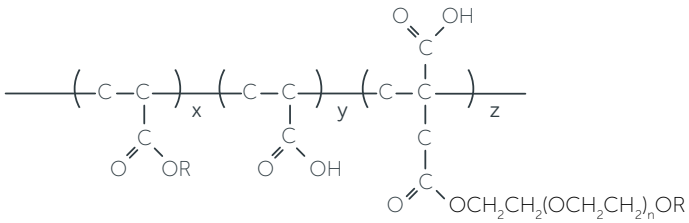
Structure® 2001 / Structure® 3001 polymers

Thickeners for highly alkaline, high salt formulations

INCI: Acrylates / Steareth-20 Itaconate Copolymer
Acrylates / Ceteth-20 Itaconate Copolymer

Structure 2001 and 3001 polymers are acrylic emulsion thickeners designed for use in such hard-to-thicken formulations as hair dyes, relaxers, permanent waving lotions, specialty gels, and depilatories. These associative, alkali-swellable polymers are well-suited for such formulations because of their thickening efficiency over a broad alkaline pH range and their stability in many aggressive environments. Structure 2001 and 3001 polymers are extremely user-friendly. They can be easily mixed into most formulations, and once they are neutralized, create clear, shear-thinning gels.

Figure 1: Structure 2001 and Structure 3001 polymer chemistry



Polymeric thickeners are cost-effective, efficient and easy-to-use

Oxidative hair colorants, permanent waves, relaxers, and depilatories have traditionally been thickened by surfactants, fatty alcohols, and waxes. Polymeric thickeners can offer significant advantages in terms of thickening efficiency, ease of manufacturing, and reduction of irritancy while enabling formulators to prepare products that address recent market trends from hydrophobic to more highly aqueous formulations. The Structure 2001/3001 series thickeners were developed in response to the movement towards highly aqueous formulations. Because these polymeric thickeners are extremely efficient, advantages in terms of minimizing cost while maximizing performance can be achieved.

Structure 2001/3001 thickeners are supplied as low viscosity, aqueous emulsions. These pH triggered thickeners are easy-to-handle. For example, in two-component hair dye systems, the polymer can be added directly to the developer where it maintains its low viscosity. This developer can be mixed with an alkaline base. Neutralization will allow the alkali-swellable polymer to effectively and efficiently boost the system viscosity to the formulator's desired level.

Advantages of associative thickeners

Associative polymers offer advantages for hard-to-thicken formulations. Alkalinity triggers the swelling of the Structure 2001/3001 thickeners, but it is the association of pendant hydrophobic monomers which gives the polymers their outstanding efficiency. This association is physical, not chemical, so in the formulation the polymer is highly shear-thinning. This property is critical in many hair care products where the product needs to be easily squeezed from an applicator and massaged into the hair, yet must set up instantly once the shear is removed.

Recommended applications

Because of differences in monomer composition and ratio, each polymer exhibits a unique set of performance attributes. In addition, blends of the two thickeners can allow a formulator to achieve an optimal balance of properties.

Application	Structure thickener
Hydrophobic hair color	3001
Hydrophilic hair color	2001
Permanent waves	3001
Relaxers	2001
Specialty hair gels	2001
Depilatories	2001, 3001

Structure thickeners are also well-suited for skin care products, specialty cleansers for the face, body and hair, diaper creams and other difficult-to-thicken formulations.

Features and benefits

Feature	Benefit
Low viscosity (as supplied)	Easy-to-use aqueous–based emulsion polymers can be readily poured and mixed
Shear-thinning	Formulation can be easily squeezed from an applicator, or mixed in a bowl, but will set up readily on the hair
Water soluble when neutralized	With just water, product will easily rinse from the hair
Stable to hydrogen peroxide	Structure polymers are excellent choices for inclusion into the hydrogen peroxide containing developer of oxidative hair dyes
Stable viscosity of neutralized systems	Structure polymers can also be used in one-component, pre-neutralized formulations such as hair dyes, gels and relaxers
Synergistic with many common surfactants	Viscosity boosts can be achieved through appropriate polymer/surfactant blends
Solvent tolerant	At concentrations up to 20%, common solvents will not affect Structure polymer thickening efficiency
Easily neutralized	Our thickeners can be neutralized by most commonly-used counter ions
Anionically-charged	While use with cationic ingredients is not recommended, Structure polymers are compatible with most non-ionic and anionic ingredients

Suggested use levels

Application	% as polymer solids
Aqueous gels	1-3%
Relaxers	1-3%
Hair dye	2-4%

Formulation guidelines

While Structure 2001/3001 polymer thickeners are extremely user-friendly, and in general can simply be added to water, neutralized, and easily mixed, the following guidelines may be helpful.

