Fabric Softening Agents- Towards A Gentle, Economical And Safer Future For Fabric Treatment

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INTRODUCTION

There was a time when fabric softeners were considered unnecessary. Washing was done using ordinary soap made of tallow fat and caustic soda. This gave excellent detergency but tallow fat form an insoluble residue with calcium and magnesium in hard water (*Figure 1).* These residues are responsible for the greying effect on the treated fabric. In addition, the presence of saturated and unsaturated fatty acids in this ordinary soap eventually turns it rancid and odorous due to the presence of iron and other heavy metals in the wash water.

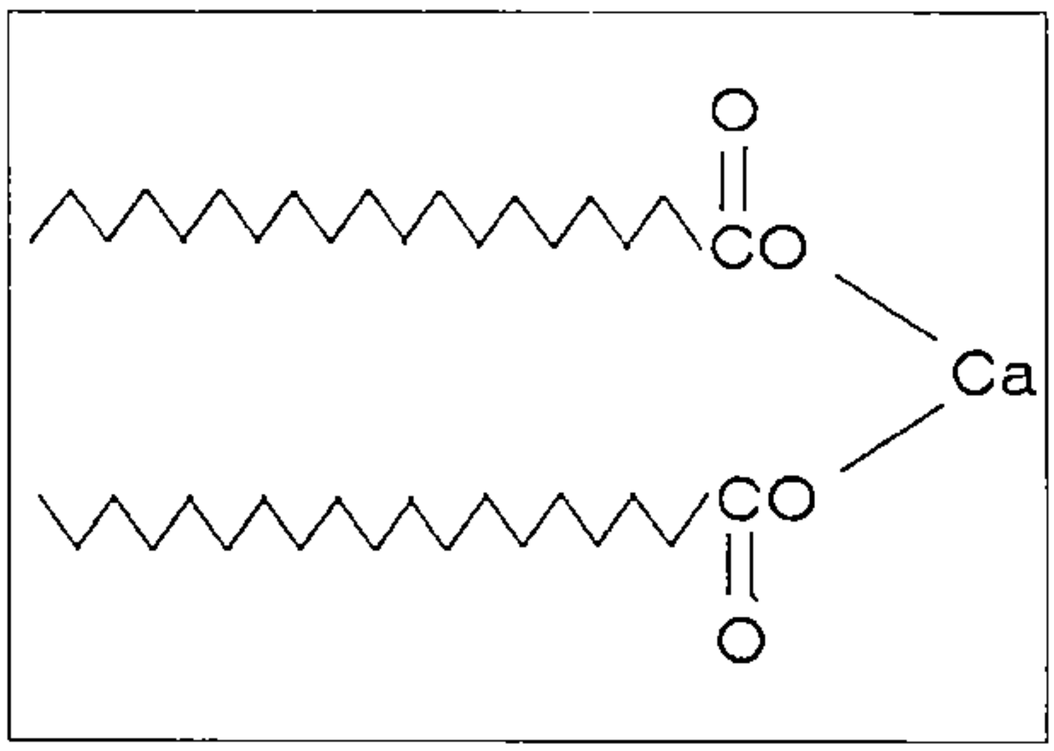

Figure 1. The structure of calcium soap responsible for the softening effect during washing.

Realising the adverse effect that the insoluble residue created, (Armark Co., 1983) synthetic detergents began to replace soap shortly after World War II with the prime objective of eliminating residues caused by water hardness. Synthetic detergents are truly effective. However, as clothes were no longer soft, a different situation arose. Synthetic detergents are used together with surfactants and a variety of inorganic builders to enable washing to take place without any precipitation of hard water residue. Although the calcium and magnesium salts of surfactants in synthetic detergents are water soluble, the use of high levels of inorganic builders caused the fabric to develop an unpleasant harsher feel (Whalley, 1995).

During the early 1950s, fabric softeners were introduced to counteract the adverse washing effects. Currently, the use of fabric softeners is accepted in all modern domestic fabric washing procedures. The fabric softening agents that are now widely accepted by the industry are the nitrogen-containing cationic compounds. These molecules are unique in that they contain a positively charged nitrogen atom and at least one long chain hydrophobic alkyl group

derived from animal fats or vegetable oils containing 16-18 carbon atoms. The existence of the positively charged nitrogen atoms lead to a marked difference in the nature of the surface active properties compared to the anionic and nonionic compounds. The positively charged nitrogen atom enables the molecule to be absorbed onto the negatively charged surface thus making it substantive. Also, the positively charged fabric softening agent posseses antistatic properties. The effect is to neutralize the electrostatic charges on the modern synthetic fibres which cause garments to cling during wear. The charged fabrics can also attract electrostatically charged dirt particles, which contribute to ready resoiling.

