ACULYN™ 22 Rheology Modifier/Stabilizer

A very efficient thickener for difficult to thicken surfactant systems

This bulletin focuses on our ACULYN™ 22 Rheology Modifier/Stabilizer, a very efficient thickener for difficult to thicken surfactant systems. Our ACULYN rheology modifiers find utility in an ever-increasing breadth of personal care applications because of their unique ease of use, wide compatibility, cost effectiveness and favorable balance of rheological properties.

Dow is committed to providing technology enhancement to the personal care industry. To learn how our expertise in polymers and preservatives can spark your own creativity, please contact us.

Description

ACULYN™ 22 Rheology Modifier/Stabilizer is an anionic hydrophobically modified alkali-soluble acrylic polymer emulsion (HASE) with unusually high aqueous thickening and stabilizing efficiency. This thickener is a liquid, cold-processable product that instantaneously thickens upon neutralization providing ease of handling and increased manufacturing efficiency. ACULYN 22 is offered at 30% solids and is compatible with high levels of surfactants. The polymer has a well-established toxicological profile and is safe in normal use.

CTFA / INCI name: Acrylates / Steareth-20 Methacrylate Copolymer

Features

- High efficiency
- Yields clear gels
- Highly associative
- Very pseudoplastic
- High surfactant synergy
- Synergistic interaction with inorganic clays
- Particulate stabilizer
- Emulsion stabilizer
- Foam stabilizer
- Broad pH range stability
- Peroxide compatible
- Salt tolerant
- Shear tolerant
- High yield value
- Instant neutralization/thickening
- Cold-processable
- Liquid
- Broad compatibility

Benefits

- Easy to handle
- No preparation necessary
- Non hygroscopic
- Increased manufacturing efficiency
- Allows for use of continuous production processes with use of in-line static mixers
- Can be processed with membrane pumps and, when diluted, with turbine mixers and high speed propellers
- Able to formulate clear products
- Can be used with electrolytes
- Synergistic interaction with surfactants, particulates and hydrophobic raw materials
- Stabilization of hydrophobic (low solubility) components
- Compatible with nonionic, anionic, Zwitterionic and some cationic surfactants
- Ability to stabilize suspensions
- Mild, soft, non-greasy, non-sticky
- Stable in pH 5.5 to 12 formulations
- Thickens and stabilizes hydrogen peroxide
- Does not promote or support contamination, unlike natural thickeners
- Flexibility in choice of preservative system
- Supported by comprehensive environmental, health and safety data

Applications

- Anti-dandruff shampoos
- Bath foams
- Curl activators
- Depilatories
- Emulsifier free formulations
- Foaming facial cleansers
- Hair styling gels
- Liquid soaps
- Lotions
- Moisturizing creams
- Shampoos
- Shower gels
- Skin masks
- Waterless hand cleaners
- Wave sets

Physical Properties

The following are typical properties of ACULYN™ 22 Rheology Modifier/Stabilizer; **they are not to be considered product specifications.**

Chemistry: ..... HASE polymer
Association: ..... very high
Ionic nature: ..... anionic
Appearance: ..... milky liquid
Solvent: ..... water
Solids, %: 30
pH (as supplied): 2.7
Density: 1.06
Equivalent weight*: 218
Rheology: ..... short, non stringy
Shear thinning: ..... very high
Viscosity, mPa s (as supplied): 100
Pseudoplastic index: 7.0
(viscosity @ 6 rpm/viscosity @ 60 rpm): ....(2% solids in water)
INCI name: ..... Acrylates/Beheneth-25 Methacrylate Copolymer

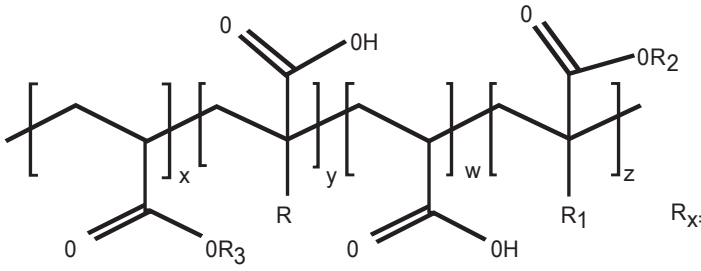
*grams of dry polymer neutralized by 1 equivalent (40 grams) of NaOH.

