

Comparison of Silicone Quaternium 20 and Polyquaternium 10 in hair care formulations

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KEYWORDS: Hair care, conditioning, cleansing, silicone polymers, cellulosic polymers, silicone quaternary 20, cationic 10, wet comb, dry comb.

ABSTRACT

Hair care is one of the most important market segments for the personal care business. Despite the fact that there have been many marketing twists on the benefits offered by hair care products, the basic needs for products is that they clean and condition. Additional market demands are ever changing, and new benefits are always being proposed to the consumer, including inclusion of proteins and amino acids, pro-vitamins and a plethora of other additives. The formulator is challenged to provide products that are efficient in cleansing and in conditioning often with additives that may adversely affect the formulation.

Mort Westman (1), an industry leader, states "In the past 30 years, only two innovations in shampoo technology have been of sufficient importance to have a major impact on formulation practices, ingredient supply, and consumer usage. These innovations are the incorporation of a cationic polymer into an anionic surfactant system in the early 1970s and the functional incorporation of silicone in the late 1980s. In each case, the improvement served as a technological shock wave, causing a flurry of competitive patent activity and product emulation".

This article will evaluate products that resulted from these major raw material developments.

FORMULATION TIP

The formulation of hair care products is a difficult undertaking when new ingredients are added. They must not affect the desirable properties that are required in the formulation.

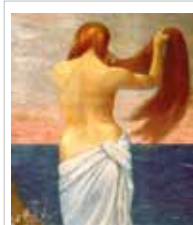
Shampoos not only need to foam they must give a particular type of foam depending upon the type of formulation. They must cleanse, but not strip. They must spread but still have body. Getting all these requirements in one formulation is difficult enough, but is you add some new market driven ingredient, you must make sure that ingredient does not destroy those required properties.



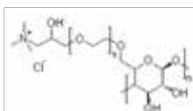
Don't let your formulation
Cause a bad hair day

Humanity has been cleansing and conditioning of hair, using many different methods since the earliest times. Hair care is an overall term for hygiene and cosmetology involving

the hair which grows from the human scalp, and to a lesser extent facial, pubic and other body hair. Hair care routines differ according to an individual's culture and the physical characteristics of one's hair. Hair may be colored, trimmed, shaved, plucked, or otherwise removed with treatments such as waxing, sugaring, and threading. Hair care services are offered in salons, barbershops, and day spas, and products are available commercially for home use (2).



Mankind has been caring for hair since the earliest times.

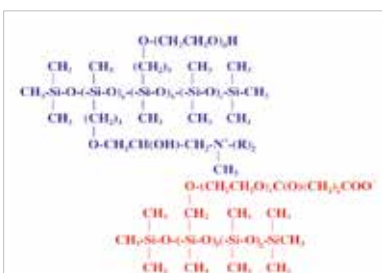


Structure of Polyquaternium 10 (3).

This article will compare a cationic polymer (Polyquaternium 10) and silicone polymer (Silicone Quaternium 20) in both a 2 in 1 shampoo and a conditioner.

Polyquaternium-10 (4) is a cationic, water-soluble substantive conditioner for hair care. It provides film formation on hair and moisturization. It is non-irritating and compatible with a wide range of surfactants. It enables the formulation of clear products.

Silicone Quaternium 20⁶ is a water-soluble, alcohol soluble and hydro alcoholic soluble silicone that imparts outstanding hair conditioning especially in 2-in-1 shampoos. It also provides a smooth silky feel to skin and can be used for shaving products



Structure of Silicone Quaternium 20 (5).

FORMULATION OF SHAMPOO

Part ID	Ingredients	FH193A	FH193B
A	D. I. Water	52.00	52.00
	Polyquaternium 10	0.30	0.60
	Guar Hydroxypropyltrimonium Chloride	0.00	0.30
	Na ₂ EDTA	0.10	0.10
	SLES-2 (25%) / Sodium Laureth-2 Sulfate	27.50	27.50
	Cocamidopropyl Betaine	10.00	10.00
	Disodium Cocamphodisacetate	5.00	5.00
	Coco Glucoside	3.00	3.00
	Silicone Quaternium 20	0.00	0.30
	Citric Acid (40%)	q.s.	q.s.
	DMDMH	0.30	0.30
	Sodium Chloride	q.s.	q.s.
	Total	100.00	100.00

Table 1. Formula of 2-in-1 Shampoos.

