BYK
Additives & Instruments

Technical Information B-RI 21

LAPONITE

Performance Additives

A member of ALTANA

LAPONITE – Performance Additives

Contents

Introduction

LAPONITE is a unique speciality additive; a layered silicate manufactured from naturally occurring inorganic mineral sources. It is used to improve the performance and properties of a wide range of industrial and consumer products making them more valuable to your customers. There are two key areas of functional use for LAPONITE.

- **As a rheology modifier** – LAPONITE may be added to the formulation of many waterborne products such as surface coatings, household cleaners and personal care products. It will impart thixotropic shear sensitive viscosity and improve stability and syneresis control.

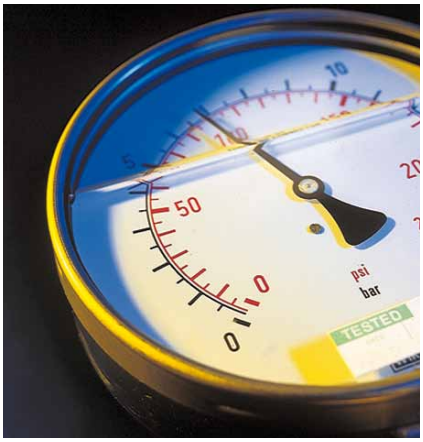
- **As a film former** – LAPONITE is a film forming agent and is used to produce electrically conductive, antistatic and barrier coatings.

Focus on Research and Development

BYK is continuing to develop the LAPONITE product range to extend its application into new fields. Grades are available that can give improved rheological performance in "harsh conditions", such as formulations that are produced using hard water, or have very high or very low pH, or have higher levels of surfactant or electrolyte. Guideline formulations showing the extensive application range and versatility of LAPONITE are available from BYK.

In partnership with our customers we are dedicated to ensuring that formulations containing LAPONITE will consistently offer tangible advantages to their users ...
... advantages that can enhance the performance and increase the value of your products.

Product Range and Properties



LAPONITE is a colloidal layered silicate; two groups of products are available:

- **gel forming grades**
- **sol forming grades**

Some definitions as they apply to LAPONITE:
Colloid – often a macromolecule, typically having dimensions < 500 nm
Gel – a high viscosity colloidal dispersion
Sol – a low viscosity colloidal dispersion

Gel forming grades disperse readily in water, under agitation, to form clear, colourless dispersions. The viscosity of such dispersions depends upon the solids content and the electrolyte content of the water used. At 2 % in tap water highly thixotropic gels are formed; at the same concentration in deionised water, low viscosity sols will be produced. Both forms of dispersion are suitable to use in, or add to formulations at this point. LAPONITE develops viscosity by interaction with the soluble components in a formulation.

Sol forming grades also disperse readily in water, under agitation, but these grades contain dispersing agents which delay the formation of a thixotropic gel structure. At concentrations of up to 30 % solids, low viscosity liquid sols can be produced.

There are two types of sol forming products available from BYK.

Temporary sol grades have a relatively short time of stability at low viscosity. Dispersions with higher solids content will have shorter stability times.

Permanent sols grades stabilised by modification with patented dispersing agents. It is possible to make sols that are stable for up to one year at solids contents up to 30 %.

LAPONITE SL25 is a commercially available liquid dispersion containing 25 % solids. Such materials have been referred to in open literature as "Liquid LAPONITE".

Both types of sol forming grades provide unique flexibility by allowing the formation of structure to be delayed until a pre-determined point during manufacture of a formulation.

Activation of LAPONITE Sol Dispersions

When the sol premix is added to a water based system containing other solids or electrolytes, the effect of the dispersing agent is overcome and viscosity begins to rise. The rate at which the desired level of structure is achieved will depend on the exact composition of the system, but in many formulated products this can often be within minutes of adding the LAPONITE sol premix.

Sol forming grades of LAPONITE are also effective in hard water – the dispersants used are effective sequestrants for $Ca^{2}+$ and $Mg^{2}+$ ions.

High solids content liquid dispersions of LAPONITE are especially useful for production of electrically conductive, antistatic and barrier coatings.

LAPONITE – Properties and Benefits

Property	Benefits
Synthetic layered silicate	• High purity • Colourless dispersion • Excellent consistency • Free from abrasives
Colloidal sized primary crystal	• Produces clear gels or sols in water to give ultra-clear products • Disperses rapidly in water without the need for high shear
Inorganic material	• Cannot support microbial growth • Not affected by high temperature • Non-yellowing • Non-toxic • Non-flammable • Free from crystalline silica

figure 1

Summary of LAPONITE Grades and Characteristics

Every time LAPONITE is evaluated in a new product, the formulator's attention is consistently drawn to the unique and novel rheological properties of this speciality additive.

These include:

- High viscosity at low shear rates which produces very effective anti-settling properties
- Low viscosity at high shear rates
- An unequalled degree of shear thinning
- Progressive and controllable thixotropic restructuring after shear

It is the combinations of these key properties which result in LAPONITE being one of the most versatile thickeners across the range of water-borne formulated products.

