

# MQ resins in personal care applications

This article describes MQ resins, a series of silicone polymers that find application in many personal care formulations.

## Silicone polymers

The first concept that one needs to understand in dealing with silicone polymers is a concept called 'construction'. Specifically, construction relates to the monomers that are used to construct a

silicone polymer. The selection of the type and number of monomer types in a specific polymer will determine the structure of the polymer. The structure of the polymer in turn determines the functional properties and how the polymer will behave in formulations.

The shorthand for the construction of silicone homopolymers is shown in Figure 1.<sup>1</sup>

Knowing this shorthand, silicone polymer chemists can construct a simple description of silicone polymers. This is best shown in the case of silicone fluids.

## Silicone fluids

The most simple of the silicone fluids is what we refer to as MM, or 0.65 viscosity fluid. The structure is shown in Figure 2.

All other silicone fluids are compounds and have the construction MDnM, shown in Figure 3. While common usage calls these materials dimethicone, silicone fluids, silicone oils, the construction

shorthand is very specific as shown in Figure 4.

Table 1 shows the approximate 'n' value for dimethicone polymers commonly used in personal care formulations. It should be clear that the nomenclature MD<sub>127</sub>M is a more precise definition of a dimethicone having a viscosity of 200 centistokes than simply dimethicone, since it clearly specifies a structure and is clearly not a blend. All these attributes are lacking in the description dimethicone.

## MQ resins

MQ resins are an interesting class of materials that find increasing applications in personal care formulations. As the name implies, the two groups present in the molecule are 'M' and 'Q'. The INCI name for Q resins is trimethylsiloxyisilicate, but as we shall see, the function of this class of compounds is determined by the exact structure and not the assigned INCI name. The application in specific areas of

Figure 1: Shorthand for silicone construction.

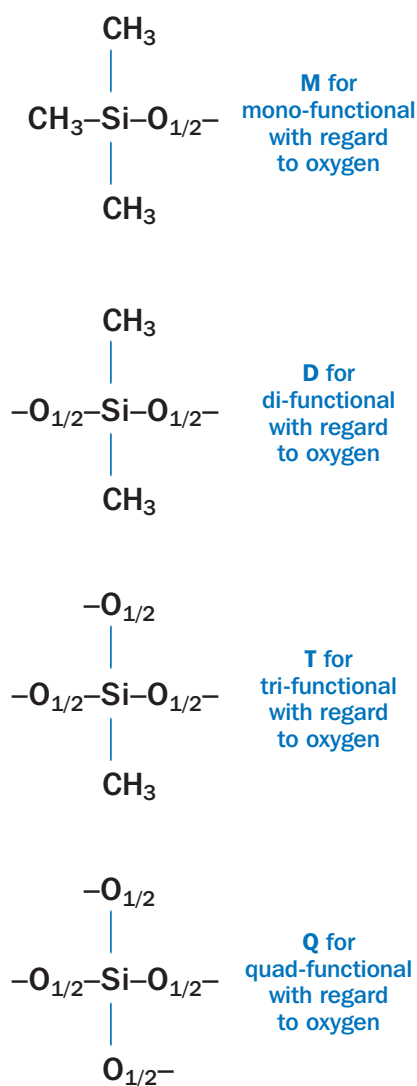


Figure 2: Shorthand MM 0.65 cst silicone fluid.

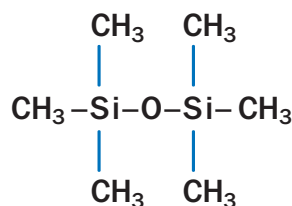


Figure 3: MDnM silicones dimethicone.

