Softeners in the textile finishing industry*

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Introduction

SOFTENERS have gained great importance in textile finishing; almost no piece of textile leaves the production facilities without being treated with a softener. This softening treatment is to give the textiles the desired handle, make further processing easier and improve the handling properties. A nice, soft handle is often the decisive criterion for buying a textile and is therefore of most vital importance for marketing many textiles.

A Softener's main purpose is to improve the aesthetic properties of textiles

* It gives the fabric the desired handle; usually with imaginative descriptions such as soft, full, super soft, smooth, elastic, firm, dry, sludgy etc.
* It positively influences the technological properties such as antistatic, hydrophilic properties, elasticity, sewability, abrasion resistance etc.
* It gives synthetic fibres a certain degree of natural feeling and improve the handling properties through secondary effects (antistatic, smoothness, moisture regulation etc.).

Fig. 1: Desirable properties of textile softeners

- easy handling (liquid, pumpable, stable dilution)
- good compatibility to chemicals, easy to combine
- stable to high temperatures, not volatile by water vapour
- no yellowing
- no effect on fastnesses
- no colour shade changes
- low foaming, stable to shearing, no deposits on rollers
- regular and complete bath exhaust
- sprayable
- not toxic, not caustic, not corrosive
- easily biodegradable
- dermatologically harmless
- no restriction for transport and storing (flash point)

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Softening agents are also processing aids for raising, sanforizing, sewing or re-winding yarns which cannot be overlooked or are absolutely necessary for further processing. A fully developed product which complies with the demands the market calls for, must also fulfill many characteristics (Figure 1).

It goes without saying that one or two products cannot cover all these demands.

Compromises must be made or - and this is surely the better solution- optimized products for each field of application must be chosen. This explains the large selection of textile softening agents found on the market.

Features of the softening agent chemistry

Textile softeners are usually marketed as water emulsions with a solid content between 15 and 25%. Besides the additives, a marketable product also contains non-ionic emulsifiers or at least non-ionic dispersing agents to achieve a good chemical stability (salt stability). To optimize the product properties, the softeners also normally contain other special additives.

Softening agent additives

Textile softening agents are classified according to their ionic character (Figure 2). With a few exceptions, they mainly consist of fatty acid amine condensation products [1,2,3,4]. Hardened tallow fatty acids which contain equal parts of stearin and palmitine acid, are normally used as fatty acids. Technical oil acids may be used in special cases. Depending on the kind of amines and the applied quantities of fatty acids, either non-ionic or cationic substances result, whereas quaternary compounds of fatty acid amine condensates can be achieved through a further synthese step (quaternerization). Amphoteric compounds are often achieved through conversion of suitable fatty acid amine condensates with sodium chlorine acetate. Anionic compounds have a special status here: they are normally produced through sulphatization or phosphatization of fatty compounds.

Through the introduction of silicone chemistry for textile finishing, functional polysiloxanes have their firm place in the finishing agent range. All silicones are based on an alternating Si-O-polymer structure.

Fig. 2: Classification of textile softeners according to their ionogenity

Ionic activity	Electric charge
nonionic	no charge
slightly cationic (pseudo cationic)	at acid pH's slightly positive
cationic	at acid pH's very positive
quaternary	positive no matter of pH
amphoteric	dependent on pH slightly negative to slightly positive
anionic	negative

On the one hand the oil viscosity differs and therefore in the medium molecular weight and on the other hand through different functional side groups in the polymers. The amino functional polysiloxanes have become the most important product group [5] within the textile softening agents.

Besides the amino functional polysiloxanes, ethoxylated/ propoxilated silicones as well as those with epoxifunctionality have also become important.

Figure 3 shows some formula examples of softener additives.