PROCEDURE

FH193A: Prepare a premix solution by dispersing Polyquaternium 10 in water with agitation. Begin heating to 50~60°C under mixing until the solution becoming a smooth uniform gel. Combine and mix the surfactants until uniform. Add the premix solution to the surfactant mixture. Add the remaining ingredients one at a time under mixing, waiting for each ingredient to dissolve before adding the next one. Adjust the pH to 6.0~6.5 with the citric acid. Adjust the viscosity to 6,000 ~ 9,000 cps by adding q.s. sodium chloride.

FH193B: Disperse guar in water until a smooth uniform gel generated; add the remaining ingredients one at a time under mixing, waiting for each ingredient to dissolve before adding the next one. Adjust the pH to 6.0~6.5 with the citric acid. Adjust the viscosity to 6,000 ~ 9,000 cps by adding q.s. sodium chloride.

Specifications	FH193A with Polyquaternium 10	FH193B with Silicone Quaternium 20
Viscosity (cps)*	6,000	6,800
pH	6.45	6.50
Appearance	Clear Gel	Clear Gel
Stability @45 °C	Good	Good
Feel (1-10, 10 the best)	8.9	9.0
Compatibility	Good	Good

*Viscosity was tested by using Brookfield, LVT, #4 spindle, and 12 rpm

Table 2. Analysis.

FORMULATION OF HAIR CONDITIONER

Formula Code	FH157A w/Polyquaternium 10	FH157B w/ SILICONE QUATERNIUM 20
Ingredients	Wt/wt %	Wt/wt %
Part A:		
D.I. Water	86.20	85.40
Polyquaternium 10	0.80	0
Hydroxyl Ethyl Cellulose	0	0.80
Disodium EDTA	0.10	0.10
Part B:		
PEG/PPG 16/16 Dimethicone	3.00	3.00
Stearyl Alcohol	1.50	1.50
Cetyl Alcohol	2.00	2.00
PEG-100 Stearate	1.00	1.00
Ethylene Glycol Distearate	1.00	1.00
PEG 8 dimethicone	3.00	3.00
SILICONE QUATERNIUM 20	0	0.80
Part C		
Wheat Protein	1.00	1.00
DMDM Hydantoin	0.40	0.40
Citric Acid (40% aq)	q.s.	q.s.
Fragrance	q.s.	q.s.
Total	100	100

Table 3. Formula.

PROCEDURE

2.2.1. In a clean and sanitized container equipped with propeller mixer, add water and disperse Polyquaternium 10 or cellulose, then heat up to 75~80 °C with good agitation until clear gel was formed, add the rest of ingredients of Part A under mixing.

2.2.2. Combine Part B in a separated clean and sanitized container, heat up to 75~ 80 °C and mix well.

2.2.3. Add Part B into Part A slowly under mixing and keep temperature at 75~80 °C for 5 minutes, then cooling down to room temperature, add part C one at a time under mixing. Using Citric acid adjust pH in the range of 4.5 to 5.5.

Specifications	FH157A with Polyquaternium 10	FH157B with SILICONE QUATERNIUM 20
Viscosity (cps)*	16,500	11,000
pH	4.75	4.80
Appearance	White Cream	White Cream
Stability @45 °C	Good	Good
Feel (1-10, 10 the best)	9.0	9.0
Compatibility	Good	Good

*Viscosity was tested by using Brookfield, LVT, #4 spindle, and 12 rpm

Table 4. Analysis.

FOAM PERFORMANCE EVALUATION OF 2-IN-1 SHAMPOOS

Method: All products were evaluated with the same procedure. A 1000 mL cylinder with 10 mL increments was used. All samples and distilled water was prepared at 25 °C. 1.00 gram of test material was used, and 100 mL distilled water was added to dissolve the test material in a 250 mL beaker. After the test material was totally dissolved, the solution transferred into the cylinder. An outlet of air pump was on the bottom of the cylinder to generate the bubbles. Record the foam height within 20 seconds for each test materials, each material was evaluated 3 times and their averages were documented.

The scale for Foam Height is 1000 mL is outstanding and 100 mL is very poor. The type of foam was also noted whether it is tight or loose. Bubbles were generated by electronic air pump.