The substantivity allows cationic softening agents to be widely used not only as fabric treatment but also in other products whose functions are dependent on the structure of the cationic material such as:-

Hair care products

Biocides/fungicides/disinfectants

Foaming and wetting agents

Household cleansing products

Mineral processing agents

Organophilic clays

Mixing and anticaking agents

Corrosion inhibitors

In the fabric softeners industry, the oldest and still most widely used cationic surfactant is the dialkyl dimethyl ammonium chloride derived from tallow-based fatty acids (*Figure 2*). However, to satisfy consumer demand and stringent environmental regulations, there is constant need for new and better fabric softeners to be developed. Although many softening agents are now in the market,

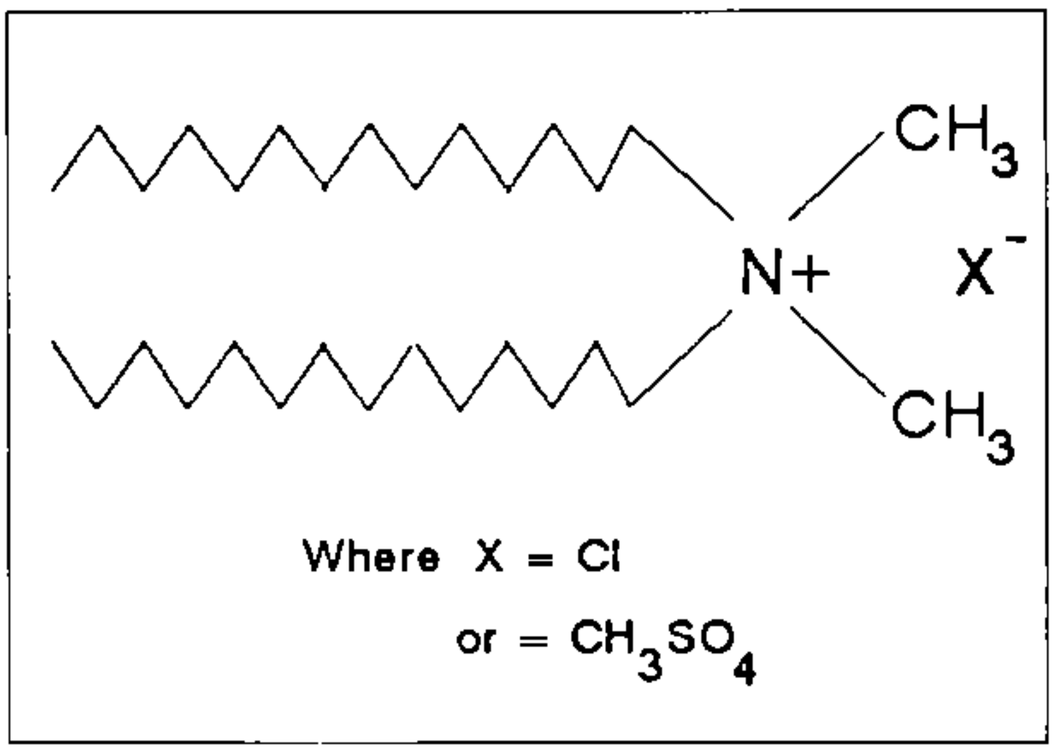

Figure 2. The structure of two common types of dialkyl dimethyl quaternary ammonium compounds.

none of them is perfect. Each of the agent has its own uniqueness but is also lacking in some other characteristics. This paper will discuss the various types of softening agents available in the market with emphasis on their properties.

DIALKYL DIMETHYL QUATERNARY AMMONIUM COMPOUNDS (DADQAC)

These are one of the oldest and most widely used softening agents. They were first developed to counteract the harsh feel that synthetic detergents gave on the washed fabric. Conventionally, for textile softeners, the alkyl radicals are derived from tallow, hydrogenated tallow and palm oil products. Being the first household fabric softener introduced in the market, according to McCarthy and Drozdowki (1989), DADQAC however only imparts superior softening in hot water. The raw material has poor dispersability, poor freeze-thaw stability and is solid at room temperature. These properties make the softener hard to handle and formulate and yet is the most expensive compared to other softening agents. Softeners based on DADQAC are normally added during the final rinse and are sold in aqueous form at a concentration of 4-6% .