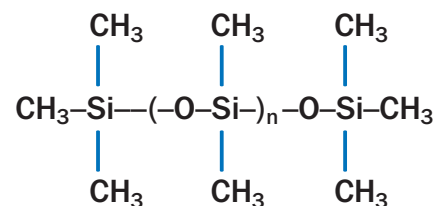
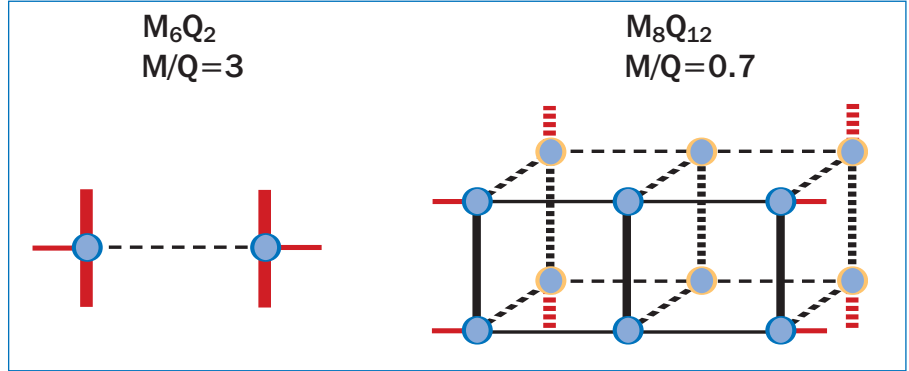
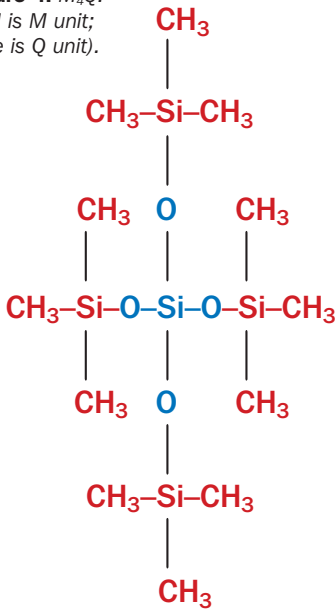


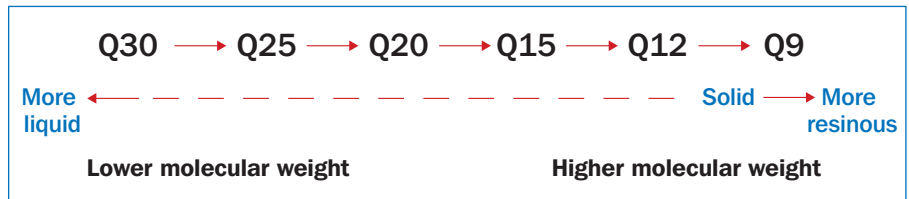
Table 1: Silicone fluids.

Viscosity at 25 °C (centistokes)	Approximate molecular weight	Approximate 'n' value	Average construction
5	800	9	MD <sub>9</sub> M
50	3780	53	MD <sub>53</sub> M
100	6000	85	MD <sub>85</sub> M
200	9430	127	MD <sub>127</sub> M
350	13,650	185	MD <sub>185</sub> M
500	17,350	230	MD <sub>230</sub> M
1000	28,000	375	MD <sub>375</sub> M
10,000	67,700	910	MD <sub>910</sub> M
60,000	116,500	1570	MD <sub>1570</sub> M

**Figure 4:**  $M_4Q$ . (red is M unit; blue is Q unit).



**Figure 5:** Two MQ resin structures (red is M unit; blue is Q unit).



**Figure 6:** Properties of MQ resins evaluated.

formulation is based upon the exact structure. ‘The ratio of the M to Q units is of utmost importance’<sup>2</sup> in determining the structure and functionality.

Our shorthand for the construction would be  $M_nQ$ . The simplest compound to envision is  $M_4Q$  shown in Figure 4.

As the ratio of M to Q is decreased from 4:1, products with more complicated cubic structures are produced. Figure 5 shows two of these. The lower the M to Q ratio, the more crystalline the product, which is commonly dissolved in a solvent for ease of handling.

