UV Stability of BioEstolides™

Biosynthetic® Technologies is a specialty chemicals company that supplies BioEstolides™ to the Beauty and Personal Care industry. We produce non-toxic, eco-friendly, sustainable, biobased, biodegradable oils with enhanced performance properties available in commercial volumes. Our vision at Biosynthetic Technologies is to deliver high-performing, sustainable solutions for a sustainable future.

Abstract: All five BioEstolides™ and castor oil were compositionally stable after 8 weeks of exposure to indirect sunlight (11-14 hours per day). No significant changes in viscosity were detected in the samples. Acid values of the BioEstolide™ 30, BioEstolide™ 250 and BioEstolide™ 1300 did change initially, but plateaued during the study. All BioEstolides™ and castor oil bleached to a lighter color over the course of the study. The BioEstolide™ samples remained clear throughout the study while the castor oil began to flocculate by week 4.

From the data, BioEstolides™ are UV stable within the parameters of this study.

Summary

The objective of this report is to provide data on BioEstolides™' UV stability when exposed to natural sunlight through a standard window that has no additional UV blocker. BioEstolide™ 30, 250, and 1300, 250-100 and 1300-100 were directly compared to castor oil.

1. **Materials**
   - BioEstolide™ 30: Biosynthetic Technologies (Lot AA350017)
   - BioEstolide™ 250: Biosynthetic Technologies (Lot AA080005)
   - BioEstolide™ 1300: Biosynthetic Technologies (Lot AA090008)
   - BioEstolide™ 250-100: Biosynthetic Technologies (Lot AA150007)
   - BioEstolide™ 1300-100: Biosynthetic Technologies (Lot AA2C0023)
   - Castor oil: Walmart
   - 8 oz Jars: Quality Environmental Containers (QEC), (Type III Soda-Lime Glass, Flint)

2. **General Procedure**
   - Individually fill an 8 oz jar with BioEstolide™ 30, BioEstolide™ 250, BioEstolide™ 1300, BioEstolide™ 250-100, BioEstolide™ 1300-100 and castor oil.
   - Seal each jar with an appropriate size lid (a nitrogen buffer was *not* used on these samples)
   - Place all jars in a south facing, transparent glass window that receives sunlight for 10+ hours per day (Table 1).
   - Test samples at 0 (control sample), 2, 4 and 8 weeks for Gardner color, acid value, dynamic viscosity at 100°C and specific gravity.
   - Conduct study over 8 weeks from August 8 to October 3, 2023.
   - Temperatures in the window fluctuated between 22 to 37°C over the course of two months.
   - Samples were run using a Genesys 10S UV-Vis spectrometer with Visionlight Colorcalc software.

Table 1. Exposure parameters of the study

Sample Date	*Sunrise*	*Sunset*	*Hours UV*	*Factors not controlled*
August 8, 2023	6:49	8:50	14.02	Hours per day of direct light
August 22, 2023	7:03	8:32	13.48	Cloud cover
September 5, 2023	7:16	8:09	12.88	Temperature (max temp in oil was 35°C)
October 3, 2023	7:42	7:24	11.70	Location (Indianapolis, IN)

3. Results

In 2020, a 10-week test was conducted using BioEstolide™ 30, BioEstolide™ 250 and BioEstolide™ 1300 as well as castor oil and sunflower oil. Only Gardner color was run on these samples. Each oil became lighter over time (bleached). The BioEstolide™ 250-100 and the BioEstolide™ 1300-100 were not developed at this time.

This study expands the test to include the newest BioEstolides™ and to look at the impact of UV on acid value, viscosity, and specific gravity to determine if other changes are occurring in the products.