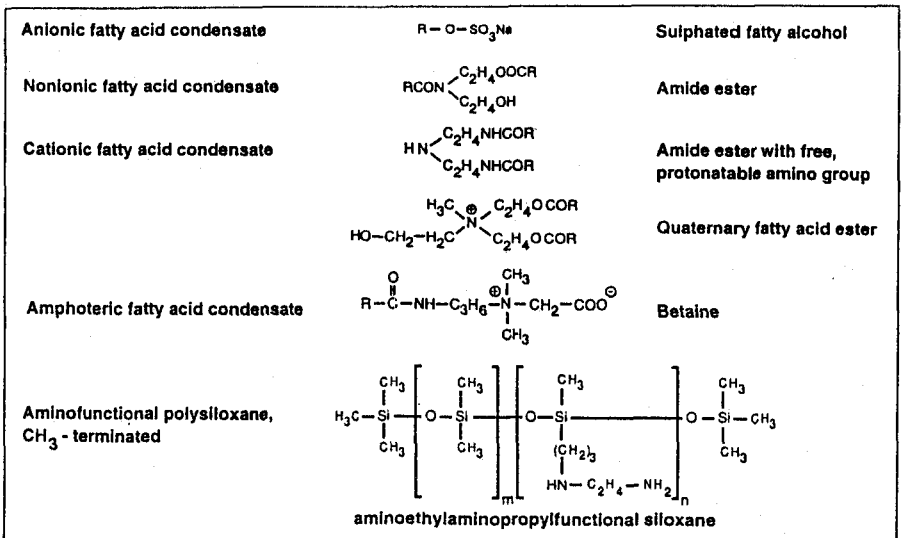

Fig. 3: Simple formula examples for active substances of softeners

Softener additives

Products based on pure fatty acid amine condensates are being used less and less in daily work. Modern softener agents contain special additives (Figure 4) besides emulsified fatty acid amine condensates which allow for much better effects and a much broader application field (2.3).

Fatty acid esters (e.g. glycerine ester) or waxes (e.g. carnuba wax) are often applied as additives.

Paraffins are well known for their application in smoothening agents. Very interesting are paraffins with a carbon chain length of C24 to C32. Paraffins with a shorter C-chain vapourises rapidly, whereas those with longer chains can be converted to usable emulsions only under pressure.

Fig. 5: Loading of the fibre and the softener

Fibre	Electric charge	Preferred ionogenity of the softener
Cotton	negative	cationic
Wool (neutral)	slightly negative	cationic
Wool (acid)	slightly positive	anionic
PA (neutral)	slightly negative	cationic
PA (acid)	slightly positive	anionic
PAC	negative	cationic
PES	-	-
PP	-	-

The substance classes of polyethylene is a further additive worth mentioning. Mainly secondary emulsions of oxidized polyethylene waxes are used here.

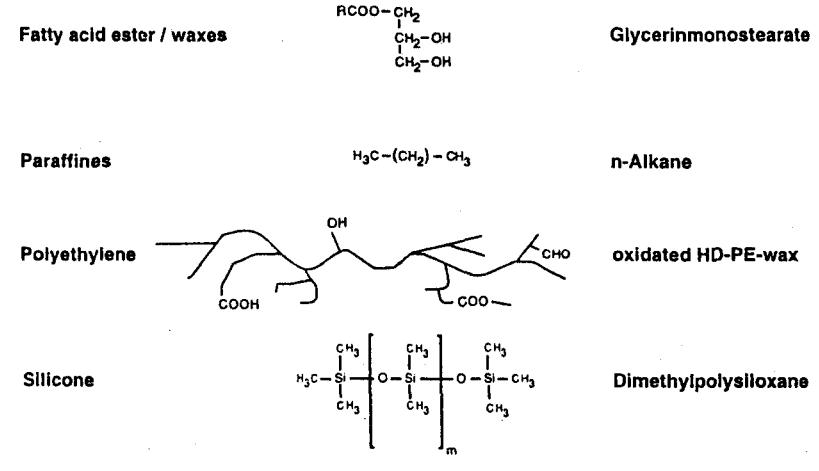

Fig. 4: Simple formula examples for softener additives

Last but not the least, silicones are often applied as additives to formulate multifunctional softeners.

