Attagel®

Rheology modifiers

Helping Make Products Better®

BASF
The Chemical Company

Forming a colloidal network

Unique rheology modification

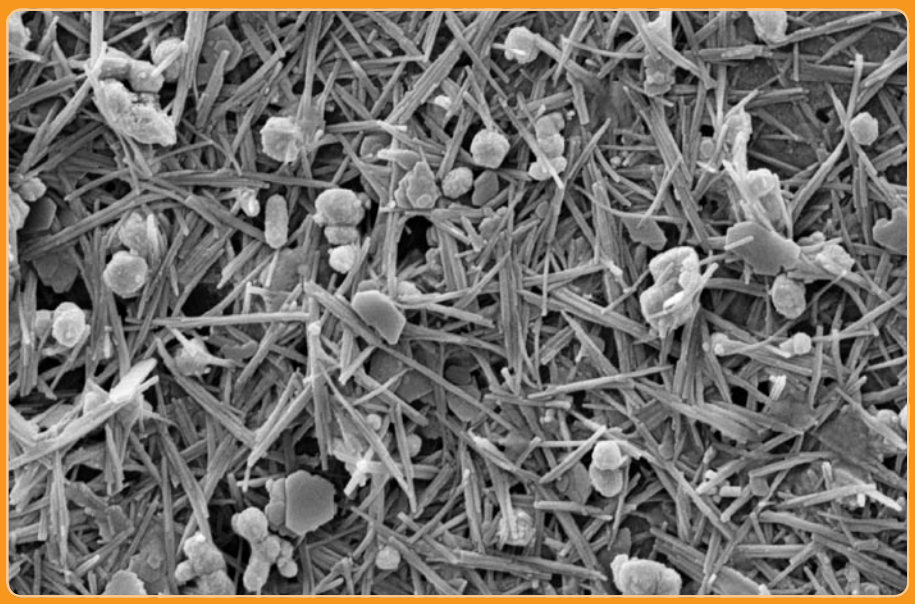


Figure 1. Photomicrograph showing particles in a slurry suspended by a colloidal network of Attagel.

Attagel rheology modifiers

- Performs in water and solvent-borne systems
- Provides syneresis control
- Consistent performance
- Thixotropic viscosity modification
- Low amount of energy needed to disperse
- Cost effective

Attagel® attapulgite rheology modifiers by BASF offer a wide range of performance benefits in many liquid systems.

- During formulation, Attagel colloidal clays disperse easily in aqueous and solvent-borne systems.
- Attagel products provide wide latitude in formulating as they are essentially inert and compatible with most additives and tolerate most physical and chemical environments.
- Attagel products need no special solvents, activators, or modifiers, except in solvent-borne systems where a surfactant is recommended.
- In end-use applications, Attagel rheology modifiers assist in syneresis control, sag resistance, film build, leveling, spatter resistance, spreadability, feathering, tint strength, and hiding.
- During storage, Attagel products reduce liquid separation (syneresis), do not swell, are stable over wide pH and temperature ranges, are insoluble in organic liquids, and generally resist settling.

Attagel rheology modifier is an ultra-fine mineral containing bundles of sub-micron particles. When the bundles are well dispersed in liquid systems, the colloidal particles interact to form a network that entraps liquid and smaller particles and suspends larger particles (Figure 1).

Attagel rheology modifiers are exceptionally effective gellants, thixotropes and suspending agents that provide consistent performance over a wide range of liquid systems. Manufacturers use them in place of more expensive rheology agents, wholly or partially, to gain the many benefits they offer during a product's life cycle. Attagel products have distinct advantages over other commonly used thickening and suspending agents.

Attagel products offer an excellent balance of cost and performance over a broad pH and temperature range and are compatible with almost all other additives. They are not subject to bacterial attack nor affected by salts, acids or bases–except in extreme cases. They do not swell nor need special solvents, activators or modifiers. Organic liquid systems do sometimes need surfactants.

The thixotropy added by Attagel rheology modifiers is invaluable in a wide variety of aqueous and organic liquid systems (Table 1). For instance, it enables paints, inks, adhesives and other products coated on surfaces to spread easily when rolled, sprayed or brushed, and then stiffen at a controlled rate to prevent sags and drips. It can also improve film build, tint strength, hiding, leveling and spatter resistance, while reducing water sensitivity and preventing syneresis.

As suspending agents, Attagel products can hold relatively large or dense particles in liquids for an extended time. They are especially useful where mixing capability is limited. If settling does occur, the sediment formed tends to be soft and easily resuspended. Typical applications include liquid soaps, pigment and ceramic slurries, refractory coatings, foundry wash, fertilizers and liquid animal feed.

What are Attagel rheology modifiers?

