

De Novo Synthesis of Bio-Paint Using Bacteria; Analysis of Spectral Trends and Comparison to Commercial Paint

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Background

- Pigments are toxic to biota and environment
- Heavy metals classified as carcinogens
- Paint production processes pollute environment

Research Questions

- Is it possible to develop a paint with pigment produced by a transformed bacteria?
- How does the distribution of spectral intensity values of bio-paint compare to that of a commercial paint?
- Will the bio-paint maintain its spectral intensity over time under various testing conditions?

Hypotheses

- Biosynthetic pigment made by bacteria can be extracted and made into a usable bio-paint.
- Bacterial bio-paint will have spectral characteristics similar to that of a commercial paint (coefficient of variation within 20%) under different testing conditions [Room-Temperature (70°F), Heat (100°F), Cold (20°F), and Wetness] for 10 days.
- Bacterial bio-paint and commercial paint will maintain their spectral intensity (Total, Red, Green, Blue) under all testing conditions for 10 days (no trends).

Methodology

Paint Making -

1. Bacteria expressing magenta pigment were grown
2. Lysed with Triton X-100 and Hen Egg White Lysozyme (HEWL)
3. Solution incubated for 24 hours at room temperature
4. Centrifuged at 15000 RPM
5. Strained using a 0.22 μm filter
6. Dehydrated, yielding crystalline pigment powder
7. Mixed with acrylic medium

Comparison (Bio vs. Commercial) -

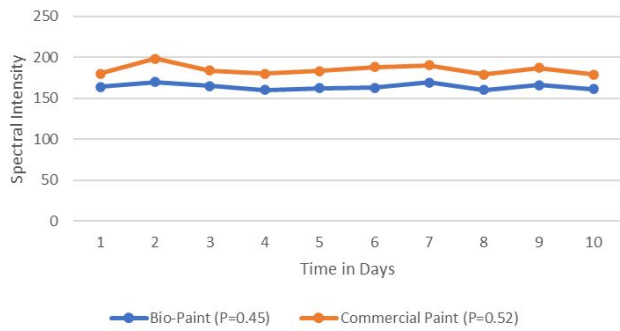
1. Four 1cm x 1cm squares of acrylic paper were painted with bio-paint and four with store-bought paint.
2. Room temperature (70°F); Heat (incubator at 100°F); Cold (freezer at 20°F); Wetness (room temperature and water drop each morning)
3. Spectral intensities measured (ColorPicker) for 10 days
4. The coefficient of variation in spectral intensity for both bio-paint and commercial paint was calculated for each testing condition.
5. A regression analysis was performed.
6. Microsoft Excel and Blue Sky Statistics Software

Results

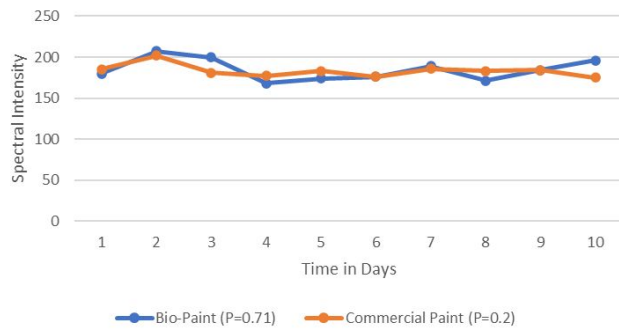
Table 1					
	Bio-Paint			Commercial Paint	
	Room Temperature (70°F)				
	Mean±SD	CV%	CV%DIF	Mean±SD	CV%
Red:	105.5±1.1	1.0	0.2	106.4±1.3	1.3
Green:	10.6±2.8	26.0	9.3	19.3±3.2	16.8
Blue:	47.9±1.6	3.3	0.0	59.1±2.0	3.3
Total:	164±3.5	2.2	1.1	184.8±6.1	3.3
	Heat (100°F)				
Red:	106.3±2.8	2.6	0.9	106.2±1.8	1.7
Green:	22.3±6.7	29.9	8.7	19±4.0	21.2
Blue:	55.9±4.8	8.5	4.4	58±2.4	4.1
Total:	184.5±13.2	7.1	2.9	183.2±7.7	4.2
	Cold (20°F)				
Red:	140.9±4.5	3.2	1.9	106.9±1.4	1.3
Green:	15.6±5.6	35.8	14.5	19.2±4.1	21.2
Blue:	61.5±6.4	10.3	7.5	59.3±1.7	2.9
Total:	218±15.2	7.0	3.8	185.4±5.9	3.2
	Wetness (Wet Conditions)				
Red:	116.3±3.2	2.7	1.3	104.8±1.5	1.4
Green:	15.7±5.0	32.1	8.8	18.5±4.3	23.2
Blue:	49.4±6.4	12.9	7.9	57.2±2.9	5.0
Total:	181.4±11.4	6.3	1.8	180.5±8.2	4.5