Chemistry

ACULYN 22™ Rheology Modifier/Stabilizer is a Hydrophobically-modified Alkali Soluble Emulsion (HASE). HASE polymers are synthesized from an acid/acrylate copolymer backbone and a monomer that connects the hydrophobic groups as side chains. The polymer is made through emulsion polymerization.

ACULYN 22 is synthesized from acrylic acid, acrylate esters and a steareth-20 methacrylate ester. The general structure for ACULYN 22 is shown below.

Structure



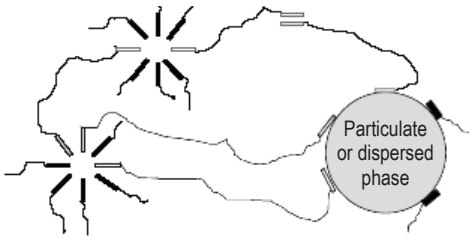
R_x=Acyl chain from 1 to 18 carbons

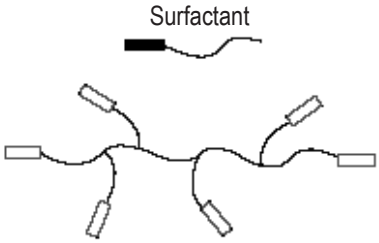
Mechanism of Action

ACULYN™ HASE rheology modifiers are able to thicken by two mechanisms that can act simultaneously and are synergistic, i.e. by the effect of charge-induced polyelectrolytic chain extension and by association of hydrophobe groups.

When the acid groups present in the ACULYN HASE molecules are neutralized with inorganic bases or organic amines, they become anionically charged and water-soluble. ACULYN™ 22 Rheology Modifier/Stabilizer thickens above pH 6.5. ACULYN HASE rheology modifiers dissolve and swell due to charge-charge repulsion and therefore thicken instantly.

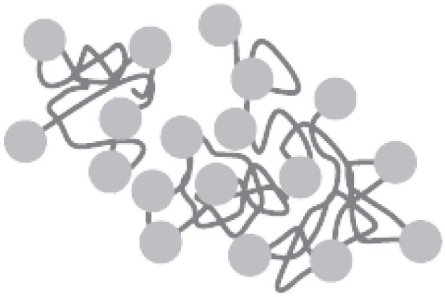
When ACULYN™ HASE polymers swell, the pendant hydrophobic groups are free to build associations with one another and with other hydrophobes available in the formulation, such as surfactants, particulates, emulsion droplets and dyes. This phenomenon creates a network structure that results in a significant viscosity build.





Associative Rheology Modifier

These associative structures can also act to stabilize and disperse particulates in a formulation.



And because of the ethoxylated hydrophobic group on the rheology modifier, ACULYN™ 22 Rheology Modifier/Stabilizer can also act as a primary emulsifier for some emulsion systems, such as water resistant sunscreens, to minimize the level of surfactant or emulsifier.

Features of HASE Rheology Modifiers

The chart to the right shows features indicative of the behavior of HASE rheology modifiers under different conditions. Please note that these behaviors may vary to some extent according to specific formulations.

All ACULYN™ rheology modifiers are easy to formulate, have good to excellent salt tolerance, compatibility with anionics and nonionics and low odor. HASE polymers have excellent shear thinning properties and good stability in two-part peroxide systems. Blending of the ASE and HASE chemistries can offer further enhancements and synergies.

Ease of formulation:	Excellent
Associative:	Yes
Salt tolerance	
NaCl:	Excellent
Di/trivalent ions:	Good
Shear thinning behavior:	Excellent
Solvent compatibility:	Excellent
Low pH compatibility:	Good
Anionic surfactant compatibility:	Excellent
Nonionic surfactant compatibility:	Excellent
Zwitterionic surfactant compatibility:	Good
Cationic surfactant compatibility:	Some
Peroxide stability	
1 part system:	No
2 part system:	Excellent
Lack of odor:	Excellent

ACULYN™ 22 Rheology Modifier/Stabilizer Behavior Profile

ACULYN™ 22 Rheology Modifier/Stabilizer possesses many properties that make this polymer highly desirable for use in personal care, as shown by the data presented below.