Attagel thickeners and suspending agents are made from specially processed attapulgite, a hydrated magnesium aluminosilicate and a principal member of the fuller's earth family of clay minerals having the ideal formula: $3MgO - 1.5Al_2O_3 - 8SiO_2 - 9H_2O$. Attapulgite occurs as tightly packed bundles of submicron particles whose lathe-like structure gives it unique colloidal and sorptive properties.

Attagel thickeners and suspending agents provide benefits, including easy dispersion, formulating latitude and long-term stability. The

Adhesives and Sealants	Attagel thickeners provide superior thickening, sag resistance, and ease of application, especially in highly filled systems.
Asphalt Coatings	Attagel 30 provides for easy application (especially spray application), excellent storage stability and syneresis control in roof coatings, underbody coatings, driveway sealers and other asphalt cutbacks and emulsions.
Chemical Suspensions	Attagel 50 provides easy and stable suspensions of insoluble additives in a wide range of solutions, including biocides, ceramic glazes, fertilizers, household cleaners, paint remover and veterinary medicines.
Paints and Coatings	Attagel 40 and 50 are used in latex and other general waterborne formulations. Attagel 50 is used in more demanding aqueous and solventborne coatings, such as primers, topcoats, maintenance coatings, marine finishes, and semigloss and gloss enamels. Both products work as co-thickeners with cellulosic, associative and alkali swellable thickeners.
Pesticides and Herbicides	Attagel 50 stabilize and suspend ingredients in wet-flowable and suspension concentrates in pesticide and herbicide formulations, even at high loadings.
Plastics	Attagel 50 controls viscosity to aid flow and prevent sag upon deposition in vinyl plastisol and epoxy systems. It also helps prevent settling and "float out" in lightweight filler compounds.
Tape Joint Compounds	Attagel 30 provides for smooth, scratch-free application in these thick films, as well as for sag resistance, viscosity control, spreadability and excellent feathering at low cost.

Table 1. Broad range of applications

Typical physical and chemical properties	Attagel 30	Attagel 40	Attagel 50
Physical appearance	Micronized Powders		
Average particle size (µm)	0.1	0.1	0.1
Residue, +325 mesh wet, % max.	3.5	0.15	0.01
Hegman fineness of grind (in dioctyl phthalate)	<5	5+	6+
Oil absorption (ASTM D281)	100	110	115
Free moisture, as produced (% wt. loss at 650°C)	12	12	12
Volatile matter, as produced (% wt. at 650°C, moisture-free basis)	10	10	10
Ignition loss, as produced (% wt. loss at 1000°C)	24	24	24
Bulking value	**Attagel 30**	**Attagel 40**	**Attagel 50**
lb./gal.	19.7 (2.36 kg/l)	19.7 (2.36 kg/l)	19.7 (2.36 kg/l)
gal./lb.	0.0507 (0.42 l/kg)	0.0507 (0.42 l/kg)	0.0507 (0.42 l/kg)
pH (ASTM D 1208)	8.5	8.5	8.5
Color	Light cream	Light cream	Light cream
Specific gravity	2.4	2.4	2.4
Density (tamped volume wt.), lb./cu. ft.	35	30	23
B.E.T surface area, m^2/g (moisture-free basis)	150	150	150
Chemical analysis (volatile and moisture-free basis)	**Attagel 30**	**Attagel 40**	**Attagel 50**
Major constituents exist as complex silicates rather than as free oxides.			
Silicon (SiO_2)	65.2%	65.2%	65.2%
Aluminum (Al_2O_3)	12.7%	12.7%	12.7%
Magnesium (MgO)	12.3%	12.3%	12.3%
Iron (Fe_2O_3)	3.5%	3.5%	3.5%
Calcium (CaO)	3.9%	3.9%	3.9%
Phosphorus (P_2O_5)	1.0%	1.0%	1.0%
Potassium (K_2O)	0.8%	0.8%	0.8%
Titanium (TiO_2)	0.5%	0.5%	0.5%
Trace elements	0.1%	0.1%	0.1%

Table 2. Typical physical and chemical properties of Attagel 30, 40 and 50 thickeners