A formulator may want to create an aqueous pre-mix containing about 50% water and 50% polymer as supplied. By no means is this a requirement of using Structure 2001/3001 polymer thickeners, but it may further reduce processing time and increase processing ease.

When using Structure 2001/3001 polymer in a single-component system, remember to add the neutralizer last. This minimizes mixing energy inputs and allows for more efficient processing.

As mentioned earlier, Structure 2001 polymer and Structure 3001 polymer can be blended to optimize the performance attributes of both. For example, one might take advantage of Structure 2001's polymer high efficiency, while blending in the salt tolerance offered by Structure 3001 polymer.

While the choice of monovalent neutralizing agent will have little effect on the thickening efficiency of Structure polymers, we suggest, where possible, to avoid the use of divalent counter ions. When working in high electrolyte formulations, add the thickener first, then add salts.

Performance properties

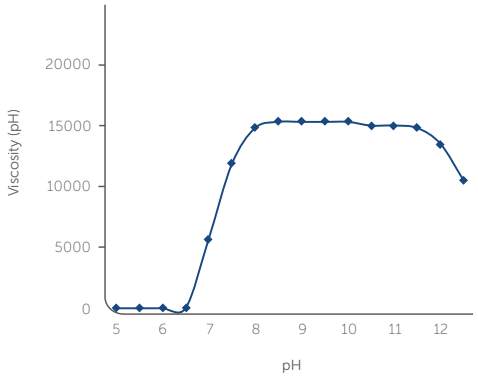
Performance of the Structure thickeners is formulation dependent. The viscosity attained is a function of formulation variables such as salt concentration, type and level of surfactant present, pH, and polymer concentration. In highly aqueous formulations, Structure thickeners are effective at 1-4% solids levels. In traditional high-surfactant systems, marked viscosity improvements can be seen at solids levelsas low as 0.5%.

Effects on viscosity: the effect of pH

While Structure thickeners achieve their high efficiency from the physical association of pendant hydrophobes, it is exposure to alkaline pH which first allows these polymers to swell and subsequently associate. The Structure 2001/3001 polymer series thickeners achieve very high, stable viscosities from pH 6.5 through pH 13 and higher.

At low pH, the Structure thickeners will remain in their low viscosity emulsion form. However, they are compatible with ingredients that require low pH stability, like hydrogen peroxide.

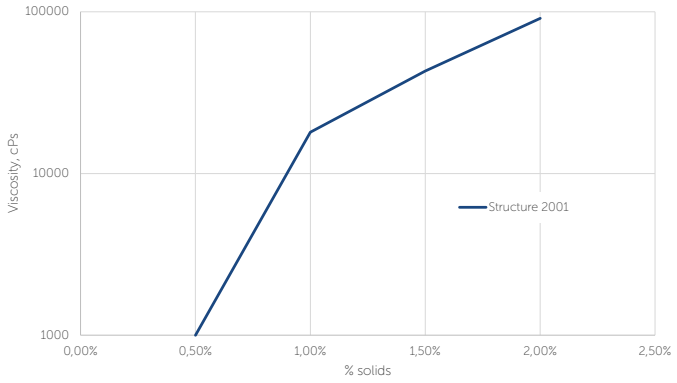
Figure 2: pH Effects on viscosity for Structure 2001 polymer



The effect of polymer concentration

At low use levels, the Structure 2001/3001 thickeners give very high viscosities. The relationship between polymer solids and viscosity is logarithmic, not linear, meaning that small increases in solids produce large boosts in viscosity. These efficiencies may translate to greater formulation latitude and/or cost savings.

Figure 3: Polymer concentration effects on viscosity



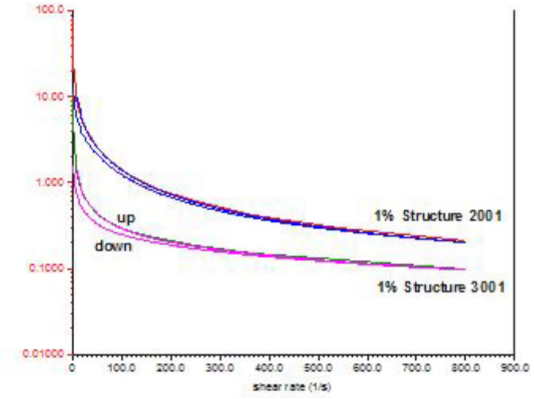
Brookfield 20 rpm

Effects of shear

The dominant thickening mechanism for the Structure series of polymers is the formation of physical associations between the pendant hydrophobic monomers. Since this association is physical rather than chemical, shear can easily disrupt these associative linkages, making the polymers highly pseudoplastic.