Rheology

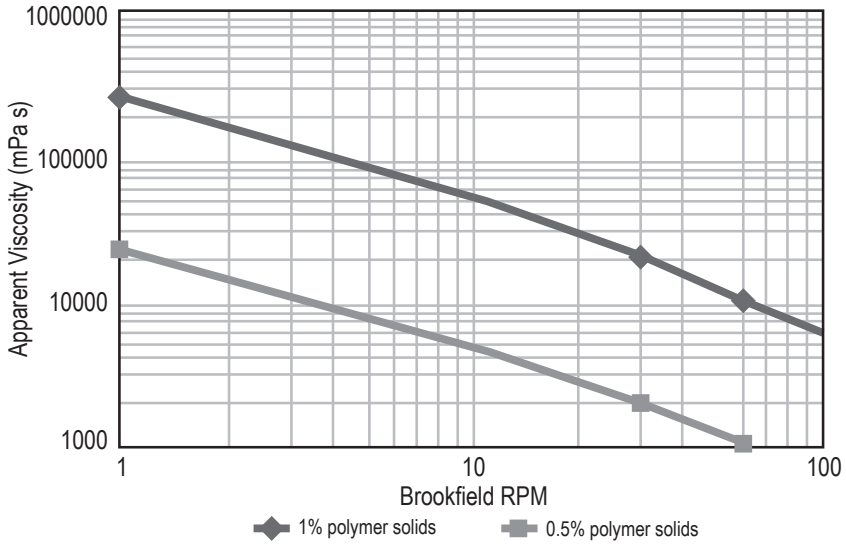
Effect of Shear Rate

ACULYN™ 22 Rheology Modifier/Stabilizer thickener is a low-viscosity dispersion that becomes a highly viscous clear solution when neutralized with alkali. Provided that proper mixing conditions are used, ACULYN 22 thickens instantaneously upon addition of base, allowing rapid preparation of solutions and products. There is no need for pre-wetting, high shear mixing or long soak times.

The presence of the C_{18} hydrophobe causes neutralized solutions of ACULYN 22 to be very pseudoplastic, in general showing a high degree of shear thinning because of easily broken van der Waals forces. The yield value also allows the thickener to stabilize suspensions, while still being pourable.

The alkaline solutions are clear, and their flow properties are characterized by a complete lack of stringiness and tackiness and by shear thinning. At the same time, the solutions are viscous at low shear rates. The log-log plot of apparent viscosity vs. shear rate is linear for the sodium salt over the range of spindle rotation rates between 0.5 and 60 rpm. The shear thinning behavior in the following graph is measured in water and the behavior can change in formulations.

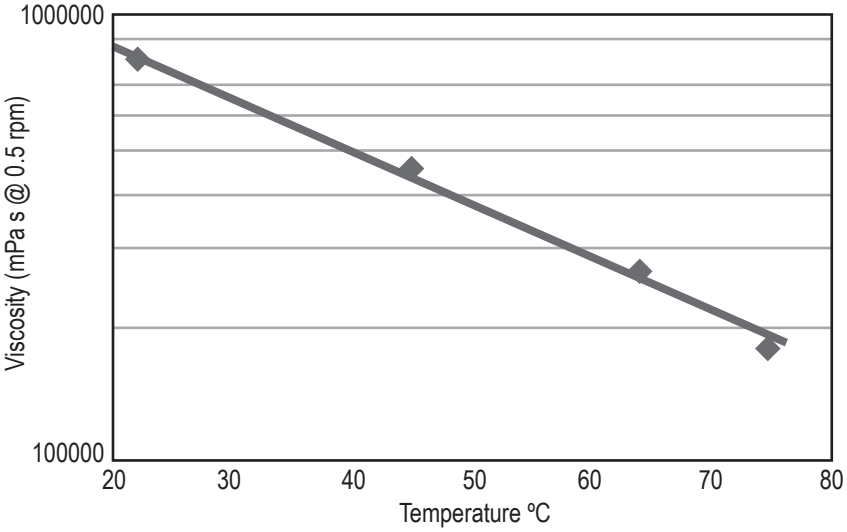
Effect of Shear Rate on Viscosity of Sodium Salt of ACULYN™ 22 Rheology Modifier/Stabilizer



Effect of temperature

Thickening with ACULYN™ 22 Rheology Modifier/Stabilizer unergoes a modest decrease as the temperature rises from 20ºC to 75ºC.

