60°
1 Arizona Trail 310	1000	49.7	1.3	6.0	1.1
2 Volcano Ash 310	1000	40.9	0.8	2.5	0.9

- **100hrs**

Sample	100 hrs			ASTM G155	ΔL*	Δa*	Δb*	ΔE^*_{ab}	ΔGloss
	L*	a*	b*	Gloss 60°					
1 Arizona Trail 310	47.5	1.5	6.6	1.6	-2.2	0.3	0.6	**2.3**	**0.6**
2 Volcano Ash 310	39.5	0.8	2.4	1.2	-1.5	0.0	-0.1	**1.5**	**0.2**



Sample 1 after 100hrs exposure



Sample 2 after 100hrs exposure

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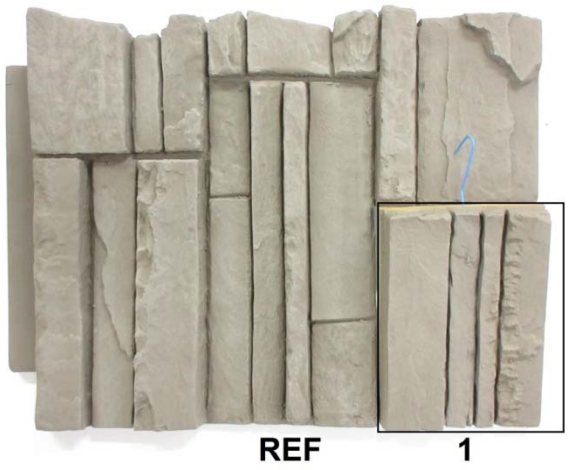
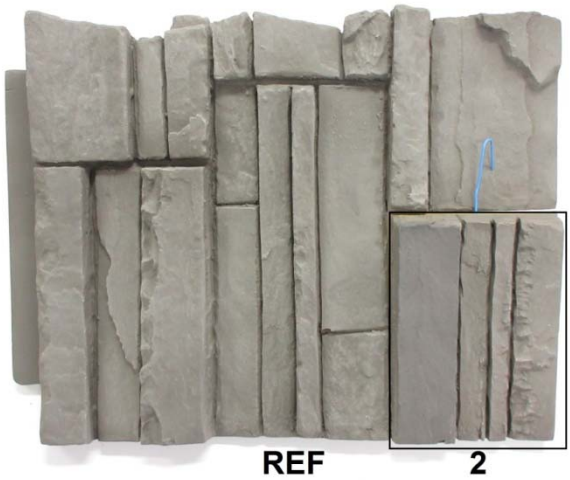
- **300hrs**

Sample	300 hrs ASTM G155				ΔL*	Δa*	Δb*	ΔE^*_{ab}	ΔGloss
	L*	a*	b*	Gloss 60°					
1 Arizona Trail 310	48.3	1.5	6.8	1.2	-1.3	0.2	0.8	**1.6**	**0.1**
2 Volcano Ash 310	40.4	0.8	2.4	1.0	-0.6	0.0	-0.1	**0.6**	**0.1**



Sample 1 after 300hrs exposure



Sample 2 after 300hrs exposure

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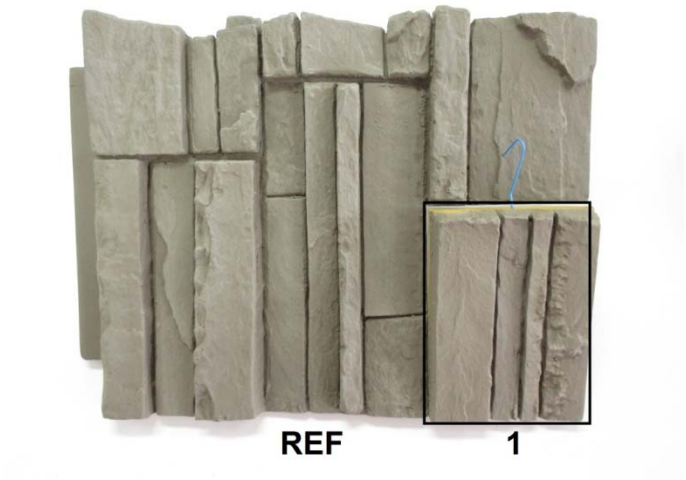
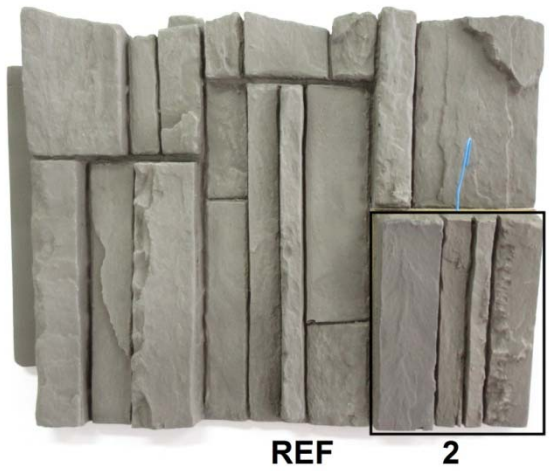
- **500hrs**