Clearly, there are a variety of structures for the class of compound, depending upon the M to Q ratio. MQ resins can drastically change the physical properties and feel of a cosmetic formulation. A series of six MQ resin products designed for a range of personal care applications were evaluated in a number of personal care formulations.

If the ratio of M:Q is close to 4.0:1.0 a low viscosity liquid results, which finds application in modification of surfaces improving spreading, dispersing and conditioning.

If the ratio of M:Q is close to 1.0 a solid, film forming resin results. This type of product is interesting for transfer resistance and pigment coating.

The solid MQ resins were evaluated as a 70% active product in isododecane. Figure 6 shows the properties of the products evaluated.

**Colour rich lipstick**

Each of the five lipstick formulations was identical except that the control had no MQ resin, FL503C had 3 w/w% of Silwax J219M, FL503C.1 had w/w% of Silmer Q20, FL503C.2 had 3 w/w% of Silmer

Q30, and FL503C.3 had 3 w/w% of Silmer Q25.

The addition of Silmer Q20/25/30 not only improved the stability and colour dispersion but also increased surface gloss too.

**Ideal shade foundation with and without MQ resin**

The 8 foundation formulations were identical except for the following quantities of MQ resin (the control had none): FM610D – 2 w/w% Silwax Di-1021M, FM610.1 – 8.5 w/w% Q20, FM610.2 –

8.5 w/w% Q15, FM610.3 – 8.5 w/w% Q12, FM610.4 – 8.5 w/w% Q9, FM610.5 – 8.5 w/w% Q30, FM610.6 – 8.5 w/w% Q25.

FM610.1 with Q20 is stable both at room temperature and 45°C for 7 weeks, exhibiting improved stability over the control.

**Eye shadow**

The eye shadow formulations were identical apart from the following quantities of MQ resin (the control FM616 had none and had 31 w/w% of DC 9040 while the rest had 21 w/w%): FM616 A – 10 w/w% Q20,

**Table 2: Products evaluated.**

Product	M:Q ratio	Activity (%)	Solvent
Silmer Q9	0.9:1	70	isododecane
Silmer Q12	1.2:1	70	isododecane
Silmer Q15	1.5:1	100	None
Silmer Q20	2:1	100	None
Silmer Q25	2.5:1	100	None
Silmer Q30	3:1	100	None

**Table 3: Specifications for FL503 series.**

Specifications	FL503	FL503C	FL503.1	FL503.2	FL503.3
S.G.	1.010	1.018	1.013	1.018	1.011
Appearance	Poppy love Smooth bullet-like	Poppy love Smooth bullet-like	Poppy love Smooth bullet-like	Poppy love Smooth bullet-like	Poppy love Smooth bullet-like
Melt Point	50-62	50-62	49-61	49-61	49-61
Hardness	56	54	53	53	53
Stability @45°C	Good	Good	Good	Good	Good
Feel (1-10, 10 the best)	9.1	9.2	9.3	9.3	9.3
Compatibility	Good	Good	Good	Good	Good

**Table 4: Specifications for liquid foundation.**

Specifications	FM610	FM610D w/Di1021M	FM610.1 w/Q20	FM610.2 w/ Q15	FM610.3 w/Q12	FM610.4 w/Q9	FM610.5 w/Q30	FM610.6 w/Q25
Viscosity (cps)	3000	2800	2600	2500	2500	2600	2100	2100
pH	6.02	6.01	6.08	6.00	6.01	6.04	6.08	6.10
Appearance	Honey liquid foundation	Honey liquid foundation	Honey liquid foundation	Honey liquid foundation	Honey liquid foundation	Honey liquid foundation	Honey liquid foundation	Honey liquid foundation
Stability @ RT/45°C	Not good	Good	Good	Not good	Not good	Not good	Not good	Not good
Feel (1-10, 10 the best)	8.5	8.6	8.6	8.6	8.5	8.5	8.7	8.7
Compatibility	Good	Good	Good	Good	Good	Good	Good	Good

