Formulating with Quaternized Guar

Body washes and 2-in-1 shampoos have created a new market for quaternized guar products. These natural materials have excellent conditioning properties without causing buildup.

By Tom Schoenberg
McIntyre Group Ltd.
and
Dr. Manny Chowdhary
Economy Polymers and Chemicals

IN RECENT YEARS, quaternized guar has become a popular conditioner for both hair and skin cleansing products. It is used in major 2-in-1 shampoos and is the primary conditioner in numerous body washes. It is a unique conditioner derived from guar, a natural hydrocolloid. When formulated into a body wash, shampoo or hair conditioner, quaternized guar provides excellent conditioning without unpleasant polymer buildup after repeated use.

The word guar, derived from Sanskrit, means food for cows (gau means cow and aha means food). Guar gum belongs to the legume family and is primarily cultivated on the Indian subcontinent. Most of it is grown in northwest India and in the Sindh province of Pakistan. About 90% comes from India and about 5-10% from Pakistan. Small amounts are grown in Texas and Oklahoma.

The gum is derived from the endosperm of the guar bean, which has the following composition: hull (14-17%), germ (43-47%) and endosperm (35-42%). The composition of these three components is shown in the following chart.

	Protein	Fiber	Moisture
Hull	5.0	10.0	36.0
Germ	55.0	10.0	18.0
Endosperm	5.0	10.0	1.5

The guar seed is dicolyledonous with a diameter of approximately one eighth of an inch. The hull is softened and loosened by soaking in water and removed by grinding. Purification is accomplished by multistage grinding and sifting. Differential grinding is used to separate the germ from the endosperm. The endosperm is ground to a fine particle to produce the guar powder called guaran.[1]

Guar powder has many applications. In textiles, it strengthens yarn and keeps it smooth during printing and production. The powder is also used to increase the wet end strength of paper, thicken water for use in oil exploration and has applications in explosives, firefighting and mining.

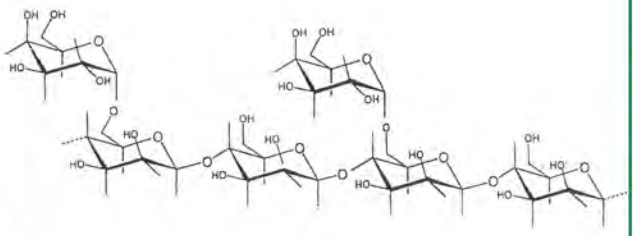
Guar gum and its derivatives offer several advantages for personal care formulators:

- It is natural and derived from a renewable resource;
- It conditions without causing polymer buildup in shampoo products;
- It is biodegradable and nontoxic and
- It is economical compared to other cellulosic products.

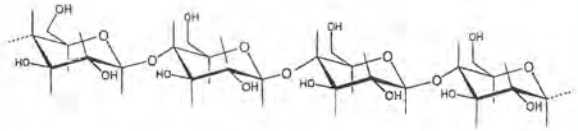
The main chain polymer of guar endosperm polysaccharide is composed of mannose. Every other mannose unit of the main chain is attached to a galactose unit at the 6 position of the mannose unit by alpha 1-6 linkages. All the mannose monomers are linked to each other by beta 1-4 linkages *(Fig. 1)*. Guar is the only one of the three main polysaccharides (the other two are starch and cellulose) that hydrate in water without chemical or physical modification.

The chemical structure shows that each mannose unit has a hydroxyl group at carbon 2 and 3. This plays an important role in the chemical modifi-

Figure 1: Guar



GUAR



CELLULOSE

cation and its unique cross-linking properties. Guar gum is stable at high pH (10-12) in the absence of air. At low pH (1-2) it depolymerizes in a short period of time.

The most valuable property of guar powder is its ability to hydrate in cold water and build viscosity. It forms a colloidal thixotropic dispersion in cold water. The rate of hydration is dependent on processing techniques. Typically, complete hydration occurs in 30 minutes. More recent improvements have produced guar that will hydrate in five minutes. The fast rate of hydration reduces manufacturing time.

Quaternized polymers are used in shampoos and conditioners to facilitate combability. The positively charged nitrogen bonds with negatively-charged hair fibers to form a polymeric film. They also make the hair feel softer and smoother to the touch. When used repeatedly, it is important that excess polymer does not build up on the cuticle surface. Polymer buildup can result in dull, lifeless hair. In order to determine buildup, 0.5% solutions of polyquaternium 10 and guar hydroxypropyltrimonium chloride were prepared.

Testing

Damaged hair fibers (twice bleached and permed) were soaked in ethanol followed by rinsing and shampooing three times with 12.0% active triethanolamine lauryl sulfate. Hair tresses were soaked for 30 seconds in 0.5 active test solution. Each tress was then washed with 1.0% active sodium lauryl sulfate (SLS) solution, followed by rinsing and drying. The soaking and washing was repeated for a total of five cycles and the hair fibers were examined with a light microscope at 400x.