Because the associative linkages reform nearly instantaneously, these thickeners exhibit little thixotropy, and quickly recover viscosity after shear. Stepped shear and thixotropy loops demonstrate dramatically the extent of the shear thinning behavior of our polymers and how quickly the viscosity is recovered.

Figure 4: Stepped shear and thixotropy loops of 1% Structure 2001 and 3001



Had the polymers exhibited the thixotropic breakdown in viscosity (common to many personal care thickeners), the gap between the upper and lower trace would have been much more pronounced. This unusual viscosity versus shear behavior enables your formulations to be gel-like at rest, yet very workable during use. For a point of reference, the following are typical shear rates of common cosmetic and toiletry actions[1].

Action	Shear rate (sec $^{-1}$)
Suspending ingredients	$10^{-3} – 10^{-1}$
Pouring	$10^{1} – 10^{2}$
Extrusion from a tube	10^{2}
Topical application of creams and lotions	$10^{2} – 10^{4}$
Applying lipstick	$10^{3} – 10^{4}$
Brushing nail polish	$10^{3} – 10^{4}$

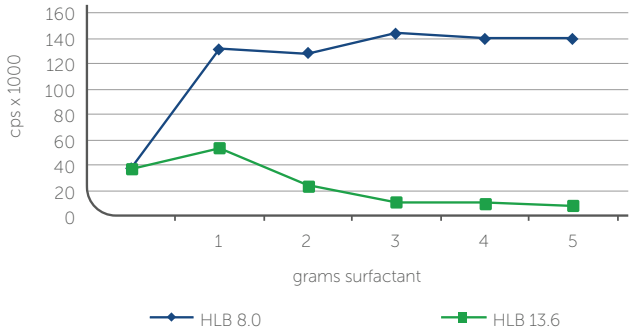
[1]Dennis Laba, (ed.), Rheological Properties of Cosmetics and Toiletries, Marcel Dekker, Inc., New York, p.5 1993.

Interactions with surfactants

Because the Structure 2001/3001 polymer's associative monomer itself is surfactant-like, most surfactants will have some effect on the performance of our thickeners.

In general, hydrophobic surfactants offer the greatest amount of synergistic viscosity boost to the Structure polymers. Hydrophilic surfactants also give a synergistic thickening effect at low concentrations but can adversely affect thickening as concentration increases.

Figure 5: Structure associative thickeners synergy with surfactants

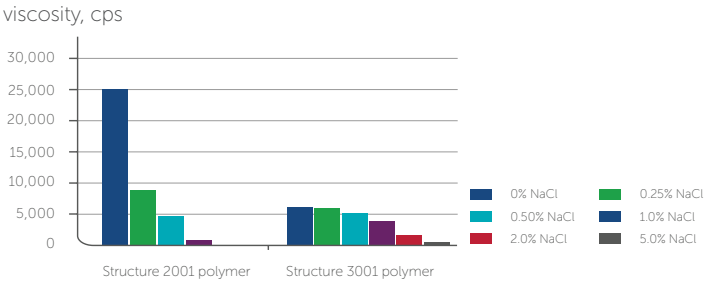


As examples, Lauramide DEA and Polysorbate 81 are synergistic with Structure thickeners, while Sodium Lauryl Sulfate and Cocamidopropyl Betaine are less so. A detailed review of our surfactant study is available upon request. Please ask for Surfactant Effects on Structure 2001/3001 polymer Thickener Efficiencies.

Salt tolerance

Relative to many acrylic thickeners, Structure series thickeners show excellent salt stability. Structure 3001 polymer demonstrates outstanding salt tolerance, and as shown in figure 6, can significantly build the viscosity of even a 2% solids sodium chloride solution. It does not phase separate, even at a level of 5% sodium chloride. Although the Structure 2001 polymer is less tolerant to salt than the Structure 3001 polymer, it still shows good salt tolerance, and has superior salt tolerance to many alternative acrylic thickeners. Graphically represented below is a worst-case scenario of salt tolerance. The addition of surfactant to the system will significantly reduce the adverse effects of salts to both Structure polymers.