Sample (Bubble for 20 sec)	Initial Reading (Average, mL)	Two Minute Reading (Average, mL)	Five Minute Reading (Average, mL)
FH193A with Polyquaternium 10	710	690	680
FH193B with Silicone quaternium 20	700	680	660

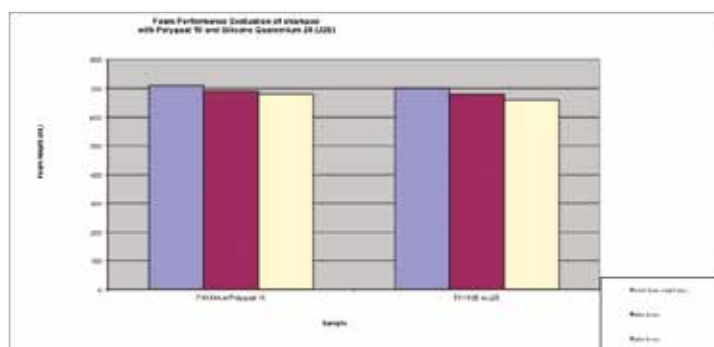


Table 5. Foam Performance Evaluation of shampoo with Polyquat 10 and Silicone Quaternium 20 (J2S).

Polyquaternium 10 provides slightly increased foam than Silicone quaternium 20.

EVALUATION OF SHAMPOOS IN PERFORMANCE ON HAIR SWATCHES

Method Used: ASTM (American Society for Testing and Materials International) E 2082- 06: Standard Guide for Descriptive Analysis of Shampoo Performance. All products were evaluated on 10-inch Virgin Brown Hair. Two × 2-gram swatches were used for each material tested, all from the same lot. All swatches were wet with water (25 °C) and one gram of test material was used for each swatch. Swatches were washed and then rinsed for at least one minute per swatch. Wet Comb Evaluation was then performed. All swatches were air-dried then the Dry Comb Evaluation was performed once hair was completely dry. Scale used is 1 to 10, 10 being the best. Used for wet and dry combing. Hair swatches need using non-conditioning shampoo before treated with hair conditioner.

Sample	Wet Comb	Rinse off	Clean Feel	Shine/Softness	Residual Feel	Fullness	Average
FH193A w/Polyquaternium 10	8.9	8.8	8.8	8.8/8.8	8.8	9.1	8.86
FH193B w/ Silicone Quaternium 20 20	9.1	9.0	9.0	8.8/9.0	8.8	9.0	8.94
FH157A w/Polyquaternium 10	9.1	9.0	9.0	9.0/9.1	8.9	9.1	9.03
FH157B w/Silicone Quaternium 20	9.2	9.1	9.1	9.0/9.1	8.9	9.0	9.06

Table 6. Wet Comb Evaluations.

Sample	Dry Comb	Dry Feel	Clean Feel/Look	Shine	Fullness/Manageable	Fly away	Residual Feel	Static	Average
FH193A w/ Polyquaternium 10	8.8	8.8	8.9	7.8	8.8	8.5	8.6	8.8	8.64
FH193B w/Silicone Quaternium 20	8.9	8.9	9.0	7.9	9.0	8.8	8.7	8.8	8.75
FH157A w/ Polyquaternium 10	9.0	9.0	9.0	8.8	9.1	8.7	8.9	9.0	8.94
FH157B w/Silicone quaternium 20	9.1	9.0	9.0	8.9	9.0	8.8	9.0	9.0	8.98

Table 7. Dry Comb Evaluations.



Figure 1. Hair Evaluation for Shampoo and Conditioners.

The results show that both shampoo and conditioner with silicone quaternium 20 are little bit better than those with Polyquaternium 10 in terms of wet comb and dry comb.

MICROSCOPIC STUDY OF HAIR SWATCHES

Method: Barska AY11374-Digital Microscope was used to take pictures of hair swatches of (a) untreated European virgin brown, (b) virgin hair treated with shampoo which has no conditioner, (c) virgin hair treated with 2-in-1 shampoo with Polyquaternium 10, (d) virgin hair treated with 2-in-

1 shampoo with SILICONE QUATERNIUM 20, (e) virgin hair treated with no conditioning shampoo followed by hair conditioner with Polyquaternium 10, and (f) virgin hair treated with no conditioning shampoo followed by hair conditioner with SILICONE QUATERNIUM 20. The images of hair swatches were taken at 100X magnification on microscopy glass slide. Pictures were processed by using Adobe Photoshop 7.0. Full scale of the image is 100 um for 100X magnification.

Virgin European Brown Hair

The typical image of untreated European virgin brown hair swatch is shown in the Figure 2a. This image shown that the hair tress is smooth and shining (shining line on the sides). Figure 2b shows that the tress of virgin hair treated with non-conditioning shampoo which has some spots damaged by the detergents in shampoo and no shining lines on the side.