DIAMIDOAMINE QUATERNARIES (DAAQ)

Diamidoamine quaternaries *(Figure 3)*, are the next major group of softeners available in the market. These products are also derived from tallow or hydrogenated tallow. In contrast with DADQAC, DAAQ offer both cost advantage and ease in formulation. They have good rewetting characteristics and are liquid at room temperature. Based on the above characteristics, DAAQ are the products of choice in a cold water system. Unfortunately, these softeners do not often perform well.

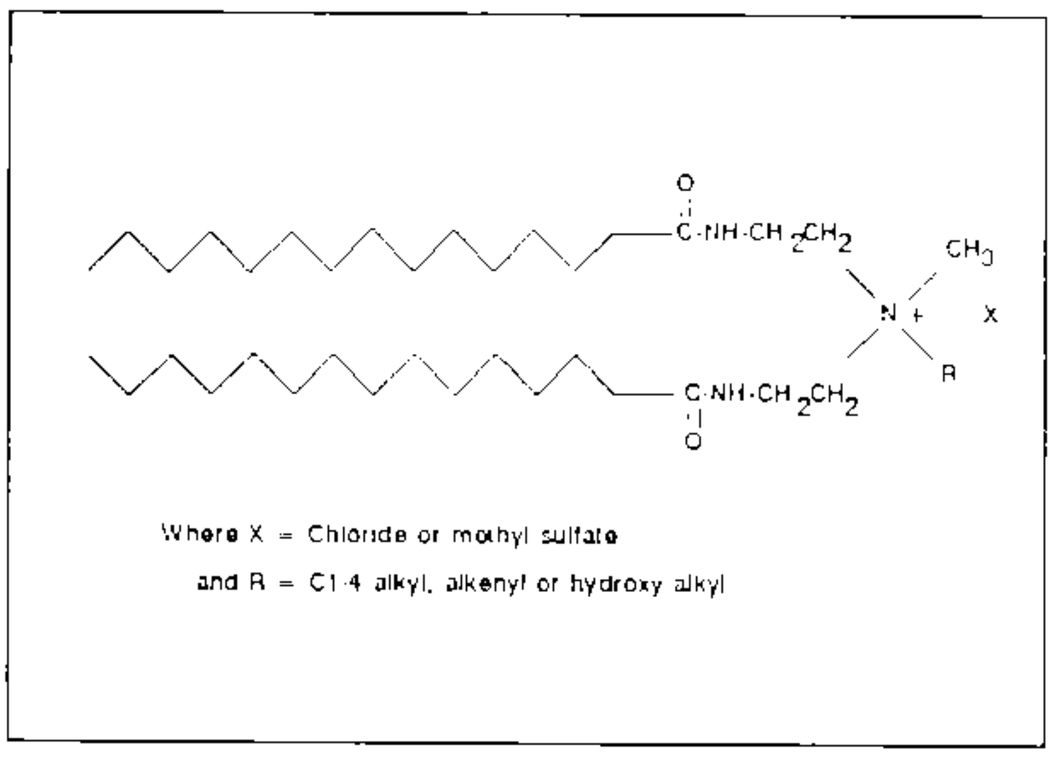

Figure 3. General structure of diamidoamine quaternaries.

FATTY IMIDAZOLINIUM QUATERNARIES (FIQ)

Fatty imidazolinium compounds *(Figure 4)* or FIQ were developed in view of the need to improve the performance of DADQAC and DAAQ. With the development of synthetic fibres and modern washing mechanisms, another problem arose. It became common for synthetic fibres alone or their mixture with cotton to become electrostatically charged very quickly, particularly in the drier climates. The effect causes the garment to cling to the skin and riding up, the charges also attracted dirt particles suspended in the air, thus creating a ready resoiling of the garments. Although