LAPONITE - Product Overview

LAPONITE grade name	Gel forming	Temporary sol forming	Permanent sol forming	Features	Benefits/recommended for use in ...
RD	■			General purpose grade	Universal application and high efficiency in water based systems; rheology control in surface coatings, household products and general and industrial fields
RDS		■		General purpose sol grade	As for LAPONITE RD, universal application and high efficiency in water based systems, recommended for use in formulations that have low levels of free water. Suitable for use in soft and hard water up to 20 °dH/ 20 °E/ 350ppm $CaCO_3$
S482			■	Very high sol stability grade	Aqueous dispersions of this grade will remain as stable liquids for very long periods of time. Recommended for use in highly filled surface coatings that have low levels of free water. Also for use in non-rheology applications, such as electrically conductive, antistatic and barrier films. Suitable for use in all levels of water hardness
SL25			■	A long term stable aqueous dispersion of LAPONITE	Ready-for-use, simply mix into a ready made formulation. Recommended for use in highly filled surface coatings. Also for use in non-rheology applications, such as electrically conductive, antistatic and barrier films. Suitable for use in all levels of water hardness
EP	■			Organic modification for extra performance in "difficult" systems	Functions well in formulas with very high or very low pH level. Recommended for systems containing higher levels of dissolved solids. Very efficient stabilisation of emulsions and suspended solids
JS		■		High sol stability grade	Optimised for use in non-rheology applications such as electrically conductive, antistatic and barrier films
Personal care grades:					
XLG	■			High purity, certified low heavy metal and low microbiological content	For rheology control in personal care and cosmetic applications, used to stabilise emulsions, lotions and creams
XLS		■		High purity, certified low heavy metal and low microbiological content	For rheology control in personal care and cosmetic applications, often used in rinse-off products containing surfactants
XL21	■			High purity, certified low heavy metal and low microbiological content	For rheology control in personal care and cosmetic applications, optimised for use in skincare formulations stabilised at pH 5.5 or lower
D	■			Optimised for rapid dispersion in sorbitol solution	For rheology control in toothpaste formulations

The typical use level of LAPONITE in a formulation may range from 0.05 % up to 1 %, or higher in some cases. Both types of sol forming grades of LAPONITE are designed to produce low viscosity dispersions in water. These dispersions will produce viscosity build and structure very rapidly when they are combined with other formulation ingredients.

figure 2

Recommended Dispersion Procedure for LAPONITE

It is essential that LAPONITE products are introduced into formulations in the correct way. This will ensure that optimum performance and efficiency is developed.

All LAPONITE grades, both gel forming and sol forming, must be added to water with mixing and allowed to disperse and hydrate fully before any other components are added.

If other components such as surfactants, resins, dispersing agents etc., are already present in the system at the time of LAPONITE addition, they can delay the dispersion process and in some cases will halt it completely.

Laboratory scale mixing procedure

Laboratory scale mixing procedure

Recommended laboratory mixing equipment is a mechanical stirrer fitted with a propeller blade revolving at 200 to 500rpm or a saw tooth (Cowles) blade revolving at 500 to 1000rpm.

Add the free flowing LAPONITE powder to deionised or tap water (at 15–25 °C) in a steady stream with rapid agitation.

Mixer speed should be high enough to produce a vortex that will cause the stream of Laponite powder to wet out into the water without the formation of clumps.

For a typical lab scale batch, it is recommended that **all of the LAPONITE material to be used in a formulation should be added gradually into the water over a period of between 10 to 30 seconds.** This will reduce the time required for dispersion for all LAPONITE grades.

Mixing should be continued for up to 20 minutes. If required, dispersion time may be reduced by increasing the temperature of the mixture up to 40–50 °C after the LAPONITE powder is fully wetted out or by use of a high shear mixer such as a Silverson. The viscosity and appearance of the LAPONITE dispersion at this time depends upon the concentration of the premix and the LAPONITE grade in use.

LAPONITE EP will produce structure in water much more quickly than other grades of Laponite; dispersions of this grade are translucent, not clear.

Gel forming grades: RD, XLG, D, XL21

When dispersion is complete, these grades produce a clear, colourless colloidal dispersion. At a concentration of 3 %, gel forming grades will build structure very quickly in the LAPONITE/water premix and can form a highly viscous pre-gel. It can be difficult to disperse strong gels of LAPONITE products homogenously into formulations. If there is not enough free water available to allow the preparation of a premix with concentration below 3 % then LAPONITE may be "de-gelled" by addition of compounds such as tetrasodium pyrophosphate or low molecular weight glycols. This de-gelling effect is overcome on addition of the premix to a formulation.

Temporary sol forming grades: RDS, XLS, JS

Colourless, translucent, low viscosity colloidal dispersions known as sols are formed. High solids concentrations of sol grades should be aged for up to one hour to allow the hydration process to complete. The liquid premix may be stored for several days and added to successive batches of a formulation.

Permanent sol forming grade: S482

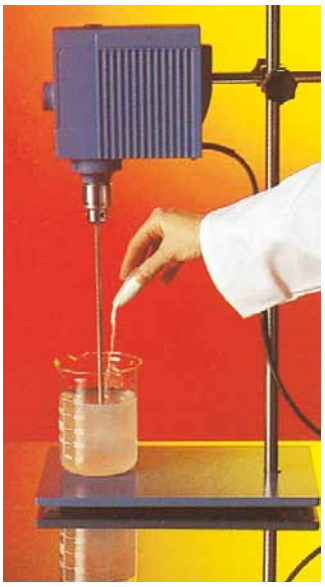
To produce a sol dispersion at 15 % to 25 % solids content it is recommended to use a mechanical stirrer fitted with a propeller or saw tooth (Cowles) blade. Add the free flowing LAPONITE powder to deionised or tap water (at 15–25 °C) in a steady stream with rapid agitation. **All of the LAPONITE S482 material should be added in a single dose over a period of ~30 seconds.**

Mixer speed should be sufficiently high to produce a steeply walled vortex which will cause all the powder to fully wet out into the water without the formation of clumps.

At solids content > 20 %, there will be a rapid increase in the viscosity of the mixture within a few minutes, producing a thick, paste-like texture. As the viscosity increases turn off the mixer and allow the dispersion to rest for 30 to 60 minutes. During this time the peptising effect of the patented additive will cause the viscosity of the sol pre-mix to reduce. After this time, turn the mixing equipment back on and continue mixing for a further 30 minutes.

Sols of LAPONITE prepared in this way may be stored for very long periods of time before use.

LAPONITE SL25 is a grade supplied as a ready-for-use concentrated aqueous dispersion.