Application of textile softeners in practise

Non-ionic softeners

Non-ionic softeners do not carry any electrical charge and therefore do not possess any distinctive substantivity. Such products are applied by means of forced application. i.e. usually in padding mangle procedures. Non-ionic softeners can be combined universally, are stable to temperature and do not yellow. This is the reason why this product class is perfect for finishing optically brightened high-white articles. The soft handle of pure non-ionic products is only average.

Cationic softeners

Cationic softeners show the best soft handle and are therefore used for household articles as well as for industrial articles. They have affinity to almost all fibres and are usually applied by the exhaust method (Figure 5). The only problem is the incompatibility with anionic auxiliaries (optical brighteners, dyeing auxiliaries) as well as their tendency to yellow in comparison with non-ionic products. Cationic softeners are mainly used for coloured textile substrates.

Amphoteric softeners

Formulations based on amphoteric substances are usually for special products of certain applications. Amphoteric products give an average handle, are normally compatible with white and give the fabric a good hydrophilicity as well as excellent antistatic properties. Furthermore, amphoteric softeners are very sensitive to skin and are often biodegradable. The main application range is hygiene and terry-cloth articles.

Anionic softeners

Anionic softeners are being used less because of the somewhat poor handle and the low substantivity, but are still of importance for certain fields.

* as sanforizing assistance thanks to their good re-wetting properties
* as crease-preventing agents in dyeing processes (anionic products do not retard at all or only to a small extent)
* for one-bath application with other anionic auxiliaries such as optical brighteners
* as a raising assistant due to good smoothing and antistatic efficiency
* as a sizing fat

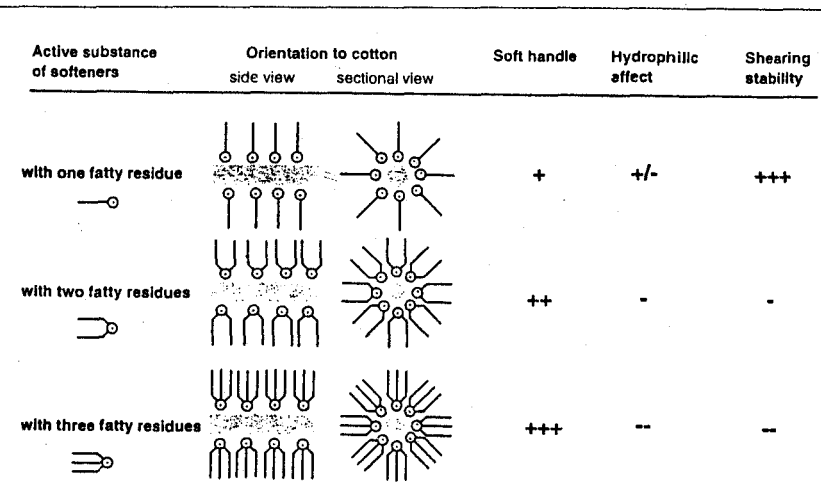

Fig. 7: Correlation between molecule structure and application technical properties