**Table 5: Specifications for eye shadow.**

Specifications	FM616 Control w/DC9040	FM616A w/Q20	FM616B w/Q15	FM616C w/Q12	FM616D w/Q9	FM616E w/Q30	FM616F w/Q25
S.G.	0.961	0.964	0.968	0.974	0.965	0.961	0.960
pH	6.26	6.33	6.25	6.23	6.19	6.28	6.30
Appearance	Bronze paste	Bronze paste	Bronze paste	Bronze paste	Bronze paste	Bronze paste	Bronze paste
Stability @RT	Good	Good	Good	Good	Good	Good	Good
Feel (1-10, 10 the best)	8.5	8.6	8.5	8.5	8.5	8.6	8.7
Compatibility	Good	Good	Good	Good	Good	Good	Good

FM616 B – 10 w/w% Q15, FM616 C – 10 w/w% Q12, FM616 D – 10 w/w% Q9, FM616 E – 10 w/w% Q30, FM616 F – 10 w/w% Q25.

As the ratio of M to Q in the MQ resin molecule increasing, the texture or feel of the eye shadow changes from a more solid powdery to liquid powdery to solid powdery feel after dry on skin.

### Waterproof mascara

The formulations for the waterproof mascaras were identical except that in Part B the control, FM617 C and D contained no MQ resin, while the rest contained the following: FM617 A – 5 w/w% Q20, FM617 B – 5 w/w% Q15, FM617 E – 5 w/w% Q30, FM617 F – 5 w/w% Q25.

In Part C, the control contained 5 w/w% of Cosmethicone SF-600, while FM617 C contained 5 w/w% of Q12 and FM617 D contained 5 w/w% of Q9.

The high molecular weight MQ resins in isododecane, (Silmer Q12, Q9) resins cannot be heated up to 75~80°C, they must be added to the batch after the batch cooling down to around 40°C.

The lower molecular weight pure liquid MQ resins (Silmer, same as Q12 and Q9, but Q30, Q25, Q20 and Q15) can be added directly to join in the emulsion, because they are pure resins with good fluidity and high boiling point.

The benefits of using Q compounds are: waterproofing, helping pigment disperse, and formation of a film.

### Sunscreen lotion

The sunscreen lotion formulations were identical except that in phase B the control, FS408-3, and FS408-4 contained no MQ resin, while the rest contained the following: FS408-1 – 8 w/w% Q20, FS408-2 – 8 w/w% Q15, FS408-5 – 8 w/w% Q30, FS408-6 – 8 w/w% Q25.

In Phase B the control contained 8 w/w% Jeasilc IDD, while FS408-3 contained 8 w/w% Q12 and FS408-4 contained 8 w/w% Q9.

The sunscreen made with Q25 feels the best and also carries good compatibility with organic sunscreen actives and solvents, improving stability and waterproofing.

**Table 6: Specifications of mascara.**

Specifications	FM617 Control Cosmethicone SF-600	FM617F M617Aw/Q20	FM617B w/Q15	FM617C w/Q12	FM617D w/Q9	FM617E w/Q30	FM617F w/Q25
S.G.	0.985	0.986	0.987	0.988	0.989	0.987	0.986
pH	7.00	7.02	7.00	7.00	7.01	6.98	7.00
Appearance	Black brown Cream	Black brown Cream	Black brown Cream	Black brown Cream	Black brown Cream	Black brown Cream	Black brown Cream
Stability @RT	Good	Good	Good	Good	Good	Good	Good
Feel (1-10, 10 the best)	8.5	8.5	8.5	8.6	8.5	8.6	8.7
Compatibility	Good	Good	Good	Good	Good	Good	Good