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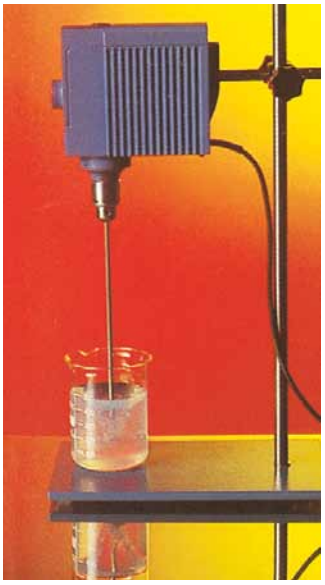

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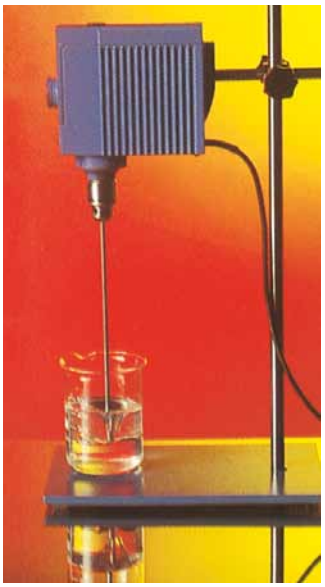

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Troubleshooting Checklist

How to Achieve Optimum Performance with LAPONITE

Order of addition

LAPONITE products should be premixed in water before other ingredients. Adding LAPONITE powder directly to a finished product, latex or electrolyte solution can result in flocculation or low viscosity build.

Preparation of LAPONITE premix

LAPONITE powder should be added to water at room temperature with rapid agitation. Slow agitation or short mixing times will produce partially hydrated LAPONITE particles which may sink to the bottom of the mixing vessel and produce a viscous gel layer which is difficult to re-disperse.

Effect of water temperature

- If water temperature is cold, 10 °C or lower, then hydration time will increase significantly.
- If LAPONITE powder is added to water at a temperature of 35 °C or higher, the rate of hydration is very rapid and gel coated clumps of powder can form.
- After the LAPONITE powder has been wetted out, the temperature of the premix may be increased to increase the rate of hydration.

Water hardness

Calcium and magnesium ions present in very hard water will reduce the rate of hydration, especially in gel forming grades of LAPONITE. Hard water can also cause a reduction in efficiency of viscosity build. This effect can be overcome by addition of a suitable quantity of a sequestering agent such as EDTA or a sodium polyphosphate salt.

The dispersants contained in LAPONITE sol forming grades allow them to be used in water classified as moderately hard, or hard (< 300ppm $CaCO_3$, or < 20°dH, German degrees of hardness). Specially modified grades have been developed to function efficiently, in water that is classified as "very hard" (> 300ppm $CaCO_3$, or > 20°dH).

Formulation pH

LAPONITE is most useful in the range pH 6 to pH 13.

LAPONITE EP has been specially developed to provide effective anti-settling and thixotropic properties in systems from pH < 1 up to pH 14.

LAPONITE XL21 has been designed for use in personal care formulations stabilised at pH 5.5, or lower.

- Recommended agents for pH adjustment include:

To lower formulation pH:

- buffering systems based upon citric acid, lactic acid or sodium dihydrogen phosphate

To increase formulation pH:

- ammonia solution, sodium hydroxide, sodium silicate, primary and secondary amines, DMEA, AMP95, DMAMP80.

Compatibility with other components

LAPONITE has one of the most extensive application ranges of all water based rheological additives – clear evidence of excellent compatibility with a wide spectrum of formulation ingredients.

LAPONITE products are anionic, and their use in formulations containing cationic compounds is not recommended.

Tertiary amines, such as TEA, can cause the formation of small flocculated particles, often described as "seeds" in systems containing LAPONITE. In formulations where tertiary amines are used to neutralise acidic resins, this neutralisation procedure must be completed before addition of a LAPONITE premix into the formulation.

Using LAPONITE with Polymer Co-thickeners …
… Creating Particle-polymer Synergy

LAPONITE products are frequently used in combinations with polymeric co-thickeners; this enables the formulator to develop useful improvements in performance especially in formulation types that are classed as "difficult-to-thicken".

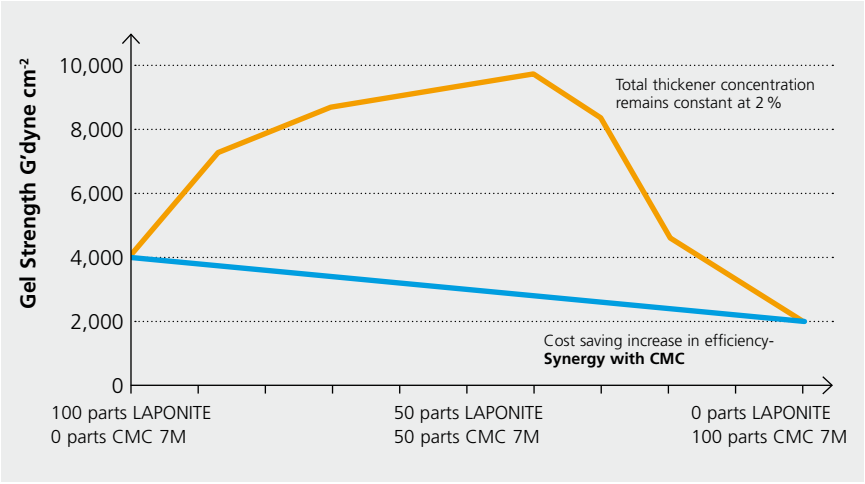
LAPONITE develops a very high level of gel structure combined with an unequalled degree of shear thinning. It has been proposed that when it is used together with polymer thickeners, the charged LAPONITE particles develop electrostatic associations with oppositely charged sections on the molecules of polymer co-thickener. This additional bonding mechanism of particle to polymer interactions has the result of generating real performance benefits.

The effect has been demonstrated when LAPONITE is used in combinations with a wide range of types of polymeric co-thickeners including CMC (figure 3) and other cellulose ethers, xanthan, guar and other natural gums, polyurethanes, ASE and HASE polyacrylic acid polymers, etc. By varying the ratio of LAPONITE to polymer co-thickener in a formula, it is possible to design custom rheological profiles for a wide range of types of product that can be sprayed or brushed, or used in pump-packs, tubs, tubes or in pourable applications.