Dispersion characteristics

Setting up a network

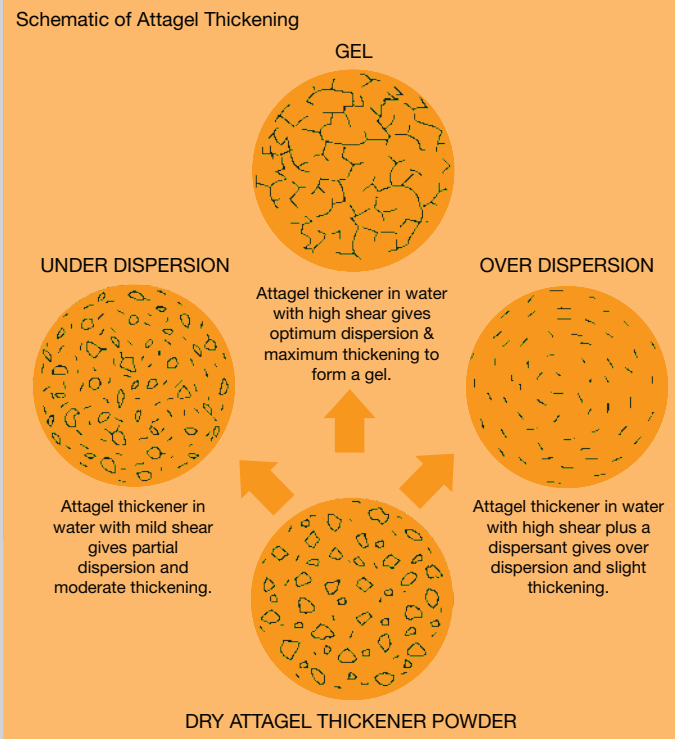
colloidal network forms a thixotropic gel that if undisturbed, is stable indefinitely. Under modest shear, however, the structure breaks down and the liquid becomes thin and flowable. When agitation ceases, the scattered particles realign to reform the colloidal network and thicken the liquid. The cycle of thinning and thickening, by changes in shear, can be repeated endlessly.

As a leader in attapulgite technology, BASF manufactures Attagel products using methods we pioneered and continue to develop. We engineer quality into these products by starting with a high-grade attapulgite mineral and processing it under strict control. The mineral is mined from our holdings in southwestern Georgia and northern Florida, USA which contain some of the purest attapulgite available. We then unlock the potential of this versatile mineral by purifying the crude and manufacturing a variety of products through well-controlled heat treatment and particle-size processing.

Attagel rheology modifiers are hydrated grades made by low-temperature drying. They are specially processed to create submicron-size particles with selected residue and moisture specifications for optimal dispersing and gelling capability.

The Attagel 30 and 40 grades work well in most aqueous applications. The Attagel 50 grade is a premium product with less residue, smaller particle size (Table 2) and uniquely rounded particle edges. It is most desired in applications where fineness, surface smoothness and sprayability of the end-use product are critical. In organic or solvent-borne applications, where dispersion can be more difficult, Attagel 50 particles can wet-out more quickly and completely, providing a more consistent and stable dispersion and thickening.

Figure 2. Processing effects on dispersion characteristics of Attagel rheology modifiers



A magnified view of idealized Attagel thickener dispersions, this demonstrates that over dispersing or under dispersing of the attapulgite will results in undesirable properties. We recommend that experiments be carried out in the laboratory using your proposed formulas to determine the optimum dispersion parameters.

Optimal formulation and mixing methods

When to add Attagel rheology modifiers

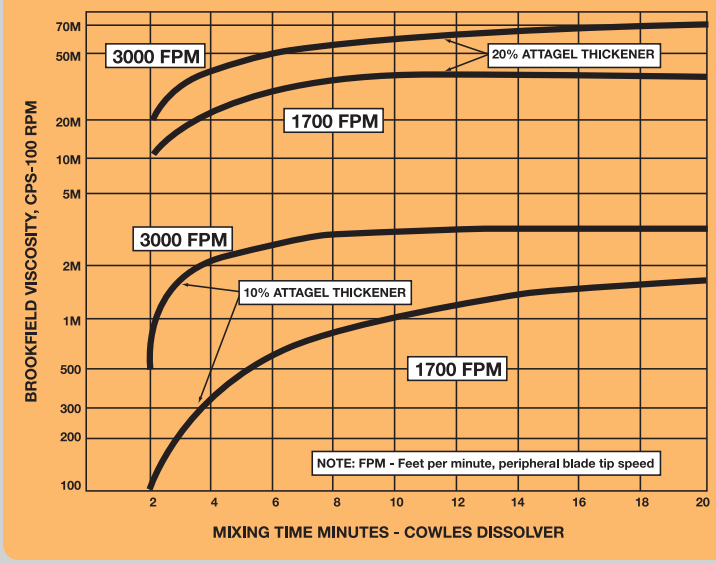
Attagel thickeners develop high viscosity when they are well dispersed. This involves breaking up the attapulgite aggregates and distributing the particles evenly in the fluid. In water-based coatings, Attagel products are usually added at the end of the pigment-grind step to prevent absorption of surfactants that can cause over-dispersion and hinder gel formation, see Figure 2. The mix should have enough water so it remains in the proper viscosity zone, for near maximum shear, as viscosity increases. In solvent-based systems, where a surfactant is needed to disperse the hydrophillic Attagel particles, the Attagel product should be added early to ensure capture of the surfactant.