Effect of Temperature on Viscosity of Sodium Salt of ACULYN™ 22 Rheology Modifier/Stabilizer (1.25% Polymer Solids)



Compatibility

Surfactant Synergies

General Effects of Surfactants

Certain anionic and nonionic surfactants give a synergistic increase in the viscosity and thickening efficiency of neutralized ACULYN™ 22 solutions. 10 to 1000 fold increases in viscosity can be achieved. Each surfactant has an optimum concentration at which maximum viscosity is obtained.

Viscosity[a] of Thickened Surfactants[b]

ACULYN™ 22 Rheology Modifier/Stabilizer (% solids)	C_{14-16} Olefin Sulfonate	TEALS[c]	SLES[c]	SLS[c]
0	50	50	50	50
1.0	800	900	525	550
1.5	14,600	4,500	4,900	1,400
2.0	54,000	21,000	15,200	4,600

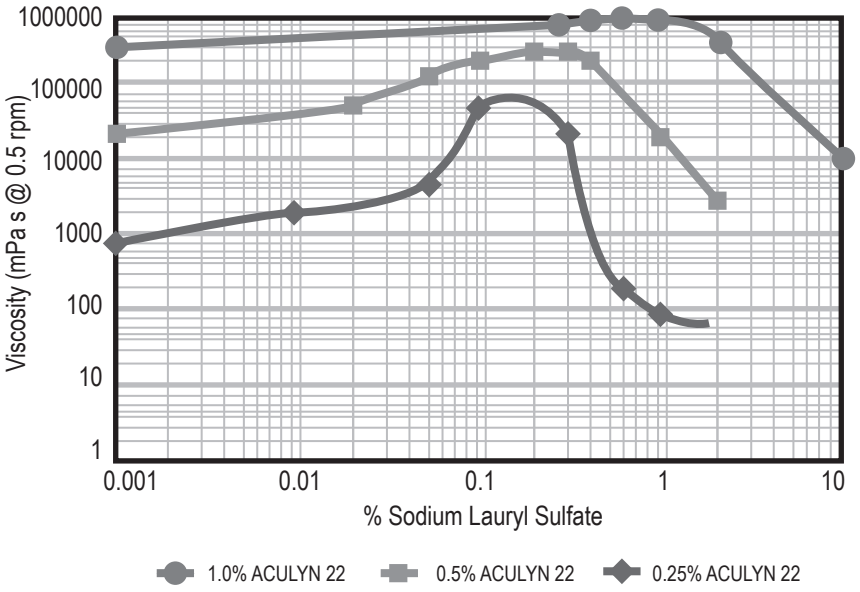
[a]Brookfield viscosity @ 12 rpm, cps

[b]Surfactant level 15% solids, pH 7 to 9

[c]Surfactant legend: TEALS = Triethanolamine lauryl sulfate, SLES = Sodium lauryl ether sulfate, SLS = Sodium lauryl sulfate

With sodium lauryl sulfate (SLS), for example, the maximum occurs at a level of 40% based on the concentration of ACULYN 22 thickener. The effect of SLS on solution viscosity as a function of the level of ACULYN 22 thickener and the effect of SLS as a function of SLS concentration are shown in the graphs below.