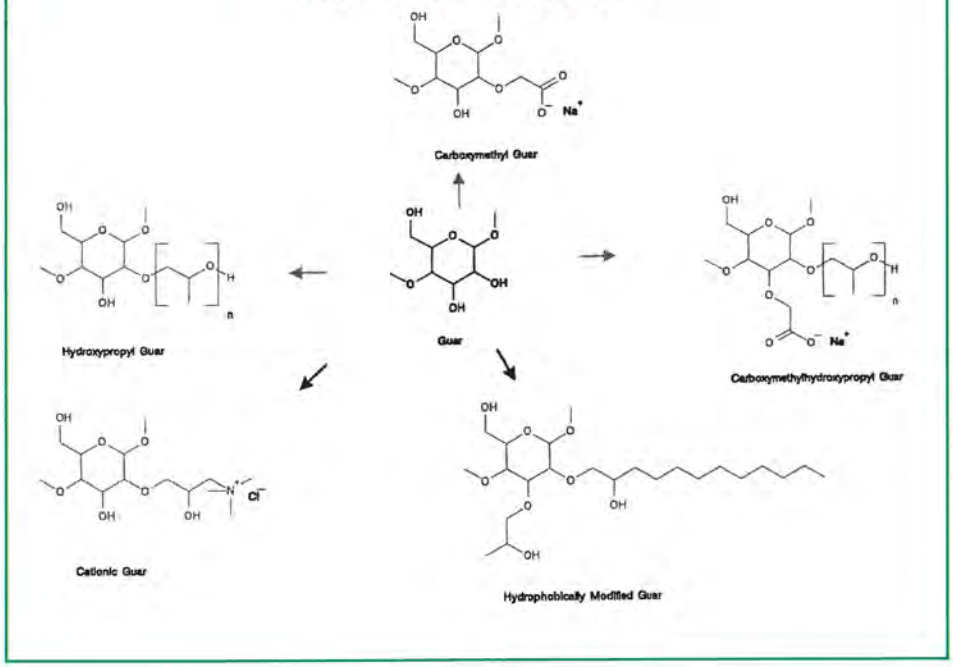
The first photo on p. 92 is of a hair fiber treated with polyquaternum 10. Signs of irregular polymeric buildup are evident. The second photo is of a hair fiber treated with the guar hydroxy- propyltrimonium chloride. The results show that guar hydroxypropyl -trimonium chloride did not build up on the cuticle surface after five treatment cycles.

The study demonstrates that differences in polymeric quaternium ammonium salts determines how the material is deposited on hair. Polyquaternium 10 tends to build up after repeated washing, whereas the quaternized guar does not build up, leaving a light continuous film on the hair fiber.[2]

Quaternized guar is a fine powder material available in self-hydrating and non-self-hydrating varieties. The formulator should make his choice based on the particular formula under consideration.

Self-hydrating guar is added to room temperature water with moderate agitation. The powder disperses readily and after 30 minutes it is completely hydrated. The other components are then added and the formula is adjusted to specification. The self-hydrating quaternized guar is recommended for products with a

Figure 2: Guar Derivatives



Hair fibers treated with polyquaternium 10 show signs of polymeric buildup after five treatment cycles.

large amount of available water.

The non self-hydrating type is recommended for products which have a low amount of available water in the formula. The reason for this is that once hydrated, the viscosity increases. The non self-hydrating type will not hydrate until it is neutralized. Therefore, the product viscosity at this stage is easier to handle. The non self-hydrating form is also added to room temperature water and blended for 30 minutes. The pH will be 9.0-10.0. Very little viscosity buildup will be observed. The other components are then added to the pH adjusted to 6.0-7.0. The guar will then hydrate and the viscosity is much easier to handle since the concentration of the quaternized guar is reduced. Both types of guar perform the same function in the formula.

Hair fibers treated with guar hydroxypropyltrimonium chloride do not show signs of buildup after five treatment cycles.

Types of Guar

Besides cationic guar, formulators can choose from other guar derivatives including carboxymethyl guar, hydroxypropyl guar, carboxymethylhydroxypropyl guar and hydrophobically modified guar. *Figure 2* describes the various structures derived from guar. The quaternized and propoxylated derivatives are the two most widely used for personal care.

Quaternized guar is also known to enhance the substantivity of silicone oil onto hair fiber. The combination is used in many of today's 2-in-1 shampoos. When properly balanced, the two compounds provide excellent wet and dry combing without buildup after repeated washing.

Quaternized guar is primarily used in conditioning shampoos, hair conditioners and personal cleansing products. Here are several select model formulas utilizing this unique hydrocolloid. The amount of quaternized guar can be varied, depending on the degree of conditioning required for the product type.

Moisturizing Body Wash

Ingredients	**%Wt.**
Ammonium lauryl sulfate	45.0
Mackalene 426 (isostearamidopropylmorpholine lactate)	6.5
Mackester EGDS (ethylene glycol distearate)	1.0
Mackernium 261 (guar hydroxypropyltrimonium chloride)	0.5
Tetrasodium EDTA (40%)	0.2
Citric acid	q.s. to pH 6.0-6.5
Paragon III (phenoxyethanol (and) DMDM hydantoin (and) methylparaben (and) propylparaben)	q.s.
Water, fragrance, dye	q.s. to 100.0

Procedure:

Disperse Mackernium 261 in room temperature water. Heat to 50°C and add ALS, Mackalene 426 and Mackester EGDS. Heat to 75°C and blend until the Mackester EGDS is completely dispersed. Cool to 50°C and add remaining components. Adjust pH to 6.0-6.5. The product has a pearly lotion consistency.