Mixing speed

High-speed mixing creates rapid thickening. Intensive, slow-speed mixing, such as with a double planetary-type mixer, may take longer to develop near maximum viscosity and may require higher solids to generate adequate shear. For example, Figure 3 shows the time difference, between low- and high-speed mixing, to reach near maximum viscosities is less in a 20% aqueous dispersion than in one at 10%. This occurs because higher solids create higher shear, which aids dispersion. Since shear rate is more critical than mixing speed, low-speed mixers can be used with the proper order of addition, or with a pregel.

Thixotropic development

Figure 3. Effect of mixing speeds and Attagel concentration on gel development



Pregelling

Pregelling Attagel products take advantage of the shear inherent in particle crowding. Manufacturers often use pre-made Attagel concentrates if not enough shear can be applied to the main mix batch. Pregels are especially useful in formulations that foam when mixed rapidly or if high-speed mixers are unavailable. They are also added to systems with abundant liquid and relatively small amounts of pigment and vehicle.

Many processes use Attagel pregels that contain 10% to 15% solids. These are formed under low-to-moderate mixing. A typical pregel formula is: 10 to 15 lb. Attagel thickener/10.2 to 10.8 gallons water (10 to 15 g Attagel per 85 to 90 ml water).

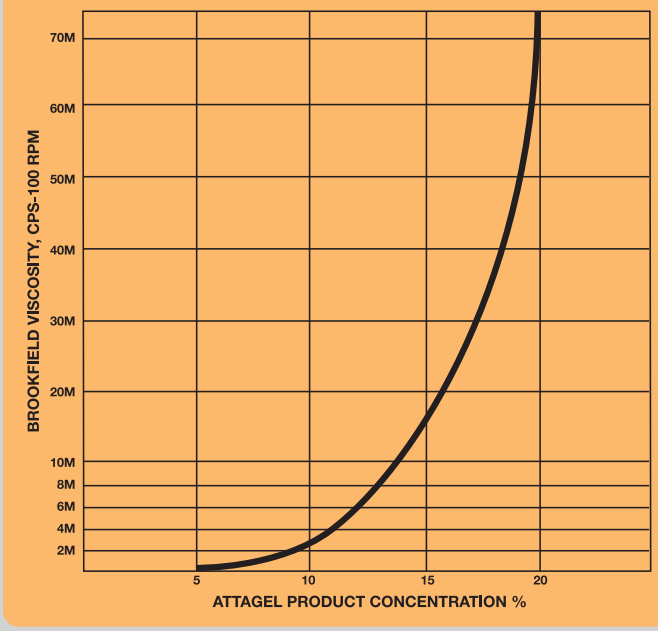
Liquid demand

Although much of the viscosity developed with Attagel thickener depends on the concentration and degree of dispersion, other ingredients can affect viscosity because the liquid demand determines the liquid available to be thickened. More crowded systems mean that viscosity change for a given amount of Attagel is more noticeable (Figure 4). In most cases, viscosity increases slowly, as concentration rises to about 8%, but increases rapidly above 8%.

Dispersion

Care should be taken to avoid over-dispersion or under-dispersion as shown in Figure 2. Over-dispersion, often caused by overuse of tetrasodium pyrophosphate (TSPP) and other dispersants or surfactants, scatters and separates particles so much they cannot form a strong gelling network. Under-dispersion, due to insufficient mixing shear or time, does not free enough particles to form a strong network. Another undesirable effect can occur, as viscosity can increase slowly as bundles wet-out and separate into individual particles and cause post-thickening. This occurs in aqueous Attagel systems that are under-dispersed because Attagel products wet-out naturally over time in water.

Figure 4. Effect of Attagel thickener concentration on the viscosity of water dispersions



Aqueous applications

How much to use

The amount of Attagel rheology modifier used depends on the consistency desired, other pigments or additives present, the solids of the system, and the free water available. Attagel product can be used as the sole thickener only if thixotropic rheology is needed, as is often the case with adhesives, liquid detergents, Portland cement mortars, and polishes. Such systems do not have high viscosity at high shear and, therefore, flow easily during application.

In smooth-brushing coatings that use Attagel product as a co-thickener, manufacturers usually start with 3 to 10 lb. Attagel per 100 gal. (4 to 12 g/l or 0.3 to 1.0%). Levels as high as 25 lb. per 100 gal. (30 g/l) are used in high-viscosity coatings, caulks, detergents and tape joint compounds (Table 3).

Aqueous applications

Partial replacement of cellulose thickeners

When using Attagel to reduce cellulosic thickeners in emulsion coating systems, at least 3 lb. cellulosic per 100 gal. (3.5 g/l) must remain in the formulation to provide freeze-thaw stability and open-time. In reducing cellulosic, in an existing formulation, 3 to 4 parts of Attagel (by weight) per part of cellulosic are generally used. The optimal level of Attagel product in these applications is usually 5 to10 lb. per 100 gal. (6 to 12 g/l), which helps to improve spattering and sag resistance.