Table 2. Gardner color values of samples evaluated over 8 weeks

	Week	Gardner Color	Acid Value	Viscosity at 100°C	Specific Gravity	Visual
BioEstolide™ 30	0	3.1	0.34	4.1	0.907	Clear, bright
	2	1.9	0.43	4.2	0.909	Clear, bright
	4	1.0	0.46	4.2	0.907	Clear, bright
	8	0.6	0.48	4.2	0.906	Clear, bright
Change from week 0		-2.5	0.14	0.1	-0.001	
BioEstolide™ 250	0	3.6	0.43	19.0	0.915	Clear, bright
	2	2.7	0.53	18.9	0.915	Clear, bright
	4	2.2	0.56	18.9	0.915	Clear, bright
	8	1.7	0.60	18.9	0.915	Clear, bright
Change from week 0		-1.9	0.17	-0.1	0.000	
BioEstolide™ 1300	0	4.2	0.37	70.5	0.919	Clear, bright
	2	3.3	0.73*	71.0	0.920	Clear, bright
	4	2.9	0.53	70.4	0.920	Clear, bright
	8	2.4	0.57	70.2	0.922	Clear, bright
Change from week 0		-1.8	0.20	-0.3	0.003	
BioEstolide™ 250-100	0	3.4	0.33	21.0	0.93	Clear, bright
	2	3.1	0.35	21.6	0.93	Clear, bright
	4	2.7	0.35	21.6	0.93	Clear, bright
	8	2.6	0.36	21.6	0.93	Clear, bright
Change from week 0		-0.8	0.03	0.6	0.000	
BioEstolide™ 1300-100	0	4.6	0.97	72.0	0.930	Clear, bright
	2	4.4	0.96	71.0	0.932	Clear, bright
	4	4.1	0.97	71.7	0.931	Clear, bright
	8	3.7	1.02	71.8	0.931	Clear, bright
Change from week 0		-0.9	0.05	-0.2	0.001	

	Week	Gardner Color	Acid Value	Viscosity at 100°C	Specific Gravity	Visual
Castor oil	0	1.5	1.16	17.5	0.962	Clear, bright
	2	0.8	1.18	17.5	0.965	Clear, bright
	4	0.7	1.18	17.5	0.962	Suspended particulates
	8	0.6	1.15	17.5	0.963	Suspended/settled particulates
Change from week 0		-0.9	-0.01	0.0	0.001	

*Outlier – data point not used for acid value plot

Viscosity and Specific Gravity

None of the test samples resulted in statistically significant changes in viscosity or specific gravity over the 8-week study.

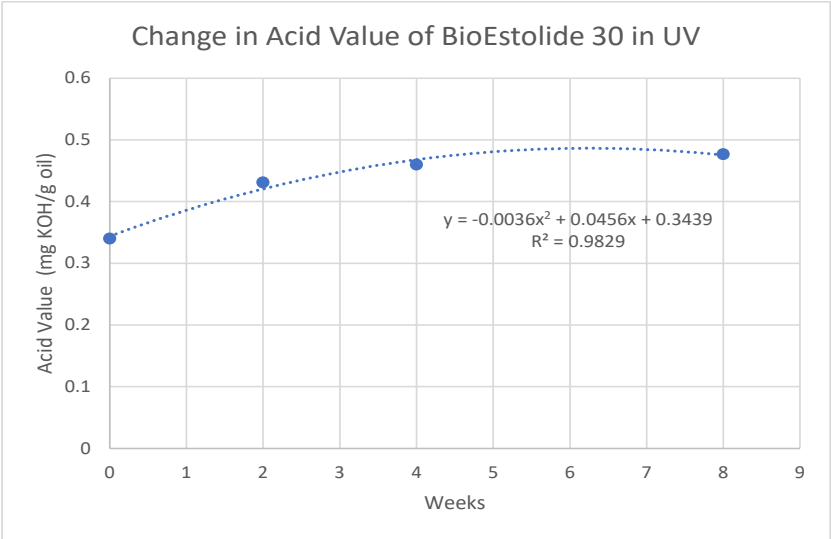
Acid Value

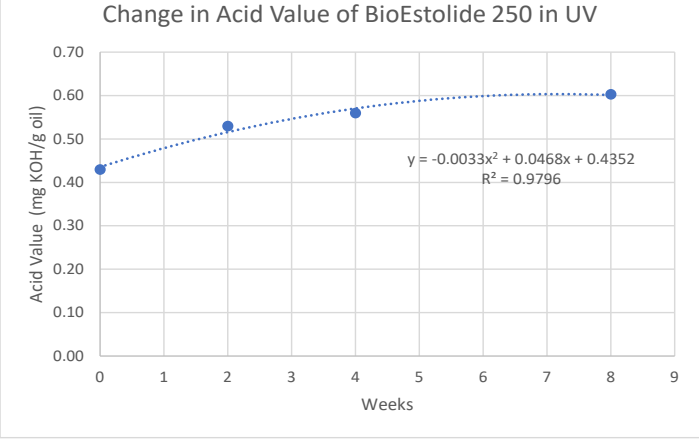
The BioEstolide™ 250-100, BioEstolide™ 1300-100 and castor oil acid value did not change significantly over the 8-week study; however, BioEstolides™ 30, 250, and 1300 did have a statistically significant change in acid value. To determine the impact on longer-term storage in the presence of UV, the graphs of the acid values were plotted:

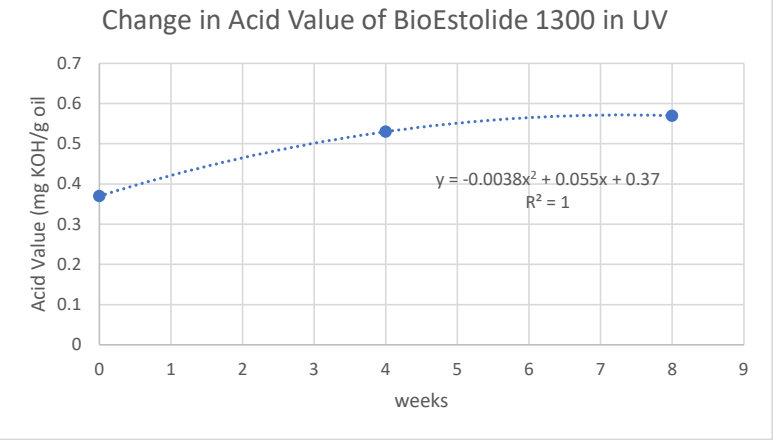
The best fit plot of the exposure to UV of all three BioEstolides™ that had significant changes in acid value is a polynomial fit with $R^2 > 0.97$ in all cases. This means that most of the change occurs during the first two weeks of exposure and tapers off between weeks 2 - 4 and again between 4 - 8 weeks.

This indicates that there is a small reaction that occurs at first; however, acid values will stabilize over time.

In addition, the change in acid value, while it is detectible, does not occur in such a significant amount as to destabilize the products.