Benefits of combining LAPONITE with polymeric thickeners include:

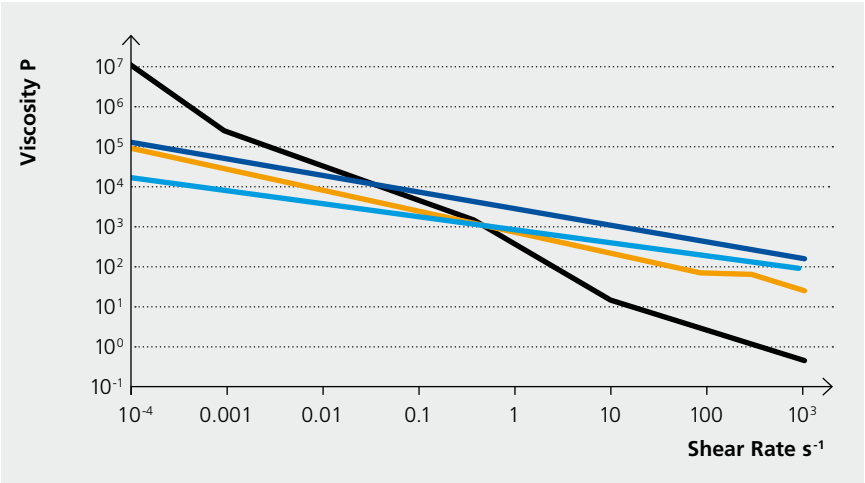
- Small additions of LAPONITE into polymer thickened systems can generate a very significant increase in low shear rate viscosity
- Synergistic increases in efficiency lead to cost saving reductions in total thickener level
- Improved tolerance to "harsh conditions" in formulations such as high levels of electrolytes, surfactants, acids and alkalis
- Precise rheological profiles can be engineered
- Pourable formulations with stable suspended particles can be readily formulated

LAPONITE – Synergistic Effect with Carboxymethylcellulose (CMC)



actual gel strength calculated gel strength figure 3

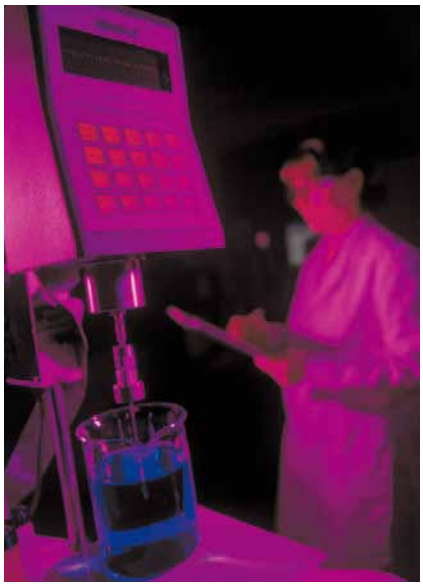
High Shear Thinning with LAPONITE

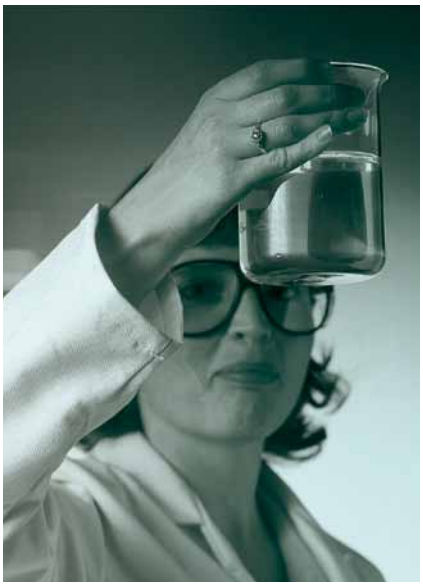


CMC carbomer xanthan gum LAPONITE figure 4

Figure 4: LAPONITE is the most highly shear thinning of commonly used rheological additives. At shear rates close to those caused by gravity ($10^{-4}.s^{-1}$), e.g. when a product is in storage, a gel of LAPONITE in water at 2 % concentration has a viscosity of ~ 10^7 P (one billion cP). Under shear rate conditions comparable with smoothing a cosmetic product on the skin ($10^3.s^{-1}$) the viscosity falls to less than 30 cP – similar to the viscosity of milk.

Quality by Action, Quality from Performance





By our Actions ...

LAPONITE is synthesised under carefully controlled conditions to ensure excellent consistency from batch to batch. These are some of the steps we have taken to ensure high quality.

- LAPONITE is manufactured under a Quality Management System which complies with BS EN ISO 9001:2000; Reg No. FM1857 and an Environmental Management System which complies with BS EN ISO 14001: 2004; Reg No. EMS 70613
- A well integrated team approach between Production, Quality Assurance, Customer Services and Logistics Departments
- Use of statistical quality improvement techniques, such as Statistical Process Control (SPC) and Statistical Quality Control (SQC)
- A team of process technologists, dedicated to the LAPONITE production plant with specific responsibilities for quality and process improvements
- Highly focused and experienced technical support scientists to develop new applications in partnership with our customers.

... and by Measuring Performance

Chemical composition, moisture content and product particle size are all measured during manufacture to control the consistency of every batch. As a speciality chemical with unique properties and a very wide application base, it is also vitally important to control the performance properties of LAPONITE. Tests have been developed to "fingerprint" LAPONITE and maintain optimum performance.

Gel Strength

The viscosity of a gel of LAPONITE in water is measured at very low shear rate.

Gel Time

We measure the time taken by a dispersion of LAPONITE in water to reach a fixed gel strength.

Dispersion Rate

A dilute dispersion of LAPONITE is pumped through a flow cell fitted in a visible light spectrophotometer. The time taken to achieve a chosen level of clarity (optical density) is measured.

Clarity

LAPONITE will produce exceptionally clear dispersions. We check every batch to assure maximum clarity.

Consumer Care

Household Products

LAPONITE is used to modify the rheological properties of many household cleaning products. It is possible to formulate gelled products for spray application which will cling to vertical surfaces to provide enhanced cleaning performance.