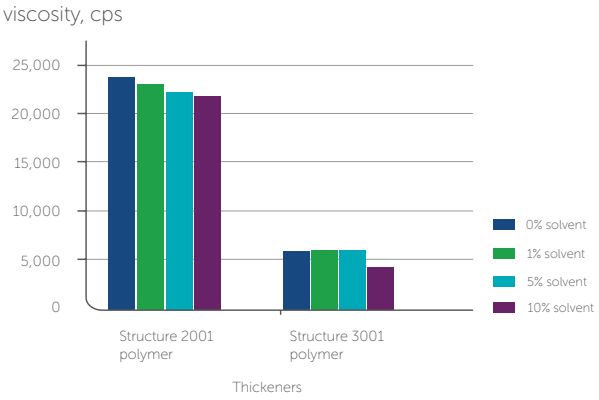
Figure 6: Salt tolerance of neutralized thickeners 5:1 polymer : base in water



Solvent tolerance

As represented below with isopropyl alcohol (IPA), the use of moderate amounts of most solvents will have no significant effect on the thickening performance of the Structure polymers. Other solvents, such as ethanol, propylene glycol, hexylene glycol, and ethoxydiglycol similarly have been found to have little effect on the thickener efficiency at the concentrations studied. Solvent concentrations > 20% will inhibit thickener efficiency.

Figure 7: IPA tolerance of neutralized thickeners 5:1 polymer : base in water



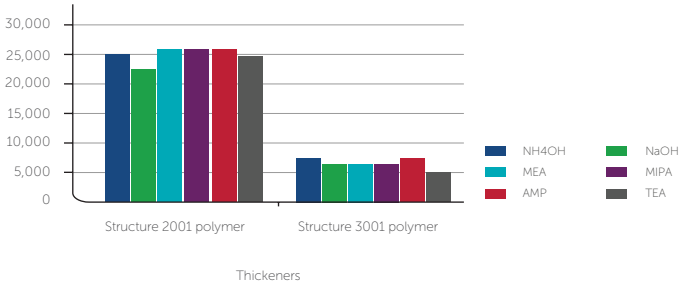
Brookfield 10 rpm, Thickener concentration = 1%

Base = NH_4OH

Effect of counter ions

While ammonium hydroxide is the base most commonly used in hair dye compositions, we recognize that other bases are being effectively used in these and other personal care formulations. A formulator's choice of monovalent neutralizing counter ion shows little effect on the performance of Structure thickeners.

Figure 8: Counter ion effect on thickener efficiency equal moles of base in water



Thickener concentration = 1%

Base Reference = 5:1 Thickener : NH_4OH

Brookfield, 10 rpm

The Structure 2001/3001 polymer thickeners can also build viscosity in the presence of divalent counter ions. However, the resultant viscosity build is lower due to interactions between these ions and the carboxylic acid groups on the polymer backbone.

Stability

Stability of neutralized thickeners

The Structure 2001/3001 polymer thickeners are stable over time in the presence of heat and high pH. The data below indicates that polymers in the Structure 2001/3001 polymer series could effectively thicken such one-component hair treatment products as hair gels, semi-permanent colors, and temporary colors. Remarkably, we also see excellent stability at pH >13, and recommend the use of Structure 2001 polymer in such caustic systems as relaxers and depilatories.

Figure 9: Stability of neutralized thickeners pH 9.5, 45˚C

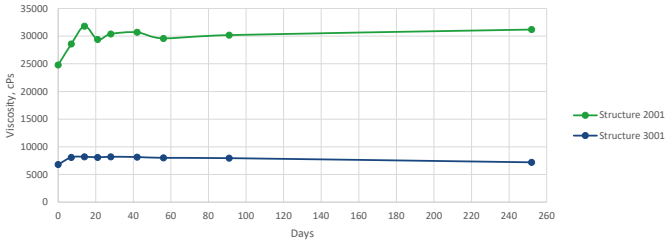


Figure 9: Thickener concentration 1% solids

Hydrogen peroxide stability

Structure polymers are stable to hydrogen peroxide over time and in the presence of heat. In standard boil bath tests, nearly all of hydrogen peroxide's activity was maintained.

20 Hour Boil Stability in 6% Hydrogen Peroxide/0.1% H_3PO_4

Polymer action	% H_2O_2 retained
Blank	100.0
Structure 2001	99.0
Structure 3001	99.0

UV stability

Acrylic polymers are known to be degraded by UV light. The Structure 2001/3001 polymer thickeners are no exception. While no viscosity instability is seen at ambient temperatures, a decrease in viscosity is noted in the presence of UV light and high temperature. The use of UV absorbers will prevent this degradation.

Storage and handling

The Structure 2001 and Structure 3001 polymers should be protected from freezing. Avoid extreme temperatures during storage. Good industrial hygiene practices should be followed when working with these polymers. Please read the MSDS before working with these or any other chemical.

Health and safety

A health and safety summary for Structure 2001 / 3001 polymers are available on request. Information on Structure 2001 / 3001 polymers relating to EU Cosmetics Directive 76/768/EEC is also available upon request.

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