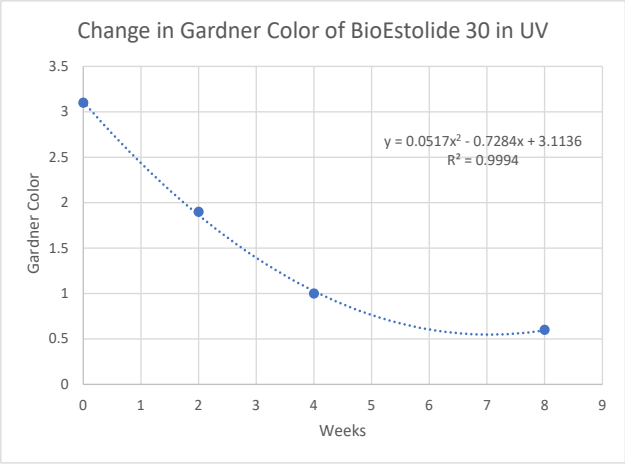


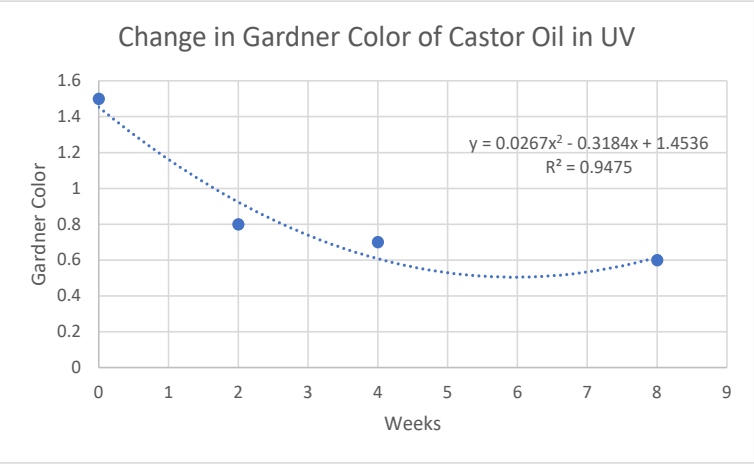


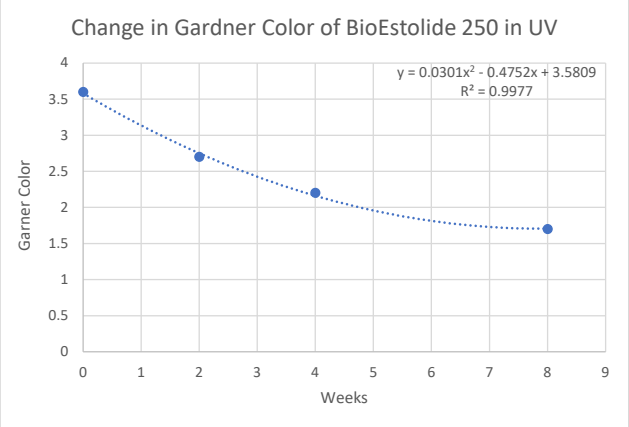
Gardner Color

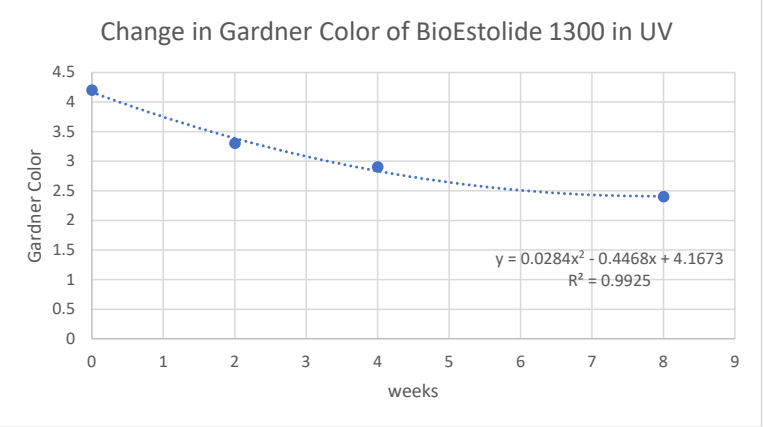
As was observed in the 2020 study, the Gardner color of BioEstolides™ 30, 250 and 1300 as well as castor oil was reduced over the 8-week study. BioEstolides™ 250-100 and 1300-100 had a very slight decrease in color.

BioEstolides™ 30, 250, and 1300 all have a polynomial best fit with $R^2 > 0.99$ indicating that the change in color is most pronounced in the between week 0 and 2; then the change slows between weeks 2-4 and 4-8.