**Table 7: Specifications of sunscreen lotion.**

Specifications	FS408 Control IDD	FS408-1 Q20	FS408-2 Q15	FS408-3 Q12	FS408-4 Q9	FS408-5 Q30	FS408-6 Q25
Viscosity (cps)	2500	2600	2400	2500	2500	2500	2500
pH	7.02	7.12	7.10	7.03	7.02	7.01	7.01
Feel 1-10, 10 the best)	8.5	8.7	8.2	8.5	8.5	8.7	8.8
Stability @43°C	Stable for 1 week	Stable for 2 weeks	Stable for 1 day	Stable for 2 weeks	Stable for 2 weeks	Stable for 2 weeks	Stable for 2 weeks
Compatibility	Good	Good	Good	Good	Good	Good	Good

## 2-in-1 shampoo

The formulations for the 2-in-1 shampoo were identical except the blank contained no MQ resin, while the rest contained the following: FH190 Control – 0.3 wt/wt% Siltech F60,000, FH190A – 0.3 wt/wt% Q20, FH190B – 0.3 wt/wt% Q15, FH190C – 0.3 wt/wt% Q30, FH190D – 0.3 wt/wt% Q25.

## Foam performance evaluation

### 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 distill water was added to dissolve the test material in a 250 mL beaker. After the test material was totally dissolved, the solution was transferred into the cylinder. An outlet air pump was sited on the bottom of the cylinder to generate the bubbles. The foam height was recorded within 20 seconds for each test material, and each material was evaluated three times and their averages were documented.

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

### Result

All foams were tight and uniform; all MQ resins do not affect shampoo foam performance compared with Blank sample and Control sample.

**Table 8: Specifications of shampoo.**

Specs formula	pH	Viscosity (cps) (Brookfield LVT #4, 30 rpm)	Appearance	Stability @42°C
FH190 Blank	5.45	7000	White cream	Stable for 4 weeks
FH190 Control w/ Siltech F60,000	5.50	7100	White cream	Stable for 4 weeks
FH190A w/Q20	5.51	7000	White cream	Stable for 4 weeks
FH190B w/Q15	5.52	7100	White cream	Stable for 4 weeks
FH190C w/Q30	5.45	7000	White cream	Stable for 4 weeks
FH190D w/Q25	5.46	7000	White cream	Stable for 4 weeks

**Table 9: Foam performance evaluation.**

Sample (Bubble for 20 sec)	Initial reading (average, mL)	2 minute reading (average, mL)	5 minute reading (average, mL)
FH190 Blank	705	695	683
FH190 Control w/Siltech F60, 000	690	680	660
FH190A w/Q20	700	690	680
FH190A w/Q15	700	690	680
FH190A w/Q30	700	690	680
FH190A w/Q25	700	690	680

## Hair evaluation for shampoo

All products were evaluated on 10-inch Virgin Brown Hair. Two x 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. No blow-drying of hair was done. All swatches 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.

### Result

Shampoo with 0.3% of Q25 resin is the best in terms of wet comb and dry comb. Shampoo with Q20 resin is good at oil-proofing for oily hair conditioning.

## Build-up experiments

Only using shampoo with Q25 to do build up test on European virgin brown hair.