Attagel thickeners work best with high-viscosity cellulosics like hydroxyethyl cellulose (HEC) and hydroxypropyl methyl cellulose (HPMC). If a ropey or livered appearance occurs with HEC, replace it with HPMC. Ropiness can also be prevented by avoiding phosphate dispersants, using a blend of polyacrylate and AMP-95™[1] dispersants, or lowering replacement ratio to less than 5 parts Attagel per part of cellulosic.

Table 3: Typical loading levels of Attagel products in aqueous applications

	Concentration		
Application	lb./100 gal.	(g/l)	wt%*
Soft settling or suspension	1-5	(1.2-6)	0.1-0.5**
Flat and semi-gloss latex paint***, flexographic ink, shampoo, hair conditioner, adhesive, polish	3-10	(4-12)	0.3-1.0
Ready-mix tape joint compound, liquid dishwashing detergent	10-25	(12-30)	1.0-2.5
Latex texture paint	15-25	(12-30)	1.5-2.5
Cinderblock surfacer, caulk	20-25	(24-30)	2.0-2.5

* Based on a 10 lb./gal. or 1.2 kg/l product.
** Systems with large particles may need up to 2.0 wt.%.
*** Used as co-thickener in latex paints.

[1] AMP-95 is a trademark of Angus Chemical Corporation.

Solvent applications

Adding value to associative thickener systems

Attagel products are used as co-thickening thixotropes in paints together with urethane-based rheology modifiers. These associative thickeners provide excellent leveling and improved gloss. They keep viscosity high at high shear, as with roller application, so paints spatter less and have excellent film build for improved one-coat hiding. Manufacturers often use Attagel thickeners to overcome problems with syneresis, pigment settling, organic pigment flooding and floating, hiding, color development and sag resistance that can occur with associative thickeners, at a rate of 3 to 5 lb./100 gal. (4 to 6 g/l) in semigloss paints and 3 to 7 lb./100 gal. (4 to 8.5 g/l) in interior flat paints. Attagel products are also used as co-thickening thixotropes, with alkali swellable and hydrophobically modified HEC thickeners to remedy sag resistance, pigment settling and dripping problems. Typical addition levels are 3 to 5 lb./100 gal. (4 to 6.0 g/l).

Easy, consistent and stable suspensions

Attagel rheology modifier provides long-term stability to liquid systems, is essentially chemically inert, and is stable over a wide range of pH and with most known additives. Particles remain suspended indefinitely. The gels formed can suspend relatively large or dense pigment or extender particles. If particles do settle, they usually form soft sediment that is easily re-suspended. The amount of Attagel needed is reduced as solids rise. Pigmented systems may need less than 0.5% for suspension or soft-settle, and those with large particles may need 0.5% to 2.0%.

Organic liquid applications

Attagel 50 rheology modifier provides good thixotropic thickening and suspension in many organic liquids, including mineral oils, mineral spirits, naphthas, vegetable oils, aromatic solvents, synthetic oils, synthetic lubricants, polyesters, epoxy resins, plasticizers, alkyds and many other systems. Since attapulgite particles are organophobic, in many organic liquids a surfactant is often needed to wet them so they can disperse fully and form stable gel structures. In waterborne systems, a surfactant is not needed.

Surfactants

Surfactant molecules act by attaching a hydrophilic portion to the attapulgite surface and extending a long-chained organophilic portion into the organic liquid. Cationic surfactants usually work best with Attagel 50 grade, providing for the most efficient thickening and the greatest water resistance. Non-ionic surfactants also work efficiently, but tend to reduce water resistance. Anionic surfactants normally are ineffective and give poor water resistance and poor thickening.

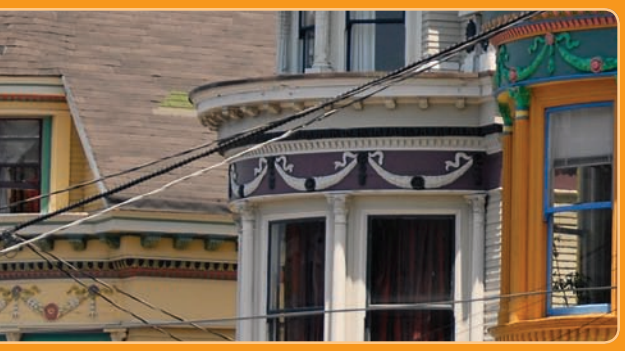
The qualities of the liquid to be thickened, specifically the polarity and level of hydrogen bonding, affect the need for a surfactant and the nature of the gel formed.