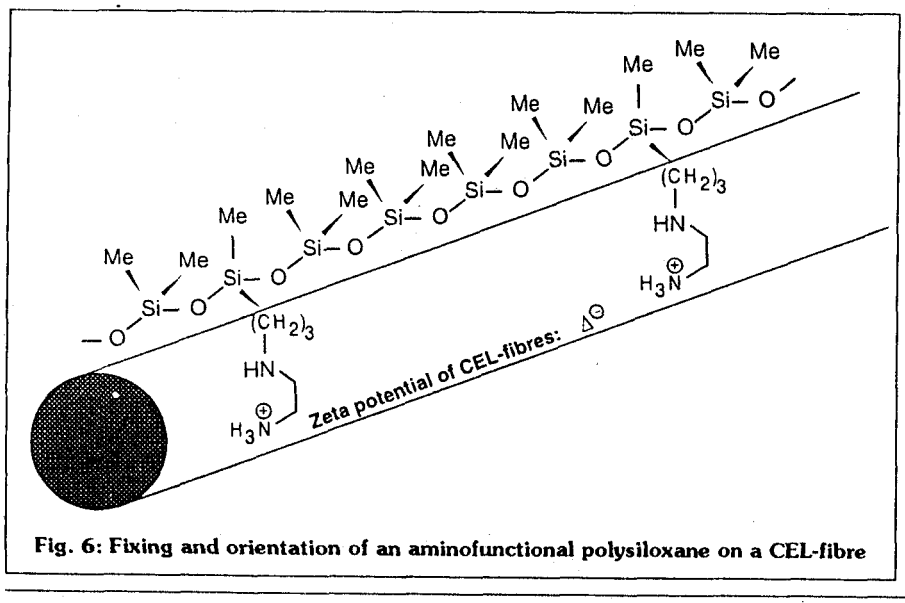

Fig. 6: Fixing and orientation of an aminofunctional polysiloxane on a CEL-fibre

Softener specialities

Pseudo-cationic softeners

Pseudo-cationic softeners can be classified between non-ionic (average handle) and cationic (yellowing) products. They take on a certain compromise, i.e. they can be used on white fabrics still having a good affinity and about the same soft handle as cationic products, providing that the drying temperature or condensation or thermofixation is not too high.

Silicone micro emulsions

Amino functional silicones have a big importance to textile softening companies. Their surface smoothening and softening properties are above all other product groups. Micro and semi-micro emulsions can be made with specially selected emulsifying recipes using aminofunctional silicones. They offer a number of advantages which are totally in keeping for modern textile finishing. The low particle size (micro emulsions <0.01μ) semi micro emulsions <0.1 μ) allow for the additives to penetrate in to the fibre core and in this way allow for an excellent product distribution of the micro emulsion. Silicone micro emulsions give textiles an excellent inner soft-

ness and a distinctive surface smoothness without looking greasy. They improve the technological properties of the textile (e.g. abrasion resistance, creasing angle), support the elasticity and optimize the sewability. Micro emulsions have a good product stability and decrease the hazard of roller coverings (6). The use of fast-running machines/ devices with high shearing forces may cause problems when working with silicone micro emulsions (bath stability) unless specially optimized products for this application field were selected.

The softening capacity of silicones is based on the gliding behaviour on the fibre surface as well as in the fibre. Polydimethyl siloxanes attached to amino-functional groups allow for a better orientation and substantivity of the silicone on the substrate (Figure 6). This again leads to a better soft handle ("super soft)" and good washing permanency (6).

(CHT micro-emulsions: Tubingal SME, MSI, SWB)

Multi-functional softeners

Nowadays, a modern softening agent should be "multi-functional". Products only based on fatty acid amine condensates are being found less today in practise. Besides the aspect of soft handle, multi-functional softeners today should have other finishing aims such as hydrophilicity, sewability, antistatic, surface smoothening, shearing stability etc. Multi-functional softeners contain further additives besides the classical fatty acid amine condensates. The properties can be expanded to many fields by choosing the right formulation.

For example: Jet softeners

A softener for application on the Jet must be drawn up in such a way that it can stand high pump and nozzle shearing forces. But more