Effect of Sodium Lauryl Sulfate (SLS) on Viscosity of Sodium Salt of ACULYN™ 22 Rheology Modifier/Stabilizer



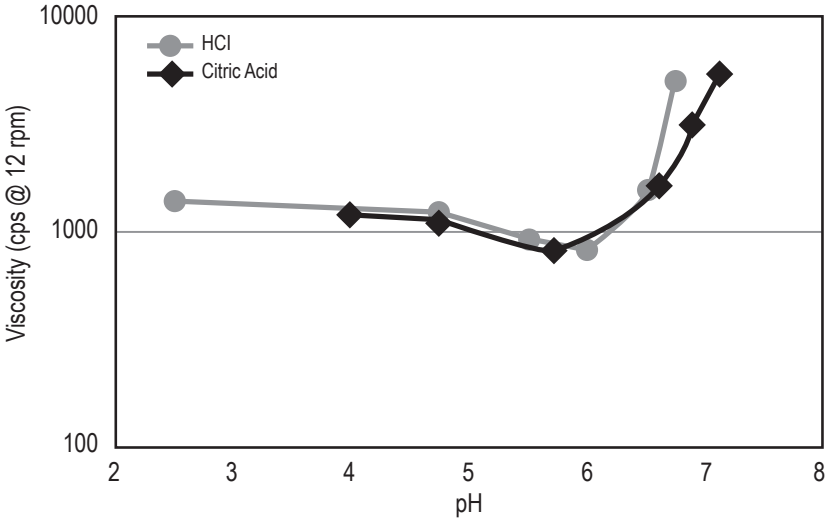
Thickening of Acid-Containing Surfactants Solutions

At high levels of anionic surfactants, acid-containing aqueous solutions with ACULYN™ 22 Rheology Modifier/Stabilizer display a high degree of thickening. By using a mixture of two surfactants, one an anionic (major component) and the other an amide(minor component), 4 clear thickened compositions are obtained with ACULYN 22 at pH 1 to 7. The presence of amide surfactant is necessary to ensure clarity in these formulations. Applications for these formulations include clear, low pH shampoos.

To correctly prepare these products, the ACULYN 22 is dispersed in the water and the two (or more) anionic surfactants are added with stirring. The solution is neutralized with caustic or other base and allowed to stir for 15 minutes. Finally, the acidity is adjusted to the required level by adding citric acid (pH 4.5 to 7) or hydrochloric acid (pH 1 to 7) to the neutralized solution of the surfactants and thickener. Addition of cationic ingredients, if any, should occur after the pH is lowered to 6.0 or less to minimize the potential interaction of the carboxyl functionality.

The graph and table below show the Brookfield viscosity of a typical formulation over a broad range of low pH.

Effect of pH on Viscosity of SLS solutions thickened with ACULYN™22 Rheology Modifier/Stabilizer