LAPONITE is often used in synergistic combinations with polymers such as xanthan gum, polyacrylates, ASE and HASE-type thickeners to give increased tolerance to higher levels of surfactants, electrolytes, or extremes of pH. **LAPONITE EP** can be used to produce thixotropic cleaners with pH values in the range < 1, up to pH 14.

LAPONITE can improve suspension stability and emulsion stability (silicone or mineral oils) by increasing the low shear rate viscosity of the formula.

LAPONITE swells on contact with water and is a very effective tablet disintegrant.

As a result of its high chemical purity and inorganic nature, LAPONITE demonstrates a compatibility with sodium hypochlorite bleach which is unsurpassed by other thickeners.

Surfactants

- compatible with non-ionic, anionic and some amphoteric surfactants. However, LAPONITE itself is a highly anionic material and it is not recommended for use with cationic compounds.

Other recommended grades for use in household products are **LAPONITE RD, LAPONITE RDS, LAPONITE S482 and LAPONITE SL25.**

Toothpaste

Here, as in many other application areas it is the unique and novel rheological properties of LAPONITE which make it the thickener of choice in toothpaste.

In addition to its use in conventional toothpastes, LAPONITE is highly recommended for speciality products such as:

- ultra-clear gels
- combination toothpaste and mouthwash
- striped pastes

LAPONITE is compatible with all commonly used toothpaste ingredients.

LAPONITE Features and Benefits include:

High gel strength	• Stability in the tube ideal for striped pastes
Unequalled degree of shear thinning	• Gel-like pastes can be readily extruded from tube • Ease of filling • Improved flavour release as paste flows more readily in mouth
Thixotropic restructure after shear	• Re-sets after extrusion to give a firm toothpaste ribbon • Improves appearance of paste
Short, non-elastic texture	• Non-stringy pastes break cleanly
Inorganic	• Does not hold flavour in paste by H-bonding

figure 5

Personal Care Products

LAPONITE products are made from naturally occurring inorganic mineral sources. LAPONITE grades for use in personal care applications are manufactured on a production unit that has been specially designed to ensure the products have consistently high levels of physical, chemical and microbiological purity.

The unique shear thinning and thixotropic rheology of LAPONITE will improve skin-feel of personal care products; formulations will have a light, non-sticky texture.In synergistic combinations with polymeric thickeners, LAPONITE can be used in skin-friendly leave-on and rinse-off products in the pH range 5 to 7.

LAPONITE XL21 has a lower acid demand than other grades of LAPONITE and is particularly suited for use in skin care formulations stabilised at pH 5.5, or lower.

Recommended grades for use in personal care products are **LAPONITE XLG, LAPONITE XLS** and **LAPONITE XL21.**

LAPONITE in Care Applications – Properties & Benefits

Property	Benefits
Manufactured under carefully controlled conditions from selected inorganic chemicals	• Product does not contain crystalline silica • Very low heavy and transition metal content • Stable to uv • Not susceptible to microbial attack • Suitable for sterilisation by gamma irradiation or ethylene oxide • Colourless in formulations
Unequalled degree of shear thinning	• Gives a light, clean texture to creams and lotions • Reduces oily feel of emulsions • Gels and pastes readily dispensed
High gel strength	• Improves stability of o/w, w/o and HIPES emulsions • "Emulsifier-free" systems can be stabilised • Improves stability of suspended abrasives and solid actives • Suitable for making non tacky gels with high yield values
Thixotropic viscosity	• Allows controlled rate of restructure after shear

figure 6

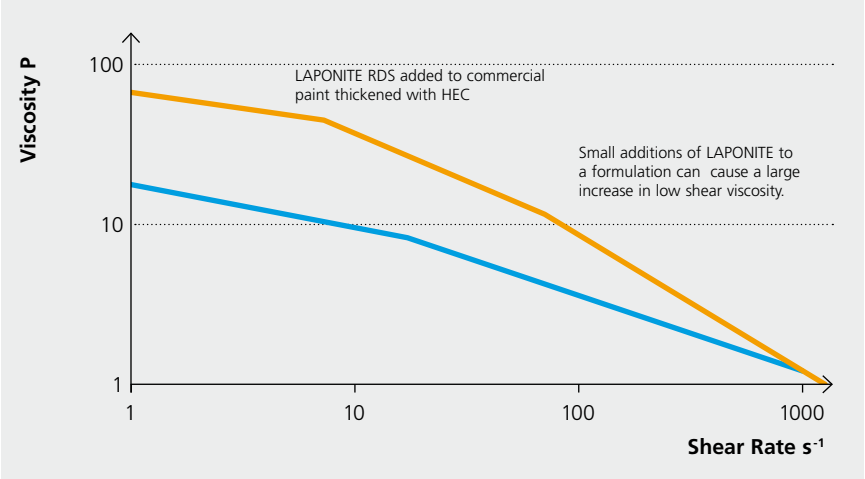
Surface Coatings

In aqueous coating systems, thickeners are used to control flow as well as to provide adequate stability in storage and suitable rheology for application. The correct choice of thickeners in a formulation should provide sufficiently high viscosity at low shear rate to prevent sedimentation of pigment and maintain good in-can appearance and storage stability. The formulation should then shear thin during application and progressively restructure on the surface being coated. This gives the desired combination of easy application with sufficient film build and levelling, but without allowing dripping or sag. LAPONITE, on its own, or in combination with other thickeners, is used to improve the properties and performance of a wide range of coatings.

Recommended grades for use in surface coatings are **LAPONITE RD, LAPONITE RDS, LAPONITE S482** and **LAPONITE SL25.**

LAPONITE RD should always be pre-dispersed and fully hydrated in water as the first stage in preparation of the mill base. If the concentration of LAPONITE RD in the premix in water is greater than 2 %, then it is recommended that a degelling agent is added. Examples of suitable agents include condensed phosphates, e.g. tetrasodium pyrophosphate (typical addition level 1 %–2 % of the weight of LAPONITE RD in the premix) and some water soluble organic solvents, such as, low molecular weight glycols (typical addition level 1 part polyethylene glycol: 1 part LAPONITE RD). If free water available to hydrate the LAPONITE RD is limited, resulting in a premix concentration of > 4 % LAPONITE RD, then use of a sol forming grade of LAPONITE is recommended.