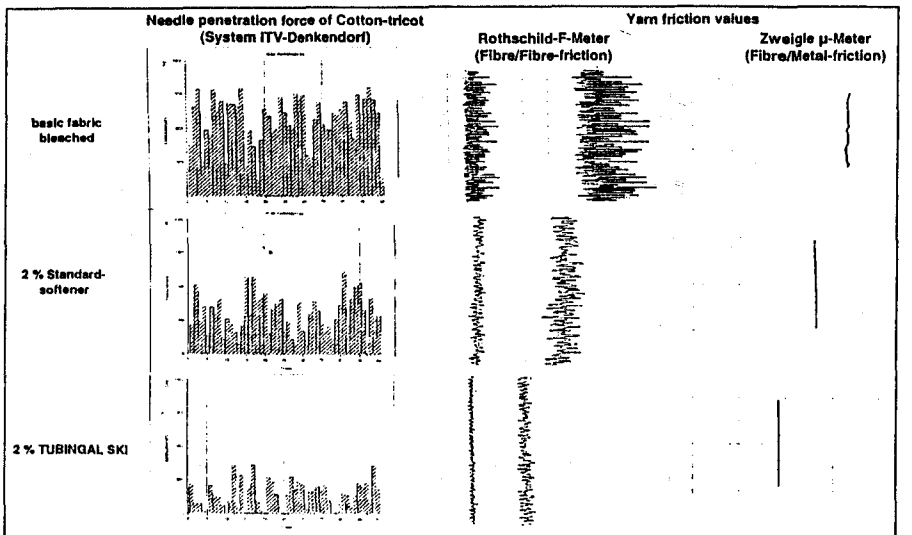

Fig. 8: TUBINGAL SKI: Sewability softener with surface smoothing effects

than that, such a product must also possess an extremely high emulsion stability/quality. A suitable defoaming system will guarantee a low foam formation during usage. The foam which is formed should be decomposed quickly. Additives which reduce the surface tension of the water can be helpful. The product must continue to have a good affinity to the textile which is to be finished so that a total bath exhaustion and a good effect can be achieved. Due to the softener in the liquor decreasing, the foam formation will become less during application. It goes without saying that the chemistry of the applied fatty acid amine condensate plays a very important part. It is easy to understand that condensates with two or even three fat residues are less suitable for the base of shearing force stable softeners due to their molecule size and their predominant hydrophobic character than a condensate with only one fat residue. Contrary to this is the soft handle (Figure 7). A good compromise must be found here and the soft handle can be improved through proper additives (product example: Tubingal SKK)

For example: Hydrophilic softeners

Through the orientated adsorption of cationic softeners, it will come to a real hydrophobicity of the cotton fibre which is hydrophilic by nature. The hydrophobic molecular parts point to the outside, screen the fibre from any hydrophilic attack (Figure 7). But in many cases a good absorbency of the material is demanded, for example when printing or sanforizing afterwards, for sportswear and also for terry-cloth articles. A hydrophilic softener may therefore not cause any dense screening off of the hydrophilic fibre core through hydrophobic change effects. The hydrophobic change effects must be interrupted. It is therefore necessary that specific "disturbance spots" are built into the softener film which allow for a spontaneous penetration of water. Besides a good absorbency of terry-cloth articles, an even perpendicular orientation of the loops is desired which expand even more after tumble processes and make the material look thicker. A good terry-cloth softener (e.g. TUBINGAL HSB should help the loops to stand and give the fabric a fluffy, soft handle as well as fullness and volume.

For example: Sewability softeners

Removal of the natural substances that make cotton fibres smooth through washing and bleach-

ing processes in pretreatment as well as long dyeing period and/or easy-care finishings together with severe drying/condensation conditions lead to sewing damages through fibres becoming brittle and decrease of the firmness especially on knit goods. Highspeed industrial sewing machines allow almost no time for the fibre to move as it is already very restricted in its mobility and elasticity. In a split second the mesh which was hit by the needle must expand from its actual diameter to the diameter of the needle. The mesh must have enough room in the interstitches to allow for expansion. This calls for a good flexibility of the mesh threads with each other (friction: thread/thread), also a low friction between the needle and the textile (friction: metal/thread). Separated mesh damages which appear after a mechanical stress of one or two household washings are often the result when choosing the wrong products and give rise to complaints. Softening agents such as TUBINGAL SKI which contain special gliding agents for surface smoothening help solve problems in this field. Figure 8 is a live example of the correlation between needle penetration force (8), thread/thread friction according to Rothschild and thread/metal friction according to Zweigle.

Conclusion

Textile softening agents are of great importance for textile finishing and textile care. The continued development of procedure technique with new machines, fabrics and fibres, the fast moving trends as well as the higher demands for quality, comfort and ecology by the consumers will in the future also play an important part for innovative products in the field of textile softeners. ❑