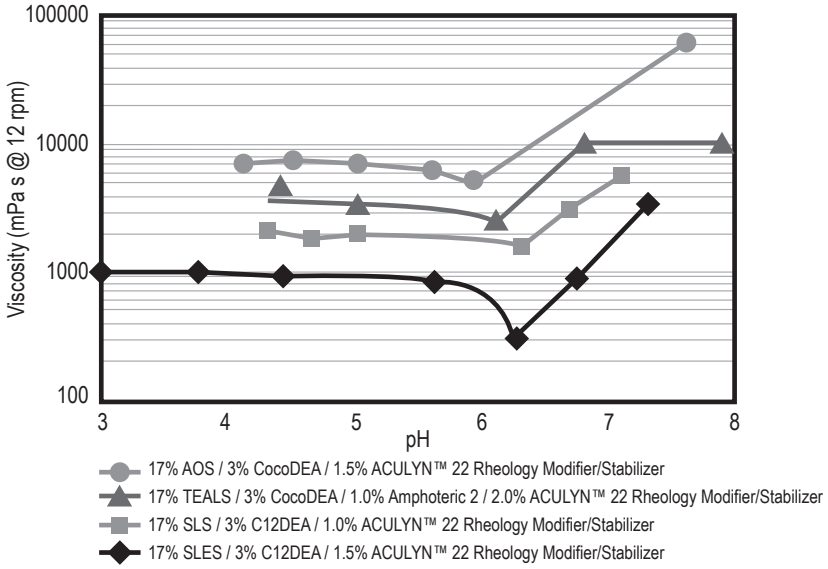


Acid Shampoos

	SLS (28%)		SLES (27%)		TEALS (40%)		AOS (40%)	
	Solids	As supplied	Solids	As supplied	Solids	As supplied	Solids	As supplied
Surfactant	17.0	60.7	17	63.0	17	42.5	17	42.5
Lauramide DEA	3.0	3.0	3.0	3.0	–	–	–	–
Cocamide DEA	–	–	–	–	3.0	3.0	3.0	3.0
MIranol C2MSF (70%)	–	–	–	–	1.0	1.4	–	–
ACULYN™ 22 Rheology Modifier/Stabilizer (30%)	1.0	3.3	1.5	5.0	2.0	6.7	1.5	5.0
NaOH (10%)	0.09	0.9	0.14	1.4	0.18	1.8	0.14	1.4
Water		32.1		27.6		44.6		48.1
Citric acid to pH 4.5 to 5.2								
Viscosity, Brookfield, cps @ pH 5, 12rpm	2100		900		3000		5700	

The graph below presents the effect of pH on the viscosity of formulations based on various anionic surfactants with ACULYN™ 22 Rheology Modifier/Stabilizer.

Effect of pH on Viscosity of Shampoo Systems Thickened with ACULYN™22 Rheology Modifier/Stabilizer

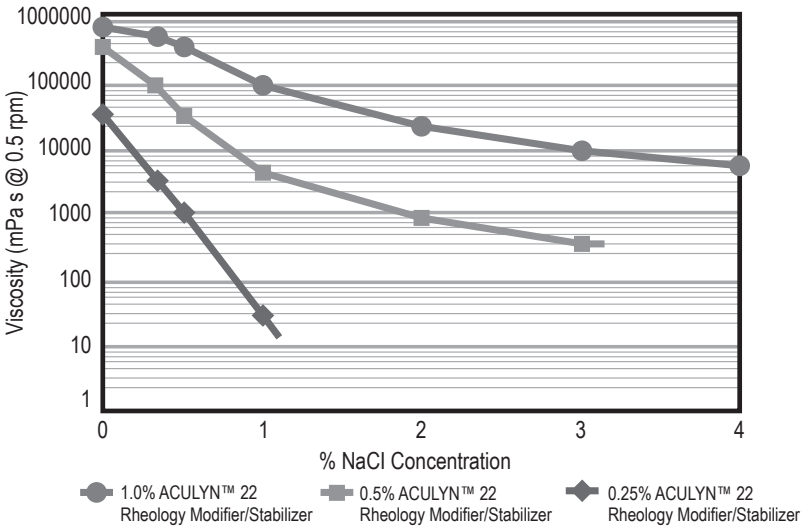


Note: The levels of ACULYN™ 22 and surfactants as listed in the above chart are on a 100% solid basis.

Salt Tolerance

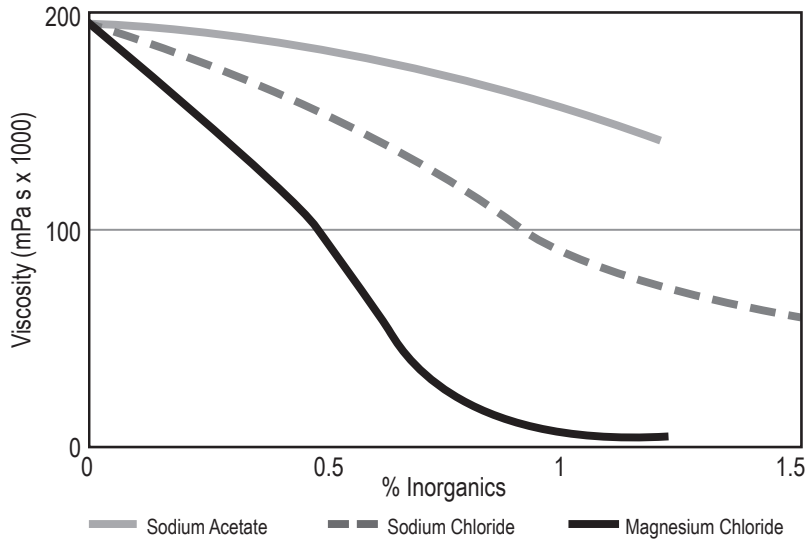
Neutralized solutions of ACULYN 22 can thicken salt solutions. The thickening efficiency decreases with increasing level of salt, and solutions with low concentrations of thickener are particularly sensitive to the presence of salt. Addition of low levels of surfactant, even when salts are present, substantially increases the thickening efficiency of ACULYN 22.