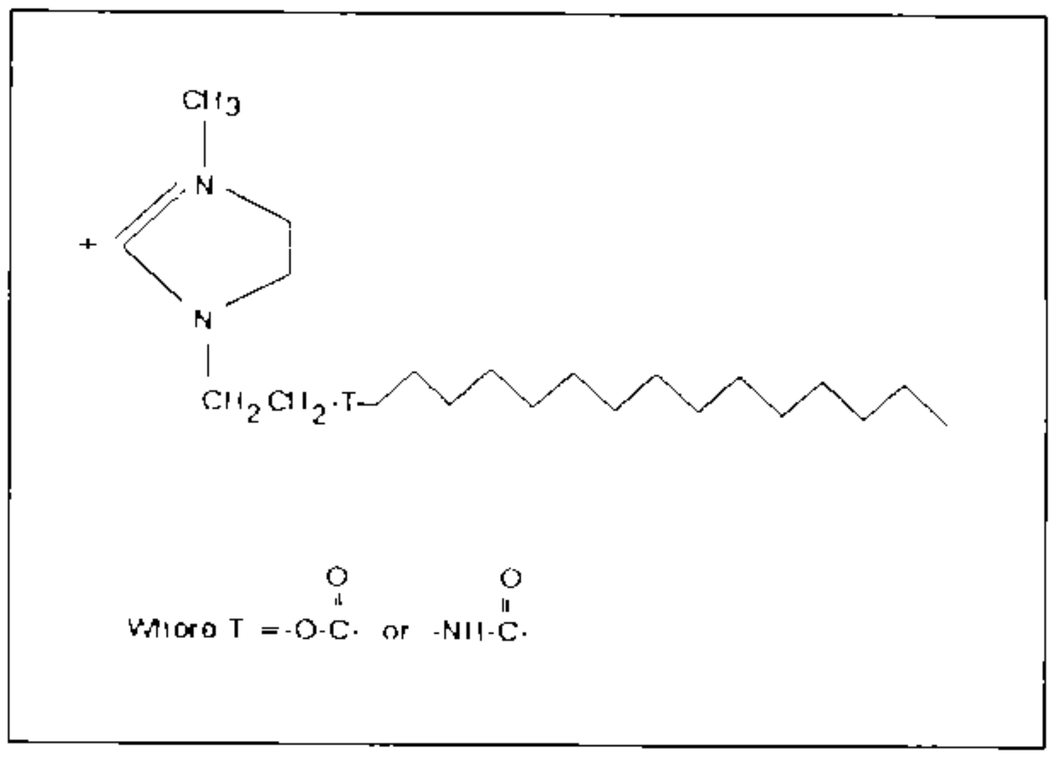

Figure 4. Two types of fatty imidazoline quaternaries.

cationic softeners are known to possess the static control characteristic, FIQ softening agents are best used for this purpose (Whalley, 1995).

DIESTERQUATS QUATERNARIES (DEQ)

Later, during the 1990s there was a dramatic change in softener formulation especially in Europe where environmental regulations forced the manufacturers to re-develop their softener formulations. Since about 80% of the raw material used to make softeners were based on DADQAC, all criticisms of softeners were directed towards DADQAC. The main criticism against DADQAC was its poor biodegradability during sewage treatment.

The new class of softening agents introduced are commonly known as Diesterquats Quaternaries (DEQ). These compounds are structurally similar to DADQAC as shown in *Figure 5*. They have two long chain alkyl groups attached to the cationic nitrogen atom to provide adequate softening and substantivity effects. But, the unique difference between these compounds and DADQAC is that DEQ contains at least one ester group situated between the long alkyl chain and the cationic nitrogen core. The ester group provides a potential breaking point for the molecule to form fatty acids which then further break down into carbon dioxide and the remaining cationic fragment.