The following is a guideline for Attagel 50 in certain organic liquids:

- Highly polar liquids with strong hydrogen bonds permit Attagel 50 grade to disperse readily and form a strong gel. Surfactants are often not needed in these liquids.
- Medium polarity liquids with medium hydrogen bonding permits Attagel 50 grade to form modest gels by itself and excellent gels when used with a surfactant.
- Low polarity liquids with poor hydrogen bonding need higher loadings of Attagel 50 and a surfactant. Addition of a polar liquid can strengthen gels in low polarity liquids. Surfactants usually are not needed if the organic liquid contains at least 5% water.
- Desiccating liquids that remove free surface moisture from Attagel 50 particles usually gel well without a surfactant, but the gel may be unstable. Addition of compatible polar liquids (e.g., 5% to 10% water, higher alcohols or glycols) is recommended to improve gelling and stability.

Surfactant ratio

The surfactant and its concentration depend on the liquid being thickened, the amount of surfactant adsorbed by other solids, and the presence of surface-active agents. Each organic liquid has Attagel 50/surfactant weight ratio that gives high viscosity and viscosity stability, low syneresis and efficient use of Attagel 50 modifier (Figure 5). Surfactant levels below this level generally have poorer thickening and viscosity stability, and greater liquid bleed. Higher surfactant levels generally have poorer thickening and/or viscosity stability, although suspension may remain high. Higher surfactant levels also increase cost and water sensitivity.



Attagel 50/Surfactant ratio	8:1	9:1	10:1
Toluene, gm	77.5	77.8	78.0
Surfactant, gm	2.5	2.2	2.0
Attagel 50, gm	20.0	20.0	20.0

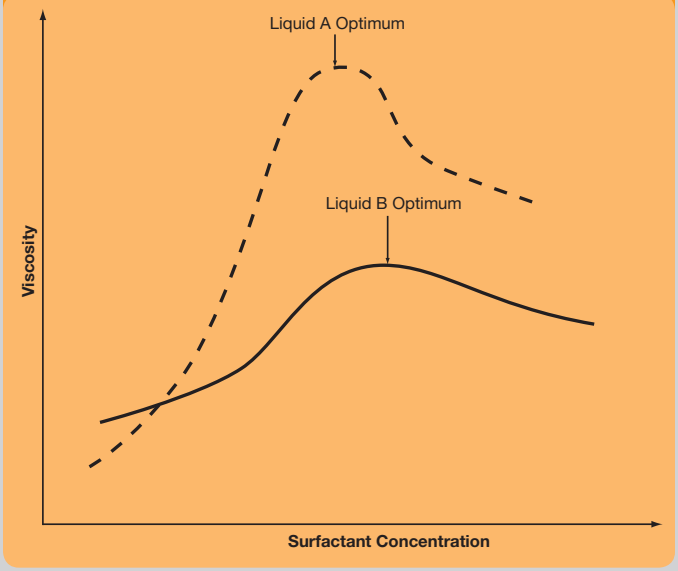
Table 4. Optimizing surfactant ratio

When formulating with Attagel 50 rheology modifier select a starting thickener/surfactant ratio for the liquid and experiment with higher and lower ratios to find the best level for your application.

Example: Optimizing surfactant ratio

To thicken toluene with Attagel 50 thickener and the surfactant PA-14* acetate, the recommended starting ratio is 9:1. As a first step in finding the optimum surfactant level, measure viscosities of a 100 gm batch at varying ratios of 8:1 to 10:1 as shown in Table 4.

Figure 5. Typical curves: Viscosity vs. surfactant concentration



How much Attagel rheology modifier to use

Attagel 50 thickener loading required to gel a pure organic liquid is typically 10 to 20% weight. The more viscous the liquid, however, the less thickener is needed. Higher solids concentrations also decrease the amount of Attagel 50 product required, because the solids reduce the amount of liquid to be thickened. High solids content also makes Attagel 50 thickener more efficient because the particles interact with the modifier's structure and strengthen the gel.

Other thickening agents or fibers also reduce the amount of Attagel 50 product required. In the presence of such co-thickeners, Attagel rheology modifiers are needed to produce thixotropy, sag resistance and syneresis control which many co-thickeners do not provide.

Attagel 50 rheology modifier produces stable suspensions of solids in organic liquids. If the suspended particles settle, they tend to form soft sediment that is easily redispersed. The amount of Attagel 50 product needed should be determined empirically because the optimum concentration depends on such factors as percent solids present, size and density of the particles, the type and viscosity of the organic liquid, and the surfactant used.

Dispersion

Attagel 50 rheology modifier is dispersed best in organic liquids as a pregel. This involves combining some of the liquid with the thickener and surfactant to form a 15% to 20% concentrate that disperses rapidly at low shear. Pregels can be formed in two ways – Pregel Batch Method and Pregel Concentrate Method.