Sample	500 hrs ASTM G155				ΔL*	Δa*	Δb*	ΔE^*_{ab}	ΔGloss
	L*	a*	b*	Gloss 60°					
1 Arizona Trail 310	48.6	1.6	7.1	2.8	-1.1	0.3	1.1	**1.6**	**1.7**
2 Volcano Ash 310	40.5	1.0	2.8	1.4	-0.4	0.2	0.3	**0.6**	**0.5**



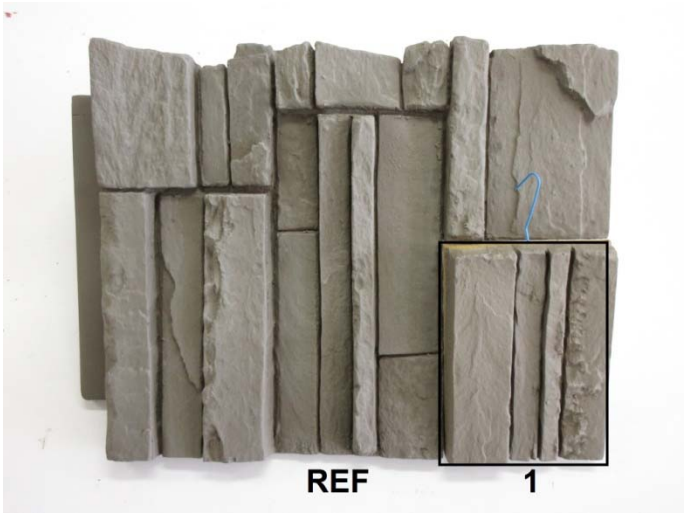
Sample 1 after 500hrs exposure



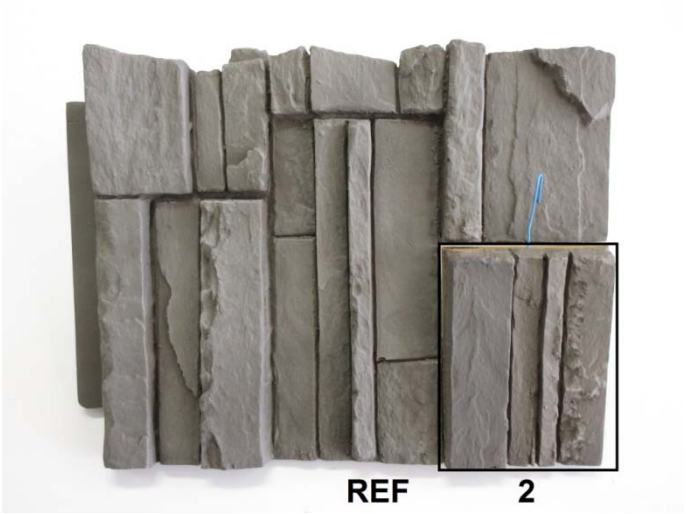
Sample 2 after 500hrs exposure

- **700hrs**

Sample	700 hrs ASTM G155				ΔL*	Δa*	Δb*	ΔE^*_{ab}	ΔGloss
	L*	a*	b*	Gloss 60°					
1 Arizona Trail 310	48.7	1.7	7.4	2.2	-0.9	0.4	1.4	**1.7**	**1.1**
2 Volcano Ash 310	40.8	0.9	2.8	2.0	-0.1	0.1	0.3	**0.3**	**1.1**