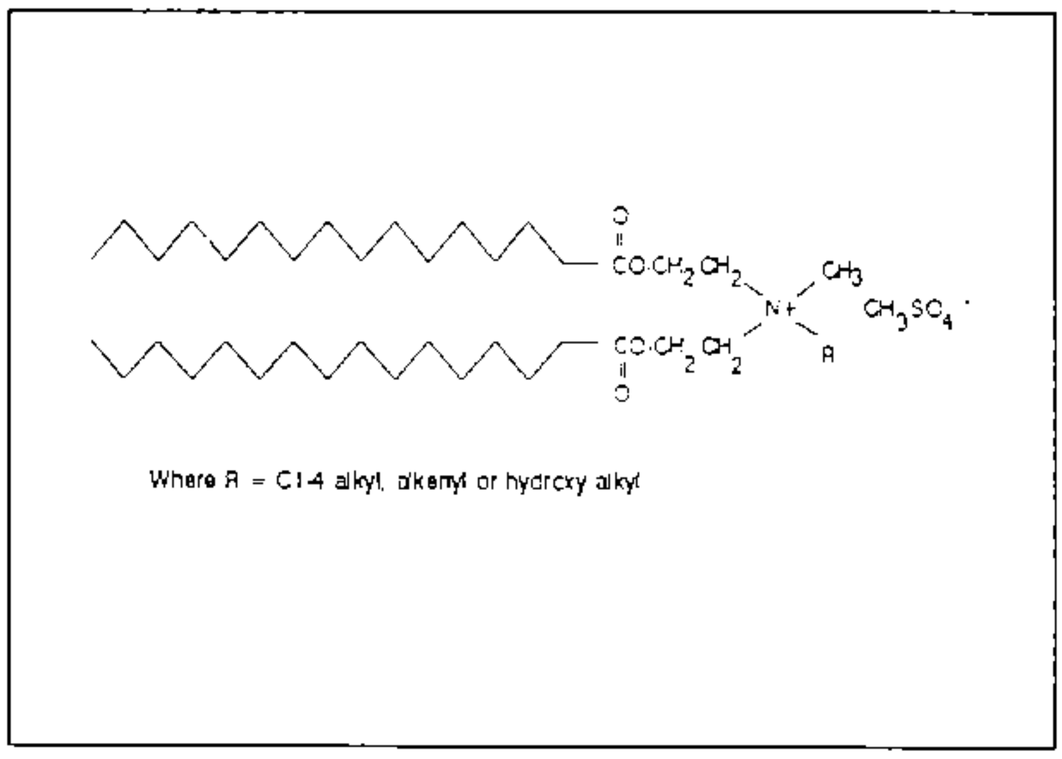

Figure 5. Diesterquats quaternaries.

Another advantage that DEQ offers is its ease in formulating stable concentrated products containing 25% of active ingredient and even superconcentrates with 50% active ingredient (Puchta *et al*, 1993). This in turn contributes to a reduction in packaging material.

However, despite their advantages, they do have a drawback. The ester group can undergo hydrolysis during prolonged storage. Therefore, to ensure adequate stability, the pH of the final product has to be maintained within 2 - 3.5 by the addition of a suitable pH buffer system (Whalley, 1995).

OTHER CRITERIA IN CHOOSING SOFTENER INGREDIENT

In general, none of the raw materials used in the softeners mentioned above, is perfect in performance. This is why the best formula is a blend of two or more ingredients to give added or synergistic benefits to the formulation. In summary, the DADQAC exhibits superior softening performance but fails to fulfil the requirements for static control. This shortcoming can often be overcome by blending with FIQ.

Another important factor besides the nature of the softening agent, is the source of the alkyl chain. Tallow based products are known to perform best and are more cost effective (Egan, 1968). They contain highly saturated fatty acids which are often required to minimize colouration and odour. However, unsaturated fatty acids are also important when cost, handling ease and highly concentrate formulations are concerned (Keys, 1995).

As per marketing demands, the trend is now towards vegetable-based products, particularly palm oil. Such products offer various advantages to the Muslims in particular. Palm oil is now one of the most abundant raw materials available in Malaysia. More importantly, their abundance ensures a regular and continuous supply of raw material in the future. Having almost an equivalent amount of saturated fatty acids as the tallow, palm oil has the potential to become the most widely used raw material in the fabric softener industry.

THE FUTURE OF FABRIC SOFTENERS

When fabric softener was first introduced, DADQAC was the major active ingredient in softener formulation providing excellent gentle feel to the fabrics. This was the only criteria required for a softener at that time. It was then realised that "softeners" not only soften but they also need to provide lubricity to the fabric to make ironing easier. Moreover, the hydrophobic part of the cationic molecule acts as a water repellent thus making drying time shorter and contributing to energy saving. Softeners also improve the suppleness of fabrics by providing a protective film on the fabric.

With all the benefits that softeners can offer, the demand for softeners has increased tremendously in tandem with the need to find cheaper raw material. Thus DAAQ was developed. DAAQ is not only cheap, it is also a stable raw material for the formulation of concentrate products which contribute to a reduction in packaging material. Later, with the

development of automatic clothes dryers and synthetic fibres, static control became critical. This was when FIQ came into the scene.

Owing to the stringent environmental regulation, DEQ was developed and it is now the major component in the fabric softener formulation while DADQAC is only used as a minor component to improve softening power.

TABLE. 1. FATTY ACID COMPOSITION OF PALM OIL, PALM STEARIN AND TALLOW

Carbon No.	Palm oil	Palm stearin	Tallow
C6	–	–	–
C8	–	–	–
C10	–	–	–
C12	0.2	0.3	–
C14	1.1	1.3	2.5
C16	44.0	55.0	26.6
C18	4.5	5.1	21.8
C18:1	39.2	29.5	42.8
C18:2	10.1	7.4	2.3
IV	53.3	35.5	25-48

CONCLUSION

It is expected that the future softener must possess the following desired characteristics:

- Good rewetting properties
- Stability of high-active concentrates
- Easy to pour
- No effect on fabric colour
- Compatible with other surfactants
- Compatible with ecological requirements

Currently, not all softeners satisfy the above requirements. Products are still being improved and formulators are searching for more compatible, high-performance softeners. Because of the competitive market, the terms "economical", "environmental-friendly" and "gentle" have become the common terms in the advertising strategy of surfactants, including cationic softening agents. ■

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