*PA-14 is a trademark of Tomah products.

Formulation assistance

We're here to help

Pregel batch method

In this technique, Attagel 50 rheology modifier is added directly into the mixing vessel during the grinding stage.

1. Add a portion of the organic liquid. If no other solids will be added, use only the portion of the organic liquid in the formula sufficient to yield a 15 to 20% Attagel 50 concentration after Step 3. If other solids will be added, use a predetermined portion of the organic liquid that gives a viscosity range for optimum shear in Step 4.
2. Mix all the surfactant into the liquid.
3. Add all Attagel 50 product and mix to adequate dispersion.
4. Add all other solids and additives. Mix together at high shear until gelling occurs.
5. Add the balance of the organic liquid and mix to homogenize.

Pregel concentrate method

Prepare a 15% to 20% Attagel 50 concentrate separately from the production batch (Steps 1 to 3 above) for use in multiple batches or to be stored for future use. High-speed/high-shear mixing or milling usually is needed to make this concentrate. When using pregels in a formulation, the usual order of addition is organic liquid, pregel concentrate (mix to homogenize) and then all other materials (mix to adequate dispersion).

Care should be taken to avoid over- or under-dispersion, see Figure 2. Over-dispersion occurs if too much surfactant is present. Particles are scattered and separated so much that they cannot form a strong network. Under-dispersion, due to insufficient mixing shear or time, does not free enough particles to form a strong network. Under-dispersion can also allow viscosity to increase slowly over time as the attapulgite bundles wet-out and separate into individual particles.

Effect of heat and moisture

Heating the components or the mixture before or during processing can help dissolve the surfactant so it is more available for dispersion of Attagel 50 modifier. Heat can also improve gelling by reducing the secondary bonding forces that hold Attagel 50 particles together and by lowering the viscosity of waxes, asphalts and other thick systems.

Too much heat can cause problems, however. It can make medium-viscosity organic liquids so thin that not enough energy can be added to the system during mixing for proper dispersion. It can also evaporate volatile organic liquids which alters concentrations or drives off surface water on Attagel 50 particles. This free surface moisture on Attagel 50 particles aids their dispersion in organic liquids, particularly in low-polarity liquids. Gels lose strength if too much surface water is removed. Excessive loss of surface water can be corrected by adding small amounts of water to systems that can tolerate it, or by adding polyhydroxy compounds, such as glycerine, glycols, mannitol, sorbitol or pentaerythritol.

Processing

Proper dispersion of Attagel 50 modifier usually requires medium- and high-shear mixing equipment, such as a Cowles Dissolver. Low-speed mixers can be used with the proper order of addition, especially if a pregel is used.

Manufacturers also use high-speed mixers, homogenizers, and colloid, roll and ball mills, to disperse Attagel 50 modifier in organic liquids. With high-speed mixers, it is best to dissolve the surfactant in the liquid (using heat, if necessary) before adding the Attagel 50 product and mixing until gelling occurs. With a homogenizer or colloid or roll mill, it is best to prepare a blended feed containing the organic liquid, Attagel 50 (at 15 to 20% concentration) and the surfactant. With a slow-speed paddle mixer or ribbon blender, it is best to use a pregel for enhanced thickening.

Stability of gels

Organic liquids gelled with Attagel 50 product and a suitable surfactant show good temperature stability, unlike other inorganic thickeners, such as some oganoclays. Organic gels can be prepared that show no melting point and exhibit only minor consistency changes over wide temperature ranges. Greases made with Attagel 50 rheology modifier and a surfactant demonstrate excellent mechanical properties and storage stability.

Despite the excellent gel stability of organic liquids thickened with Attagel 50, there are a few conditions which can hinder this stability. Thinning can occur in organic liquids gelled with Attagel 50 thickener that contain water if the pH exceeds 11. Also, the presence of soaps, naphthenates, or other surface-active materials in an organic liquid can thin gels. In some cases, decreasing the amount of surfactant or adding small amounts of 85% phosphoric acid can overcome this. The latter is particularly effective with imidazoline surfactant.

The viscosity of gels made with Attagel 50 thickener usually increases to a stable level within 12 to 24 hours of preparation. It is best to age gels for at least 24 hours before evaluating them to allow thickening to stabilize. Be sure to check viscosity and gel stability of the final product formula at the temperature and duration in which the product will be stored.