Leave On Conditioner

Ingredients	%Wt.
Mackalene 426 (isostearamidopropyl morpholine lactate)	8.00
Mackernium 261	0.05
Phenagon PDI (phenoxyethanol (and) DMDM hydantoin (and) iodoproynyl butylcarbamate)	q.s.
Tetrasodium EDTA (40%)	0.20
Citric acid	to pH5.0-5.5
Fragrance	q.s.
Water	q.s. to 100.0

Procedure:
Add Mackernium 261 to water and heat to 50°C. After 30 minutes, add Mackalene 426, Phenagon PDI, EDTA and fragrance. Cool to 25°C and adjust pH with citric acid. Cool to room temperature, filter and fill. This spray-on conditioner should be used after shampooing. After rinsing out shampoo, spray onto hair and comb through. Product will detangle, condition and provide anti-static properties. Treated hair has a smooth, conditioned feel.

2-in-1 Shampoo

Ingredients	%Wt.
Ammonium lauryl sulfate (28%)	55.0
Mackalene 426 (isostearamidopropyl morpholine lactate)	8.0
Mackester EGDS (glycol distearate)	1.5
Mackol CAS-100F (sodium cocosulfate)	2.0
Mackernium C-14S (guar hydroxypropltrimonium chloride)	0.4
Tetrasodium EDTA	0.2
Phenagon PDI (phenoxyethanol (and) DMDM hydantoin (and) iodopropynyl butylcarbamate)	q.s.
Citric acid	to pH 6.5-7.0
Water, fragrance	q.s. to 100

Procedure:
Disperse Mackernium C-14S in room temperature water. Heat to 50°C and hold for 30 minutes. Add ammonium lauryl sulfate, Mackalene 426, Mackester EGDS and Mackol CAS-100F. Heat to 70°C and blend until the Mackester EGDS and Mackol CAS-100F are dissolved. Cool to 50°C, adjust pH and add fragrance, tetrasodium EDTA and Phenagon PDI. Cool and fill. The product has a pearly lotion consistency.

Emollient Liquid Hand Soap

Ingredients:	%Wt.
Ammonium lauryl sulfate	40.0
Mackalene 426 (isostearamidopropyl-morpholine lactate)	5.5
Mackester EGDS (ethylene glycol distearate)	1.0
Mackernium C-14S (guar hydroxypropyltrimonium chloride)	0.4
Tetrasodium EDTA (40%)	0.2
Citric acid	q.s. to pH6.0-6.5
Paragon III (phenoxyethanol (and) DMDM hydantoin (and) methylparaben (and) propylparaben)	q.s.
Water, fragrance, dye	q.s. to 100

Procedure:
Disperese Mackernium C-14S in room temperature water. Heat to 50°C and add ALS, Mackalene 426 and Mackester EGDS. Heat to 75°C and blend until the Mackeser EGDS is completely dispersed. Cool to 50°C and add remaining components. Adjust pH to 6.0-6.5. The product has a pearly lotion consistency.

In conclusion, body washes and 2-in-1 shampoos have created a new market for quaternized guar products. This material is a natural conditioner that is relatively low-cost, easy to handle, compatible with most other components and does not exhibit build up on hair after repeated use. As next generation products are developed, quaternized guar should continue to be a special component which provides added value to skin cleansers, shampoos and hair conditioners.

References:

1. Whistler, R.L. & Hymowitz, T., Guar Agronomy, Production, Use, Industrial and Nutrition, Purdue University Press, 1979.
2. Lundmark, L., "Comparative Buildup Study Using a Lumicrease Dye Test Procedure," Aug. 1999.

About the Authors

Tom Schoenberg is director of international sales and marketing for the McIntyre Group Ltd., University Park, IL. He has been involved in the personal care market for more than 30 years. Most of his career has been spent in the area of product development of raw materials. During his career, Mr. Schoenberg has authored many articles relating to the application of specialty surfactants and conditioners. In addition, he holds several patents in the field.

Dr. Manjit (Manny) S. Chowdhary received his Ph.D. from Kings College, University of London, London, UK. He has 20 years of experience in carbohydrate/polysaccharide chemistry. Bayer AG awarded him scientist of the year. He has expertise in guar gum technology using both aqueous and alcohol process. He also has expertise in guar gum technology using both aqueous and alcohol process and also has expertise in chemical modification of hydroxyethyl cellulose (HEC) technology using alcohol process. In addition to the synthesis of these products, he also has expertise in the formulation of hair care products for conditioning purposes. He has been awarded nine patents and submitted more than 20 patent disclosures. In addition to research and development, he is also involved in the manufacturing of these products.