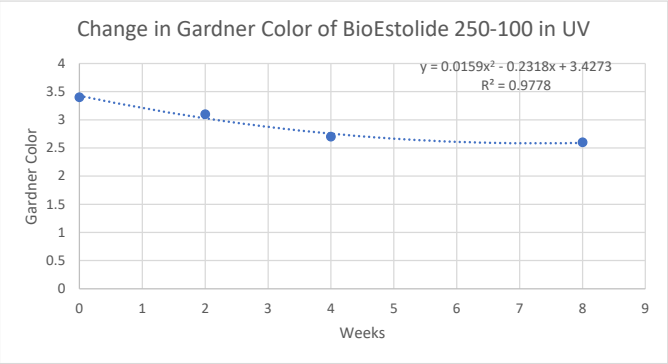


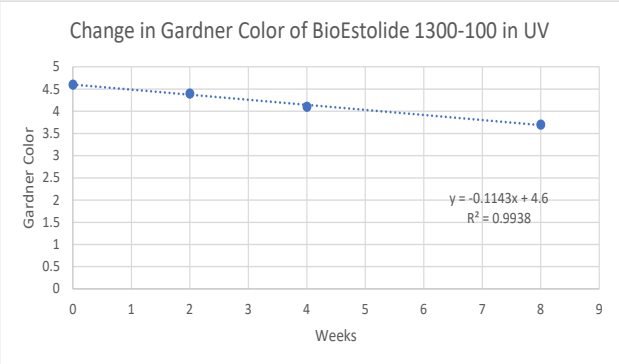






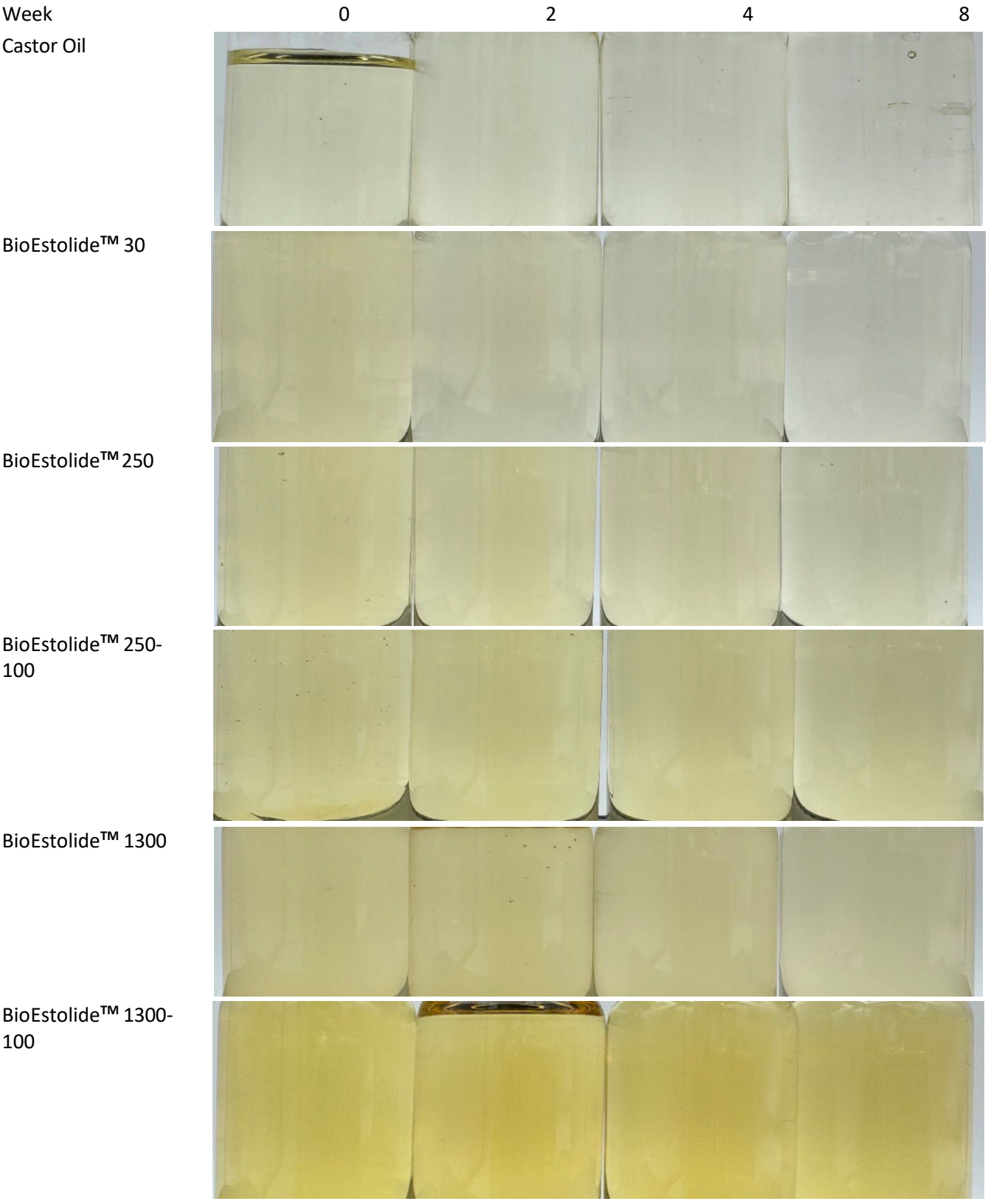
For the 100% biobased BioEstolide™ 250-100 and 1300-100 study, the change in Gardner color was exceptionally low for both samples even with less delta in their change than the BioEstolide™ 250 and BioEstolide™ 1300. This was the expected result due to the double bond functionality of the ricinoleic fatty acid used to make these products.