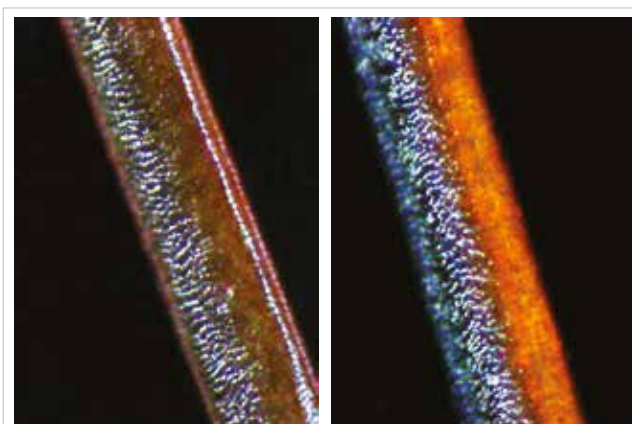


Figure 2a.

Figure 2b.

Typical images of the virgin hairs treated with 2-in-1 shampoo with Polyquaternium 10 and silicone quaternium 20 are shown in Figure 2c and 2d, the tresses are smooth in both cases but in 2c, there are some spots damaged by the detergents and Polyquaternium 10 could not fix them completely. Figure 2d shows that silicone quaternium 20 did better job than Polyquaternium 10; this can be seen from the Figure 2a and 2d which are very close in terms of smooth and shining lines on the side.

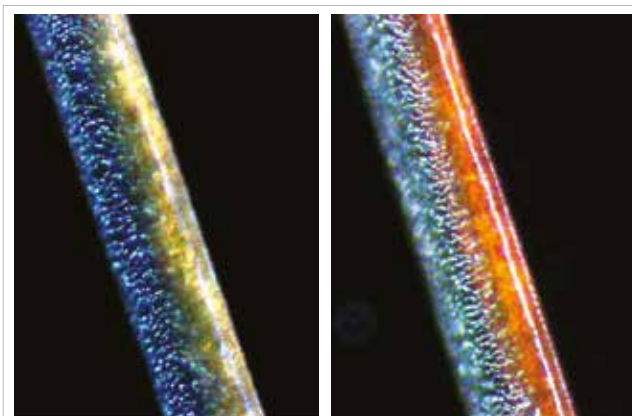


Figure 2c.

Figure 2d.

Silicone quaternium 20 performs better than polyquaternium 10 in hair conditioning, producing smooth and shiny surfaces on the hair tresses which were shown in Figure 2e and 2f.

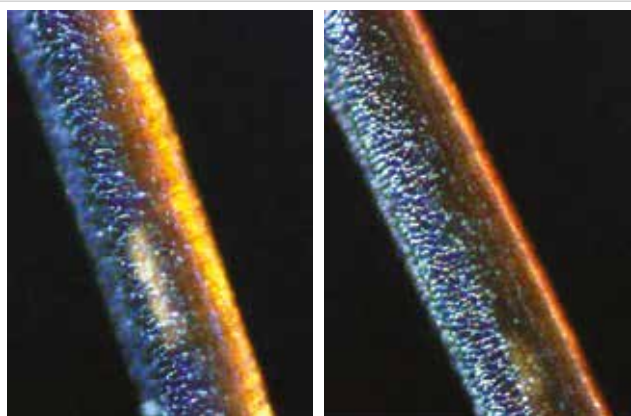


Figure 2e. Hair Treated with Conditioner w/ Polyquaternium 10.

Figure 2f. Hair Treated with Conditioner with Silicone quaternium 20.

CONCLUSIONS

1. Polyquaternium 10 provides slightly better foam levels when compared to silicone quaternium 20
2. Silicone quaternium 20 performs better than polyquaternium 10 in hair conditioning, producing smooth and shiny surfaces on the hair tresses.
3. Silicone quaternium 20 performs better than polyquaternium 10 in hair conditioning, producing smooth and shiny surfaces on the hair tresses

Formulator Tip

No one ingredient provides all the "best properties" to a formulation. The choice of the optimum raw material is often determined by the market into which the product is directed. This is in fact why there is so much specialization in products. The type of hair, the consumer expectation and the cost are all critical to success.

Formulator Tip

When considering the cost of an ingredient, always consider cost effectiveness (also called price per unit). The cost effectiveness is the cost per pound times the percentage added. All too often we only consider cost per pound. If a raw material is twice the price per pound of an alternate, but is used at one fifth, the cost per pound of shampoo will be lower.

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