A review of the steps to optimize Attagel product performance

1. Attagel rheology modifiers concentration and degree of dispersion are critical for optimizing its rheological properties.
2. Dispersion is strongly influenced by the following:
   a. Surfactants – They aid dispersion but an excess will over-disperse particles and hinder gel formation. **Surfactants are not generally recommended for aqueous systems.**
   b. Shear rate of mixing – Dispersion improves with higher shear rate and is aided by higher solids. Shear rate is more critical than mixing speed (Figure 3). Under-dispersion gives poor gel formation and, in aqueous systems, post-thickening can occur as the undispersed particles wet-out naturally over time and develop a stronger gel network. A low shear process requires pregel, higher solids, or longer mixing time.
3. Pregelling Attagel products takes advantage of the shear inherent in particle crowding. Pregels are best used when there is low shear mixing, the formulation foams when mixed rapidly, high-speed mixers are unavailable, or the formulation has abundant liquid and relatively small amounts of pigment and vehicle.
4. Liquid demand of other ingredients can affect viscosity as it determines the liquid available to be thickened. More crowded systems mean that viscosity change for a given amount of Attagel is more noticeable (Figure 4).

Aqueous applications

1. It is best to add Attagel modifiers at the end of the pigment-grind step to prevent absorption of surfactants intended for other pigments. This can cause over-dispersion and hinder gel formation.
2. The dosage of Attagel product depends on the consistency desired, the presence of other pigments or additives, the solids of the system, and the available free water. Table 3 provides typical dosages in several major applications.
3. Attagel thickener can be used as the sole thickener only if thixotropic rheology is needed. Such systems do not have high viscosity at high shear so they flow easily during application.
4. Attagel can be used to partially replace cellulose thickeners to improve spattering and sag resistance. They are best used with high viscosity cellulosics like HEC and HPMC. It is recommended that at least 3 lbs. cellulosic per 100 gallons (3.5g/l) be retained in the formulation to provide freeze-thaw stability and open-time.
5. Attagel products co-thickened with associative thickeners (urethane-based rheology modifiers) improve syneresis, pigment settling, organic pigment flooding and floating, hiding, color development and sag resistance.
6. Attagel products co-thickened with alkali swellable and hydrophobically modified HEC thickeners remedy sag resistance, pigment settling, and dipping problems.

Organic liquid applications

1. Attagel 50 is the preferred grade as the finer particles wet-out better in organic liquids.
2. To gel pure organic liquids, 10 to 20% by weight of Attagel 50 thickener is typically added. The more viscous the liquid the less thickener needed. Also, the amount of thickener is reduced with higher solids concentrations and the addition of other thickening agents or fibers.
3. Select a surfactant specific to the organic liquid to be thickened. A surfactant is not usually needed in highly polar liquids. Cationic surfactants are best.
4. Determine the optimum Attagel 50/surfactant ratio to achieve the highest viscosity and least syneresis.
5. Evaluate Attagel 50/surfactant ratios with all additives present.
6. When a surfactant is required, Attagel should be added early to ensure capture of the surfactant.
7. Pregelling is usually the best way to disperse the Attagel 50 modifier, especially if low-shear mixing is used.
8. A few formulation and process conditions can hinder gel stability and cause thinning, such as heat, moisture, pH above 11, and certain soaps, naphthenates, and other surface-active materials.
9. The gels should be allowed to stabilize for at least 24 hours before evaluating.
10. Check the storage stability of the final formula at the temperature and duration of typical storage.

For more information about Attagel rheology modifiers or any of BASF's attapulgite, kaolin, or mica products, please contact your BASF representative.

Regulatory

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FDA Status

All Colloidal Hydrated Magnesium Alumino-Silicate products, attapulgite, have the following FDA and EPA CFR approvals:

21 **CFR Part 175** – Indirect Food Additives: Adhesives & Components of Coatings
Part 175.105 – Adhesives
Part 175.125 – Pressure Sensitive Adhesives
Part 175.300 – Resinous and Polymeric Coatings

21 **CFR Part 176** – Indirect Food Additives: Paper & Paperboard Components
Part 176.170 & 176.180 – Components of Paper & Paperboard

21 **CFR Part 177** – Indirect Food Additives: Polymers
Part 177.1200 – Cellophane
Part 177.1210 – Closures with Sealing Gaskets for Food Containers
Part 177.2600 – Rubber Articles intended for Repeated Use

21 **CFR Part 178** – Indirect Food Additives: Adjuvants, Production Aids & Sanitizers
Part 178.3297 – Colorants for Polymers

21 **CFR Part 186** – Indirect Food Substances Affirmed as "Gras"
Part 186.1256 – Clay

21 **CFR Part 582** – Indirect Substances that are generally recognized as safe
Part 582.1 – Anti-Caking agent and pelleting aid
Part 582.1 – Suspension aid in liquid feed supplement

40 **CFR Part 180** – Tolerances and exemptions
Part 180.920 – Inert ingredients used pre-harvest

Please refer to the listed paragraphs in the CFR or contact BASF Regulatory directly at **ehs_p_info_center@basf.com** or at **704-398-5012** for details on restrictions and limitations.

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