Visible changes can be observed in some samples over the course of the study, with the BioEstolide™ 250-100 and BioEstolide™ 1300-100 showing less visible change.

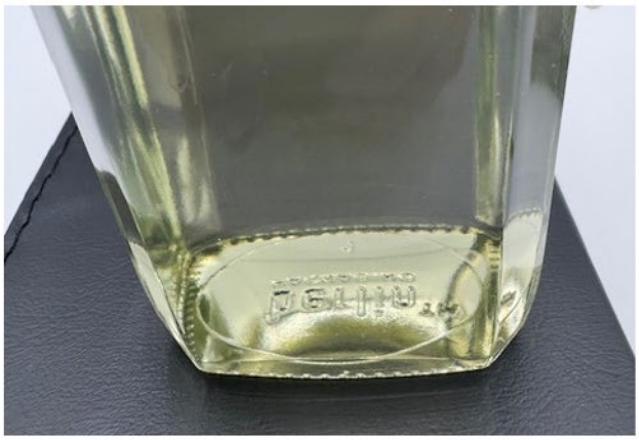
Visual study of color changes by sample over time:



Castor oil vs. BioEstolides

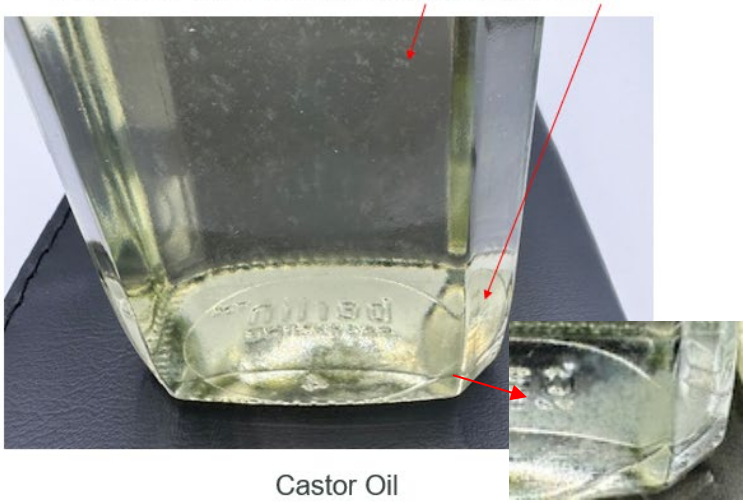
As stated in the table, by week 4, castor oil began to flocculate with visible suspended particles in the sample exposed to UV. By week 8, particles were both suspended and had settled to the bottom of the sample jar while the BioEstolides™ remained clear.

All BioEstolide samples were clear and bright



BioEstolide 30

Castor has white particles floating and settled



Castor Oil

The particulates were not isolated for qualitative or quantitative analyses.

Conclusion: BioEstolides™ are stable with exposure to UV. Biosynthetic Technologies recommends storing our products in glass, stainless steel, or plastic bottles. For formulated products, we recommend that our customers evaluate the formulation of their product in the material of packaging that they plan to sell it in to determine overall formulation stability.

BioEstolides™ Performance and Applications

BioEstolides™ are suitable for body care, face care, lip care and hair care. Using castor-based fatty acids as the base of our product lines, we have developed a class of molecules that offer exceptional moisturization, are easy to apply, and have ample playtime. BioEstolides™ offer enhanced oxidative, hydrolytic, UV, and thermal stability. The BioEstolide™ line is available in multiple viscosity grades to offer the formulator the latitude to create products. Lower viscosity grades offer excellent solubility while the higher viscosity grades disperse heavier particles and can be used as thickener.

BioEstolides™ are used to formulate creams, lotions, balms, gels, serums, aerosols, solids, and solid and gel sticks. In color cosmetics, they are used in tinted moisturizer, foundation, blush, bronzer, highlighter, lip balms, oils and sticks, mascara, and eye make-up. In sun care formulations, they solubilize chemical sunscreens or aid in the dispersion of physical sunscreens for reef-safe products. In haircare, they are used to improve manageability, create shine, and protect the hair cuticle in shampoo, rinse-out conditioner, leave-in conditioner, thermal protectant, hair dye, hair lightener, hair relaxer and other styling aids.