Effect of Sodium Chloride on Viscosity of Sodium Salt of ACULYN™22 Rheology Modifier/Stabilizer



ACULYN 22 also has a tolerance for other salts. Divalent salts such as magnesium chloride will have an impact on viscosity, more of an impact than monovalent salts such as sodium chloride or sodium acetate.

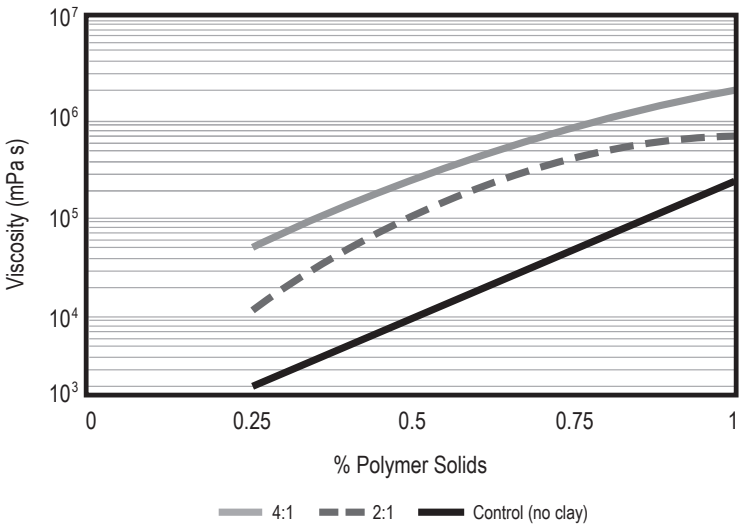
Viscosity vs. Concentration with Various Salts of Neutralized ACULYN™22 Rheology Modifier/Stabilizer



Synergies with Inorganic Clays

Adding low-cost bentonite clays appreciably increases the thickening efficiency of neutralized ACULYN™ 22 Rheology Modifier/Stabilizer. Combining appropriate levels of ACULYN 22 thickener and bentonite clays can produce free-standing gels.

Effect of Bentonite Clay on Viscosity of ACULYN™22 Rheology Modifier/Stabilizer

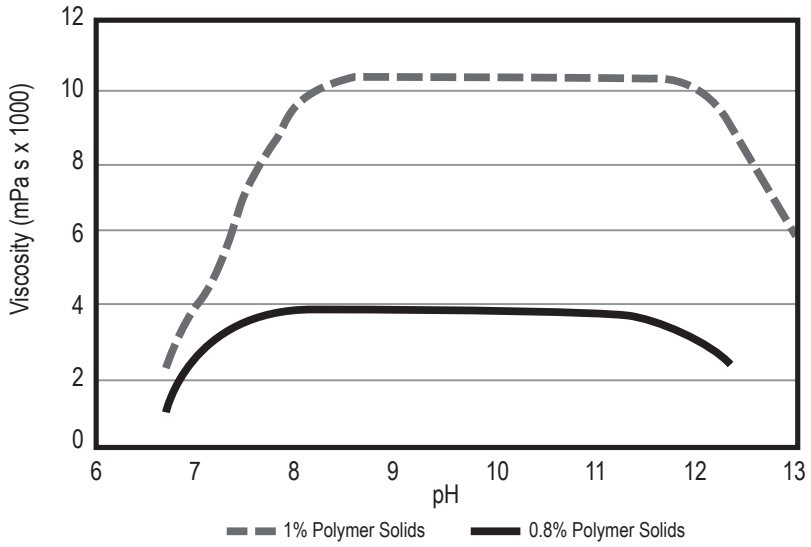


Values are low shear viscosities (Brookfield RVT at 0.5 rpm).
The figures give the ratios of clay to polymer for each curve.
Mixes of Bentonite with the ACULYN™ 22 Rheology Modifier/Stabilizer polymer show a significant yield stress (point).

pH Tolerance

Thickening drops precipitously below pH of about 7, a range in which the polymer is insoluble. With sodium hydroxide as the base, the viscosity reaches a maximum and remains stead over the pH range from 7.5 to 12. ACULYN 22 can thicken aqueous solutions containing a high level of surfactant below pH 6.5.