Table 1 shows spectral intensity characteristics and CV% difference

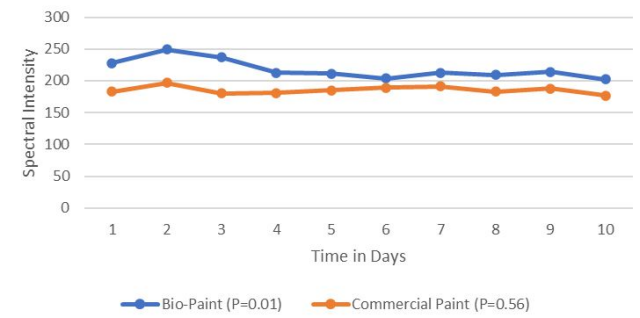
Room Temperature - Total



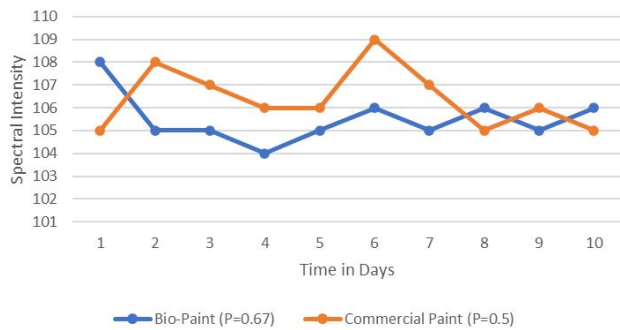
Heat - Total



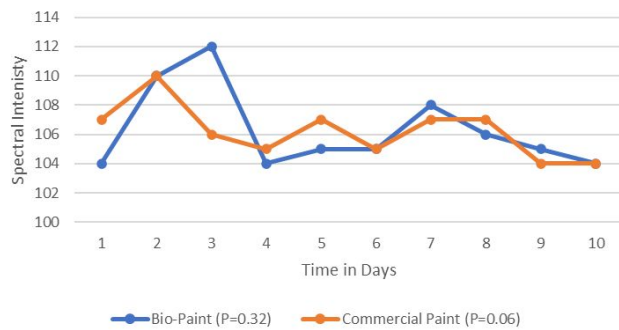
Cold - Total *



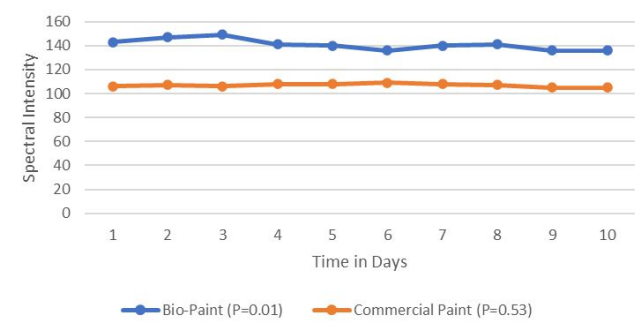
Room Temperature - Red



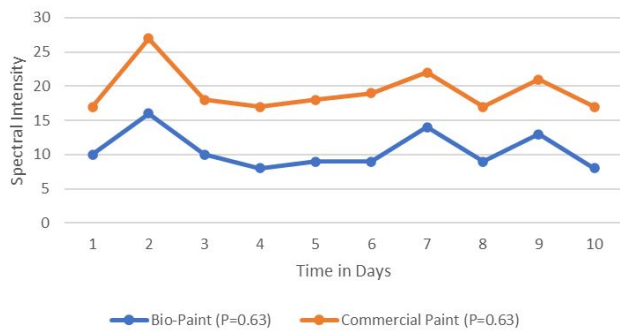
Heat - Red



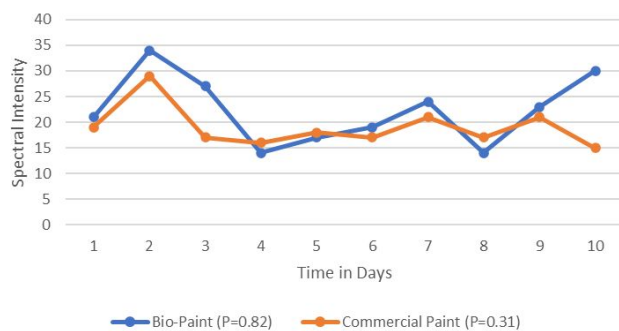
Cold - Red *



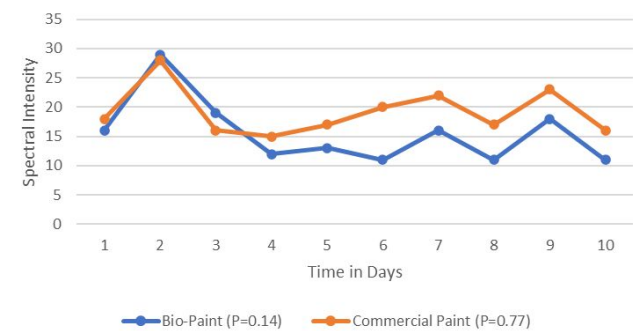
Room Temperature - Green



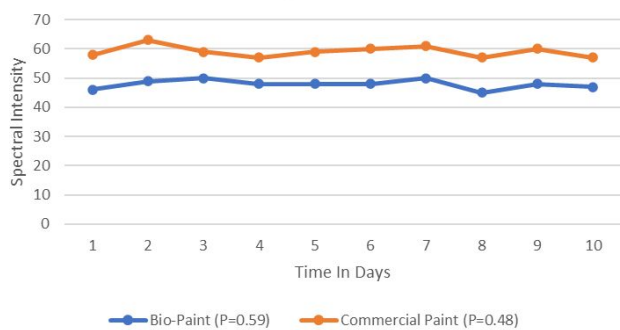
Heat - Green



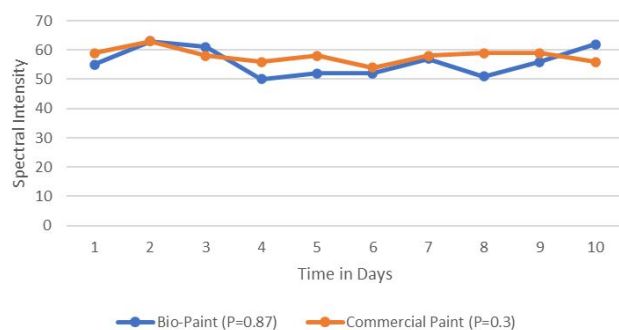
Cold - Green



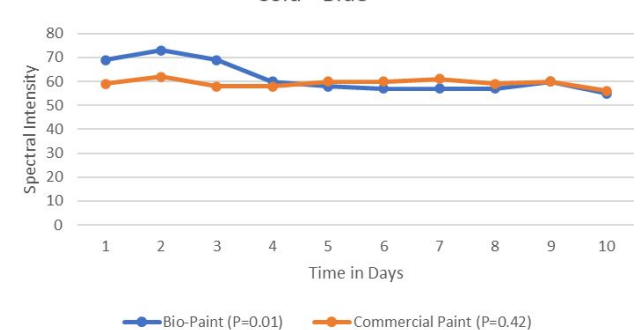
Room Temperature - Blue



Heat - Blue



Cold - Blue *



Interpretations and Conclusions

- Bacterial pigments can be made into bio-paint, supporting hypothesis #1.
- CV% differences were <20%, supporting hypothesis #2.
- Bio-paint and commercial paint are
- No linear trend for commercial paint (p-values >0.05).
- No linear trend for bio-paint under Room Temperature, Heat, and Wetness conditions.
- Cold condition total, red, and blue intensities for bio-paint changed significantly (p-values of <0.05), proving hypothesis #3 partially incorrect.
- The actual difference is quite small (Total: 3.79, Red: 1.13, Blue: 1.74)
- Possibility that the difference was detected because of multiple comparisons (family-wise error rate is 0.81).

- Results suggest that bio-paint could be a viable alternative to commercial paint
- Bio-paint maintains spectral characteristics similar to commercial paint under all testing conditions, except for cold.

Limitations and Future Study

- Small sample size
- Bio-paint was more globular than the commercial paint. Finely grinding may address this problem.
- Drying time was also longer (7 minutes vs. 1 minute).
- Tedious and expensive. Amount of pigment may not be economical. Fungi could be more economically feasible.
- Tested for 10 days. Will durability characteristics remain?
- Performance under other conditions
- Only one color, results may not apply to other pigments.
- The measuring instrument could have introduced an error (unlikely as it has good precision). Next time, I would like to use a spectrometer.
- Has a viable role where a toxic pigment can be replaced with a bio-pigment. May have a role in cosmetology.