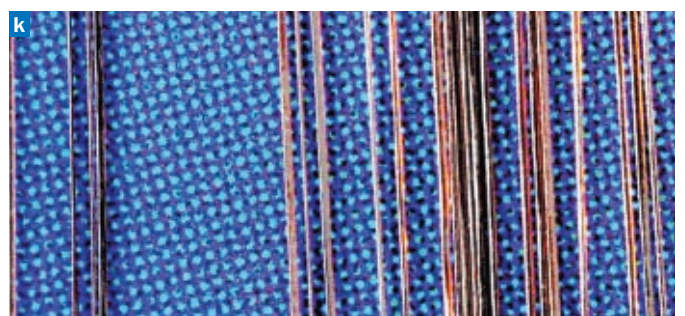
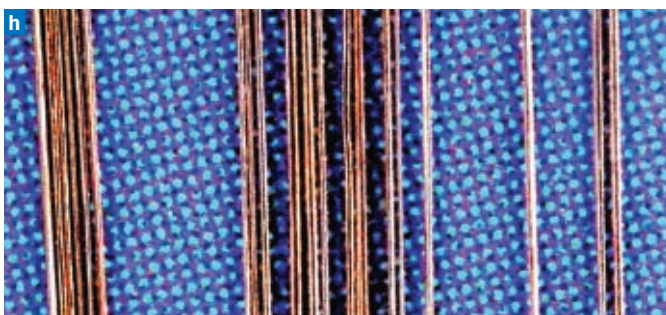
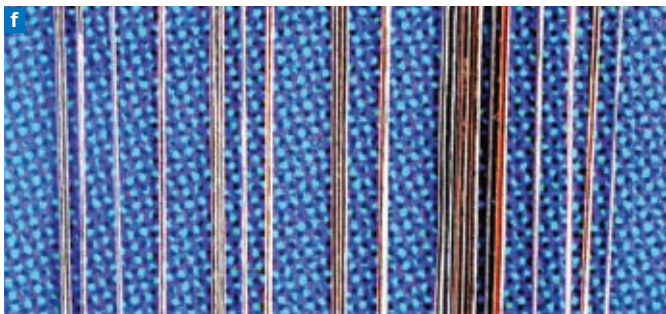
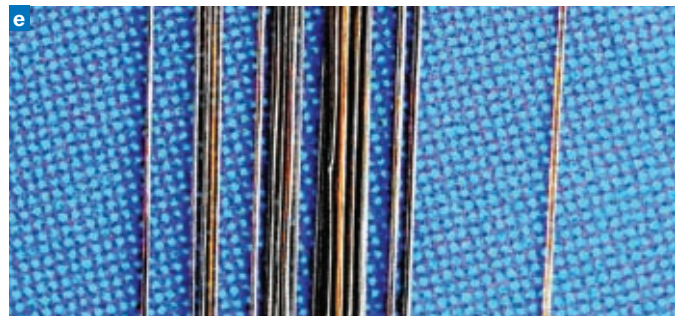
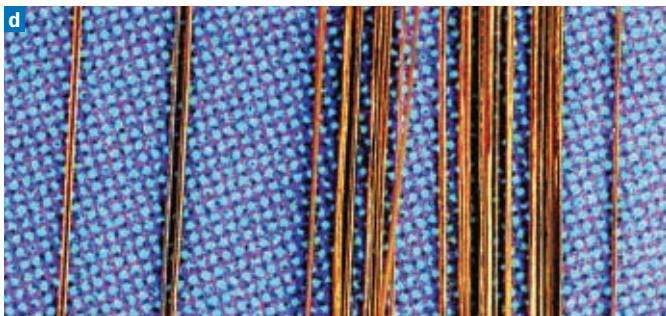
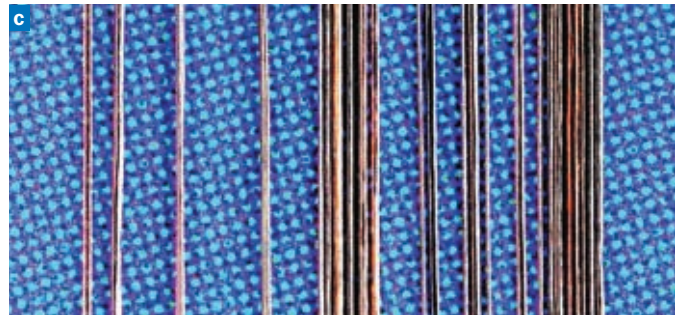
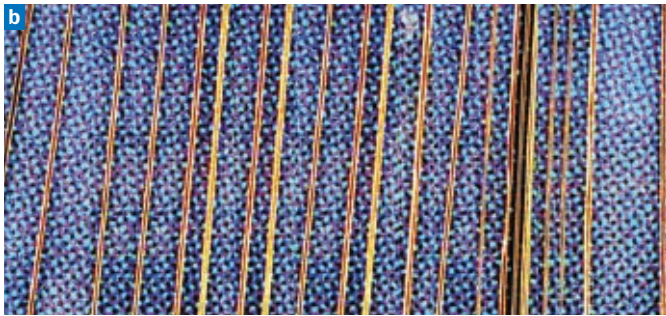
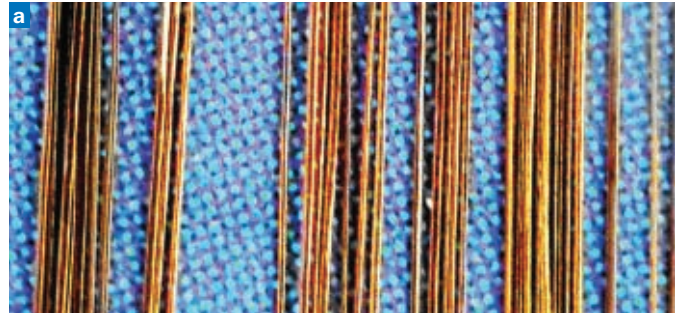
2-in-1 Shampoo FH190D with Q25 was