Effect of pH on Viscosity of Sodium Salt of ACULYN™22 Rheology Modifier/Stabilizer (1% Polymer Solids)



Performance

Extremely Efficient Thickener

ACULYN™ 22 Rheology Modifier/Stabilizer achieves thickening of solutions at very low concentrations and is therefore very efficient and cost effective. The thickening efficiency of ACULYN 22 is significantly superior compared to other types of thickeners such as cellulosics and carbomers. ACULYN 22 can be neutralized with sodium hydroxide, ammonia, soda ash (sodium carbonate), and triethanolamine as well as other bases.

Formulations and Use Guidelines

ACULYN™ 22 Rheology Modifier/Stabilizer is compatible with surfactants, solvents, oils and salts commonly found in cosmetic and toiletry products. These products undergo instantaneous thickening when neutralized with base.

This product is supplied as a low viscosity emulsion and can be incorporated directly into formulations with none of the concerns about dissolution, particulate clumping or dusting problems that can be encountered with dry products. ACULYN 22 is also cold processable.

Because thickening occurs instantaneously upon neutralization with base, in-line mixing with static mixers is possible. Upon neutralization, the ACULYN 22 emulsion becomes a clear, highly viscous solution.

The preferred order of addition when using ACULYN 22 rheology modifier in aqueous formulations is as follows:

1. Add ACULYN 22 to the water
2. Add other ingredients from the most acidic to the most alkaline
3. Add the neutralizing agent

If this sequence is not desirable, ACULYN HASE and ASE polymers can be added directly to an alkaline formulation after first diluting the ACULYN 22 product with two parts of water. Addition of the water preventsgel particles (small particles with neutralized swollen surfaces and unneutralized cores that will take considerable time to dissolve completely).

Preparation of Emulsions and Dispersions

Neutralized ACULYN™ 22 Rheology Modifier/Stabilizer thickener can also be used to make oil-in-water emulsions of organic liquids such as mineral oil, lanolin or kerosene. ACULYN 22 can also be used to suspend fillers and pigments, such as calcium carbonate, silicate clays and titanium dioxide, in water.

If ACULYN 22 is being used in an emulsion formulation, the general order of addition is as follows:

1. Add ACULYN 22 to the water phase at temperature
2. Add the other water phase ingredients
3. Mix separately the oil phase ingredients at temperature
4. Mix the oil phase into the water phase maintaining temperature
5. Neutralize the ACULYN 22 polymer
6. Cool the mixture with constant stirring
7. Add the preservative (if any) at a safe temperature

Handling Precautions

Before using this product, consult the Material Safety Data Sheet (MSDS)/Safety Data Sheet (SDS) for details on product hazards, recommended handling precautions and product storage.

Storage

Store products in tightly closed original containers at temperatures recommended on the product label.

Disposal Considerations

Dispose in accordance with all local, state (provincial) and federal regulations. Empty containers may contain hazardous residues. This material and its container must be disposed in a safe and legal manner.

It is the user's responsibility to verify that treatment and disposal procedures comply with local, state (provincial) and federal regulations. Contact your Dow Technical Representative for more information.

Dow is a member of the American Chemistry Council (ACC) and is committed to the ACC's Responsible Care® Program.

Product Stewardship

Dow has a fundamental concern for all who make, distribute, and use its products, and for the environment in which we live. This concern is the basis for our product stewardship philosophy by which we assess the safety, health, and environmental information on our products and then take appropriate steps to protect employee and public health and our environment. The success of our product stewardship program rests with each and every individual involved with Dow products – from the initial concept and research, to manufacture, use, sale, disposal, and recycle of each product.

Customer Notice

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