Effect on Paint Viscosity



HEC control 0.1 % LAPONITE RDS added

figure 7

LAPONITE in Coatings Applications – Properties & Benefits

Property	Benefits
High viscosity at low shear	• Excellent pigment suspension to give good in-can appearance and syneresis control
Highly shear thinning	• Readily formulated for brush, roller or spray application
Progressive restructuring after shear	• Allows good flow and levelling • Prevents sag • Excellent flip-flop in metallic and pearlescent spray coatings • Interaction with polymeric thickeners
Performance benefits when used with polymeric co-thickeners	• Unique synergistic increases in viscosity when combined many other types of thickener • Precise rheological profiles may be engineered

figure 8

LAPONITE sol grades may be prepared as low viscosity liquid premixes in water:

- **LAPONITE RDS – up to 10 % solids content**
- **LAPONITE S482 – up to 25 % solids content**
- **LAPONITE SL25 – this grade is supplied as a ready-for-use dispersion at 25 % solids content.**

These dispersions can be added to the coating at any stage during manufacture, although it is frequently found that best results are obtained when added as the final component. On addition of a sol grade dispersion to many types of paint formulation, rapid viscosity build will occur.

Compatibility
LAPONITE layered silicate products have been widely used in the coatings industry for over forty years and show excellent compatibility with commonly used latex systems, pigments and extenders. LAPONITE is compatible with coalescing solvents, biocides and defoamers at normal levels of use.

Formulation pH
LAPONITE has been successfully formulated into coatings across a wide pH range, for example
- pH 3 – organic acid based rust conversion coating
- pH 13 – water glass based primer coating.

LAPONITE does not require pH adjustment in order to develop its thixotropic rheological properties.

Some Speciality Applications

1. LAPONITE in Automotive Coatings
LAPONITE gives:
- Excellent appearance
- Improved flip-flop
- Improved moisture sensitivity compared with other thickeners

A special variant of the **LAPONITE RD** grade has been developed, which shows reduced tendency to build viscosity in deionised water. This allows easier combination into resin systems, but does not affect rate of paint viscosity development or moisture resistance of the coating.

Contact us for more information.

2. LAPONITE in Water Based Multicoloured Paint
Multicoloured particles of paint in a single pack are prevented from mixing together by a barrier coating of LAPONITE gel using a process developed by and available from BYK.

3. LAPONITE in Wood Coatings
LAPONITE gives:
- Excellent clarity, gloss and smoothness in varnishes
- Suspension and improved spacing of pigments
- Reduced pigment flocculation which can increase colour strength
- Prevention of flotation of waxes
- Improved pigment hold-out properties

Formulations suited to brush or spray application can be produced, for both industrial and DIY use.

4. LAPONITE in Pigment Suspensions
Stability without viscosity. In certain formulations LAPONITE can be used at very low levels to provide stability of suspended pigment without producing thixotropic viscosity. Applications include liquid printing inks, automotive paints, dip coatings and wood stains.

Agricultural and Horticultural Applications

LAPONITE is classified as an inert ingredient in formulations applied to growing crops or to raw agricultural crops after harvest.

Applications for LAPONITE include:
- Anti-settling agent for agrochemical flowables and suspension concentrates
- A medium for seed germination and fluid seed drilling
- A gel medium for rooting of plant cuttings
- Non-toxic antistatic and barrier coating for seeds
- Gels for decorative and hobby uses

Ceramics and Enamels

Glazes
LAPONITE is used as a partial or complete replacement for conventional organic polymer/clay based set up agents. It will increase stability and improve sprayability of ceramic glazes and enamel frits.

Bodies
LAPONITE is used to increase both plasticity and green strength of high value ceramic bodies, allowing cost savings by reducing the number of lost or damaged pieces.

LAPONITE has:
- High purity and high whiteness
- Excellent chemical compatibility

It is not degraded by high temperature or high shear dispersion processes.

Recommended grades are **LAPONITE RD** and **RDS.**

In a number of regions ceramic industries are located in very hard water areas. LAPONITE grades have been specially developed to give optimum performance when used in hard water. Contact us for more information.

Exploration Technology Oil/Gas

LAPONITE RD and **LAPONITE RDS** have been classified as Category E-lowest level of toxicity- in the UK Offshore Chemical Notification Scheme (OCNS).

LAPONITE gives:
- Superior flow control at elevated temperature and pressure
- Increased performance of thixotropic cements and polymeric plugs

LAPONITE products show strong synergistic interactions with polymer based rheological additives and will improved performance in harsh conditions.

Stabilisation of Emulsions Using LAPONITE

LAPONITE is a powerful emulsion stabilising agent when is incorporated into systems using a novel process developed by BYK – the **"Powdered Particle Method".** This type of surfactant-free emulsion system stabilised only by particles against creaming and coalescence are termed Pickering emulsions. In addition to providing emulsion stability, LAPONITE products simultaneously impart gel structure and shear thinning rheology, resulting in a valuable 2-in-1 benefit to the formulator.

In the Powdered Particle Method, LAPONITE powder product is added into one phase of the system, immediately before the oil phase and aqueous phase are combined. The formulation is then homogenised allowing the LAPONITE to disperse in the presence of both the oil and water phases. This novel order of addition has been shown to develop significantly better emulsion stability compared with formulations where LAPONITE is pre-dispersed into water before addition of the oil phase.

Using this procedure it is possible to make o/w emulsions with a wide range of oils and mixtures of oils, with different polarity and different oil viscosity. Emulsion particle size can be controlled by varying the shear rate of mixing:

- higher shear rates produce a smaller particle
- lower shear rates produce a larger particle.

With low shear it is possible to make stable oil particles several millimetres in diameter.