**Table 10: Wet comb evaluation.**

Sample	Wet comb	Rinse off	Clean feel	Shine	Residual feel	Average
FH190 Blank	8.2	8.4	8.4	8.2	8.3	8.3
FH190 Control w/Siltech F60, 000	8.7	8.7	8.8	8.6	8.7	8.7
FH190A w/Q20	9.2	9.2	9.2	9.2	9.2	9.2
FH190A w/Q15	8.9	8.9	8.9	8.9	8.9	8.9
FH190A w/Q30	9.0	9.0	9.0	9.0	9.0	9.0
FH190A w/Q25	9.3	9.3	9.3	9.3	9.3	9.3

**Figure 7:** Photographic results of 2-in-one shampoo test.

- a) European virgin brown hair.
- b) European virgin brown hair washed with shampoo (w/Q25) 1 time.
- c) European virgin brown hair washed with shampoo (w/Q25) 2 times.
- d) European virgin brown hair washed with shampoo (w/Q25) 3 times.
- e) European virgin brown hair washed with shampoo (w/Q25) 4 times.
- f) European virgin brown hair washed with shampoo (w/Q25) 5 times.
- g) European virgin brown hair washed with shampoo (w/Q25) 6 times.
- h) European virgin brown hair washed with shampoo (w/Q25) 7 times.
- i) European virgin brown hair washed with shampoo (w/Q25) 8 times.
- j) European virgin brown hair washed with shampoo (w/Q25) 9 times.
- k) European virgin brown hair washed with shampoo (w/Q25) 10 times.



**Table 11: Dry comb evaluation.**

Sample	Dry Comb	Dry Feel	Clean Feel/Look	Shine	Fullness/Manageable	Flyaway/Static	Water response	Softness	Average
FH190 Blank	8.5	8.5	8.6	8.5	8.5	8.4	8.5	8.5	8.5
FH190 Control	8.8	8.8	8.8	8.8	8.8	8.5	8.9	8.8	8.8
FH190A w/Q20	9.2	9.2	9.2	9.2	9.2	9.2	9.2	9.2	9.2
FH190A w/Q15	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0
FH190A w/Q30	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0
FH190A w/Q25	9.3	9.3	9.3	9.3	9.3	9.3	9.3	9.3	9.3

**Table 12: Specifications of AP stick.**

Stick	Appearance	Compatibility*	Stability (at 42°C)	Slip*	Hardness**
FA802	Off-white	8.5	At least 7 days	8.8	66
FA802A w/Silmer Q20	Off-white	9.0	At least 6 weeks	9.2	63
FA802B w/Silmer Q15	Off-white	8.2	Not stable	9.0	64
FA802C w/Q30 adjusted	Off-white	9.0	At least 4 weeks	9.3	62
FA802D w/Q25 adjusted	Off-white	9.0	At least 4 weeks	9.3	62

\*Scale used is 1 to 10, 10 being the best. Applied for Compatibility and Slip.  
 \*\*Hardness was test by using PTC Instruments Model 411 Type 00. Method: ASTM D2240.  
 Data were obtained by average of three times tests for different spots in each sample.

over 10 times. The thin uniform films of conditioner reagent on the hair are almost the same for each time after the hair washed with 2-in-1 shampoo with Q25 resin.