Sample 1 after 700hrs exposure



Sample 2 after 700hrs exposure

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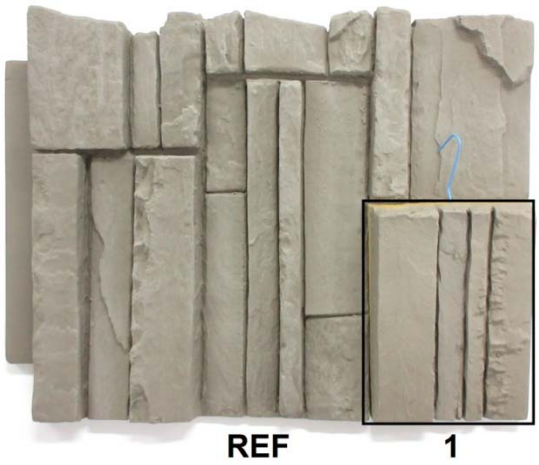
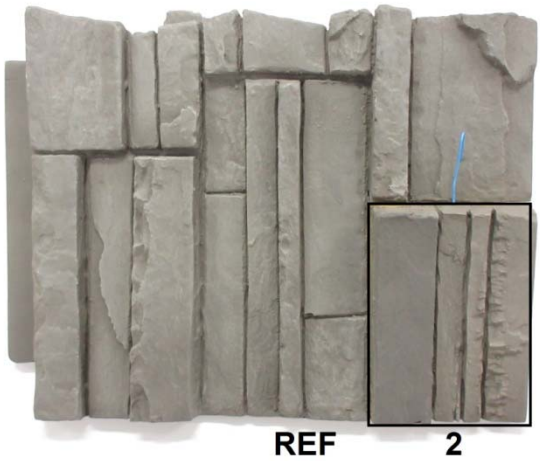
- **1000hrs**

Sample	1000 hrs ASTM G155				ΔL*	Δa*	Δb*	ΔE^*_{ab}	ΔGloss
	L*	a*	b*	Gloss 60°					
1 Arizona Trail 310	49.7	1.7	7.7	1.1	0.0	0.5	1.7	**1.8**	**0.0**
2 Volcano Ash 310	40.3	1.1	3.2	0.9	-0.7	0.3	0.7	**1.0**	**0.0**



Sample 1 after 1000hrs exposure



Sample 2 after 1000hrs exposure

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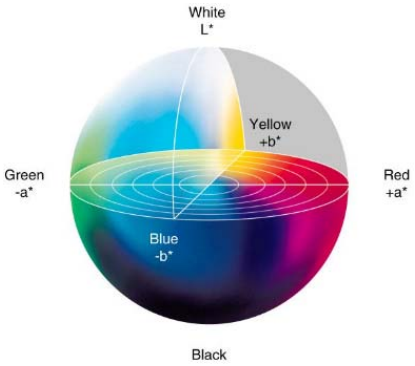
APPENDIX 1: Color & ΔE

L*.a*.b* values: color measurement

L*.a*.b*. coordinates refer to the coordinates of the color in the CIELAB 76 sphere. It is actually a three-dimensional space where the L* axis represents the "lightness" of the color (Black to white), a* is the green-red axis and b* is the blue-yellow axis. L* axis goes from 0 (darkest black) to 100 (brighter white), a* goes from -100 (green) to + 100 (red), b* goes from -100 (blue) to + 100 (yellow)[1].



ΔE (Delta E): Color difference measurement

In order to quantify the difference between 2 colors, a formula that measures the distance between the 2 colors was established and called ΔE (Delta E). The formula used to determine the distance between color 1 (L_1*, a_1*, b_1*) and color 2 (L_2*, a_2*, b_2*) is:

$\Delta E = [(L_2^* - L_1^*)^2 + (a_2^* - a_1^*)^2 + (b_2^* - b_1^*)^2]^{0.5}$

It was found that the *Just Noticeable Difference (JND)*[2] is, for most people, at ΔE = 2.3. That means that the magnitude of difference between 2 colors must be 2.3 or more to be noticed. Over the years, some industries came up with their own JND value based on specific needs and applications. The 2.3 value is, however, still widely used as the JND.

Other rating scales can also be found in the literature:

Scale #1[3]:

0.0 < ΔE ≤ 0.5: No color difference
0.5 < ΔE ≤ 1.0: Difference only perceivable for experienced observers
1.0 < ΔE ≤ 2.0: Minimal color difference
2.0 < ΔE ≤ 4.0: Perceivable color difference
4.0 < ΔE ≤ 5.0: Significant color difference
5.0 < ΔE : Different colors

Scale #2[4]:

0 < ΔE ≤ 1 : Observer does not notice the difference
1 < ΔE ≤ 2 : Only experienced observer can notice the difference
2 < ΔE ≤ 3.5 : Inexperienced observer can notice the difference
3.5 < ΔE ≤ 5 : Clear difference in color is noticed
5 < ΔE : Observer notices two different colors

[1] *a* and b* axis can technically go further than the usual ± 100 range but it never really happens in practice.*
[2] *Mahy et al. (1994)*
[3] *Published by Dr Bela Torok, M.D., Ph.D. (Ophthalmologist) on ResearchGate.net*
[4] *From « colour difference ΔE – A survey » by Mokrzycki W.S., Tatol M., University of Warmia and Mazury, August 2012.*