Stable emulsions can be produced using in the region of 1.0 % to 1.5 % of LAPONITE based on the weight of the whole emulsion. Changing the addition level of LAPONITE makes it possible to produce emulsions that are low viscosity liquid lotions up to high viscosity gels. By eliminating surfactant based emulsion stabilising agents, it is possible to make formulations faster and at lower cost, often with processing at ambient temperature.

This novel process offers several advantages over traditional emulsification methods, such as:

- Simplification of formulations; ease of use; one-pot synthesis of emulsions is often possible
- Surfactant free systems possible
- Cold-process possible – no requirement to melt surfactant emulsifiers
- Significant reduction in manufacturing time with associated reduced costs
- Shear-thinning & thixotropic rheology; can be tailored for the final application

Suitable for use in a wide range of application fields

- Personal care & Home care
- Manufacture of water based emulsion resins for coatings, adhesives and construction applications
- Exploration technology oil/gas
- Metal working
- Release agents
- Antifoaming products

The Powdered Particle method – a laboratory procedure

1. Weigh the water into a container suitable for carrying out the homogenisation step in 5. below.
2. Weigh the oil phase into a separate container.
3. Weigh the required quantity of LAPONITE powder in a weighing boat.

Carry out steps 4, 5 and 6 one after the other, in immediate succession

4. In a single action, tip all the LAPONITE powder on top of the water.
5. Pour the pre-weighed oil phase into the LAPONITE and water.
6. Homogenise the mixture using a suitable mixer (e.g. Silverson, Ultra Turrax, Cowles blade at high speed).

LAPONITE as a Film Forming Agent

Like many other colloidal materials, LAPONITE is a natural film former. However, the unusual shape of the LAPONITE crystal, combined with its anionic nature, enables LAPONITE to produce films which have useful properties:

- Conductive/antistatic
- Barrier
- Antiblocking

A film of LAPONITE can be cast onto paper simply from a dispersion of LAPONITE sol grade in water. Standard coating techniques such as metering bar, dip coating or flexogrphic printing are all suitable. Addition of an emulsion resin binder – for example, polyurethane, acrylic, vinyl acetate or many other types will enable the preparation of coating mixes for a wide range of substrates, including;

- Polymeric films, extrudates and mouldings:
  polypropylene, polyethylene, polycarbonate, polyester, acrylic, ABS, PVC
- Glass
- Paper
- Metal
- Wood

By selecting an appropriate binder and wetting agent system it is possible to produce coatings of LAPONITE which are clear, highly flexible and moisture resistant.

These unique properties are used to advantage in many applications:

- Conductive layer in electrographic and speciality antistatic paper grades
- Absorbent ink receiving coatings for ink jet printing
- Inert barriers in x-ray and photographic film
- Barrier sizing of speciality papers
- Paper and polymer antistatic packaging for food and electrical components.

Recommended grades are **LAPONITE JS, LAPONITE S482** and **LAPONITE SL25.**

Plan of LAPONITE Coating

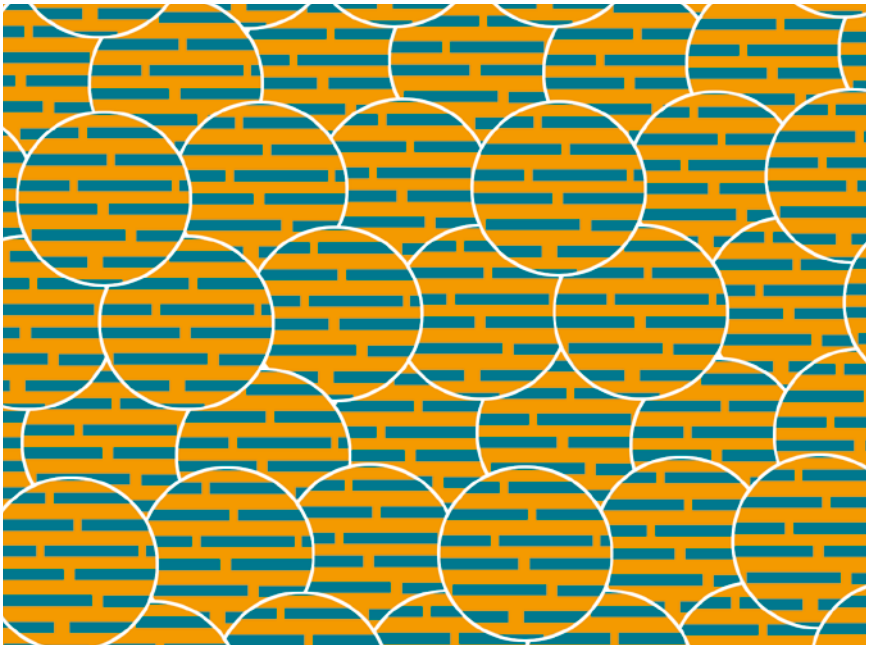


figure 8

How LAPONITE works as an Antistatic Agent

When coated onto a substrate, LAPONITE conducts electricity using two separate mechanisms.

1. Electronic
The LAPONITE coating forms a continuous interlinked and overlapping film of electrically charged particles. This mechanism is not affected by changes in relative humidity (RH). (figure 8)

2. Ionic
Free moisture – a LAPONITE film will typically absorb up to 15 % free moisture at 50 % RH. This is associated as water of hydration of the ions within the LAPONITE crystal structure. Some of this water is lost at very low humidity.

Structural water – LAPONITE contains approximately 8 % by mass of water which is chemically absorbed into the crystal structure and may only be released at temperatures above 150 °C.

Electrical charge may be conducted through this concentrated ionic solution.

Depending upon coat weight applied and the substrate, LAPONITE can be used to produce coatings with surface resistivity in the range 10^6–10^{12} ohms/square.