**Antiperspirant stick**

The formulations for antiperspirant stick were identical except the control wick had no MQ resin, while FA802A contained 2 wt/wt% Q20, FA802B contained 2 wt/wt% Q15, FA802C contained 2 wt/wt% Q30, FA802D contained 2 wt/wt% Q25.

FA802A with Silmer Q20 is the best for AP stick formulation.

**Conclusion**

Table 8 offers an overview of the various applications that MQ resins are suited to. The results show that Q25 appears to be applicable in all of the tested applications and Q30 in all but two (2-in-1 shampoo and hair conditioner).

MQ resins have been shown to be a highly versatile addition to a formulator's armoury and look set to be used in an increasingly wide selection of products. 

**References**

- 1 O'Lenick T. Understanding Silicone. *Cosmetics and Toiletries* 2006; **121** (5).
- 2 Huang W, Huang Y, Yu Y. The effect of the acid catalyst on preparation of MQ silicone resins. *Chinese Journal of Polymer Science* 1999; **17** (5): 429-33.

evaluated on 10-inch Virgin Brown Hair. Two x 2-gram swatches were used. The swatches were wet with water (25°C) and one gram of FH190D w/M2.5Q1Q25 resin was used for each swatch. Swatches were washed and then rinsed for at least one minute per swatch. No blow-drying of hair was done. All swatches were dried with paper towel and finally air-dried, and then build-up evaluation was performed once hair was completely dry. Repeat the above procedure 10 times. Keep record of each time's build-up situation.

The build-up was studied by microscopy method. The method used is described as the following: Baush and Lomb Measuring

Optical Magnifier (10X) and Coolpix L20 Nikon Digital Camera (2X) were combined to take pictures of hair cuticles from the swatches. Pictures were processed (10X) by using Adobe Photoshop 7.0. Results are listed in Figure 7.

From the figures above, we can see that each hair cuticle has uniform shiny surface after virgin hair treated with 2-in-1 shampoo with 0.3% of Q 25, this means that the coating film on each hair cuticle is thin and uniform compared with untreated virgin hair.

After the hair was treated with shampoo with resin over and over again, there is no accumulation of conditioning reagent each time on the hair even the hair washed

**Table 13: Applications of MQ resins.**

Application	Q30	Q25	Q20	Q15	Q12	Q9
Face cream	Applicable	Applicable	Applicable	Not applicable	Not applicable	Not applicable
Lip stick	Applicable	Applicable	Applicable	Not applicable	Not applicable	Not applicable
Body moisturising stick	Applicable	Applicable	Applicable	Not applicable	Not applicable	Not applicable
AP Stick	Applicable	Applicable	Applicable	Not applicable	Not applicable	Not applicable
Foundation	Applicable	Applicable	Applicable	Not applicable	Applicable	Applicable
Lip gloss	Applicable	Applicable	Applicable	Applicable	Applicable	Applicable
Sun screen	Applicable	Applicable	Not applicable	Applicable	Applicable	Applicable
Mascara	Applicable	Applicable	Applicable	Applicable	Applicable	Applicable
Eye stay	Applicable	Applicable	Applicable	Applicable	Applicable	Applicable
Eye shadow	Applicable	Applicable	Applicable	Applicable	Applicable	Applicable
2-in-1 shampoo	Not applicable	Applicable	Not applicable	Not applicable	Not applicable	Not applicable
Hair conditioner	Not applicable	Applicable	Not applicable	Not applicable	Not applicable	Not applicable