Benefits of LAPONITE Compared with Polymeric Resins:

- The conductivity of LAPONITE coatings is affected less by changes in relative humidity. Polymeric resins operate as antistatic agents by dissipating electrical charge via physically absorbed water molecules. This water is rapidly removed as relative humidity falls, resulting in a significant loss in conductivity.
- LAPONITE coatings are not easily redissolved and are suitable for overcoating with aqueous or solvent based coatings.
- LAPONITE coatings are dry and non tacky to the touch and are suitable surfaces for writing, printing or for use with water or solvent based adhesives.
- Because LAPONITE is inorganic, its films do not discolour with ageing or heating.

Barrier Properties

It has been estimated that LAPONITE has a physical surface area of over 900 $m^2.g^{-1}$. The unusual combination of particle size and shape of the LAPONITE crystal allows it to be used as a barrier forming substance, both in a film and in dispersion within a medium.

In dispersion in a liquid or gel medium, LAPONITE particles can provide a structured system which can prevent or reduce the rate of the movement of species between different phases. This effect can be used to develop greatly improved stability in many "2-in-1" type products such as:

- Striped toothpaste
- Water based multicolour paint
- Multilayer films

A film of LAPONITE can prevent migration of macromolecules or colloidal particles between two layers by providing a tortuous path for the species to travel through.

Barrier Properties

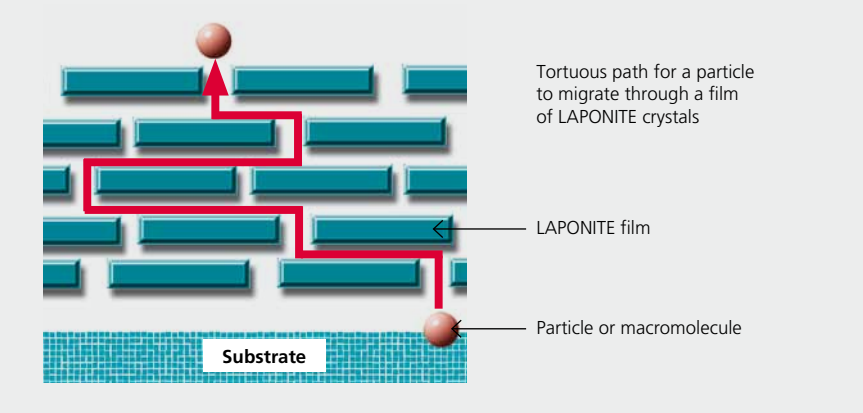


figure 9

Single LAPONITE Crystal

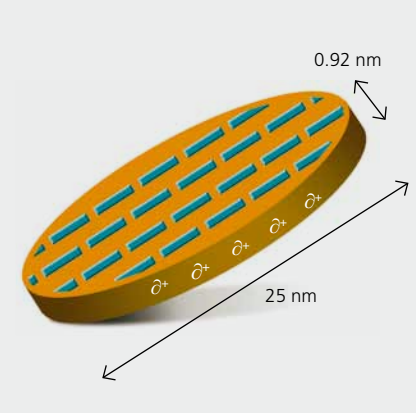


figure 10

Manufacture, Structure and Chemistry

Single LAPONITE Crystal

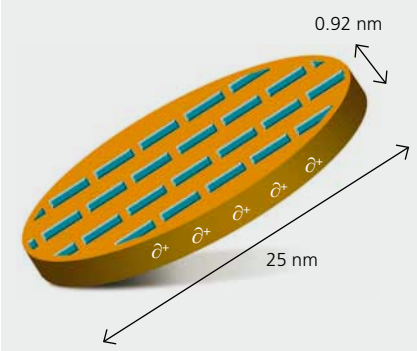


figure 10

LAPONITE is an entirely synthetic product. The synthesis process shown in figure 11 involves combining salts of sodium magnesium and lithium with sodium silicate at carefully controlled rates and temperatures. This produces an amorphous precipitate which is then partially crystallised by a high temperature treatment. The resulting product is filtered, washed, dried and milled to a fine white powder.

LAPONITE has a layer structure which, in dispersion in water, is in the form of disc-shaped crystals. It can be envisaged as a two-dimensional "inorganic polymer" where the empirical formula forms a unit cell in the crystal as shown in figure 12. This shows six octahedral magnesium ions sandwiched between two layers of four tetrahedral silicon atoms. These groups are balanced by twenty oxygen atoms and four hydroxyl groups. The height of the unit cell represents the thickness of the LAPONITE crystal. The unit cell is repeated many times in two directions, resulting in the disc-shaped appearance of the crystal shown in figure 10. It has been estimated that a typical LAPONITE crystal contains up to 2000 of these unit cells.

Macromolecules of this particle size are known as colloids. Natural clay mineral thickeners such as bentonite and hectorite have a similar disc shaped crystal structure but are more than one order of magnitude larger in size. The primary particle size of LAPONITE is compared with those of natural hectorite and bentonite in figure 13.

The idealised structure shown in figure 12 would have a neutral charge with six divalent magnesium ions in the octahedral layer, giving a positive charge of twelve. In practice, however, some magnesium ions are substituted by lithium ions (monovalent) and some positions are empty to give a composition which typically has the empirical formula:

$$Na^{+}_{0.7}\ [(Si_8\ Mg_{5.5}\ Li_{0.3})\ O_{20}(OH)_4]^{-0.7}$$

This has a negative charge of 0.7 per unit cell, which becomes neutralised during manufacture as sodium ions are adsorbed onto the surfaces of the crystals. The crystals become arranged into stacks which are held together electrostatically by sharing of sodium ions in the interlayer region between adjacent crystals. The processes that occur during dispersion of LAPONITE into water are shown schematically in figure 5. At 25° C in tap water and with rapid agitation, this process is substantially complete after 10 minutes. High shear mixing, elevated temperature or chemical dispersants are not required.

A dilute dispersion of LAPONITE in deionised water may remain a low viscosity dispersion of non-interacting crystals for long periods of time.

The crystal surface has a negative charge of 50-55 mmol.100g^{-1}.
The edges of the crystal have small localised positive charges generated by absorption of ions where the crystal structure terminates. This positive charge is typically 4–5 mmol.100g^{-1}.

Production Flow Diagram

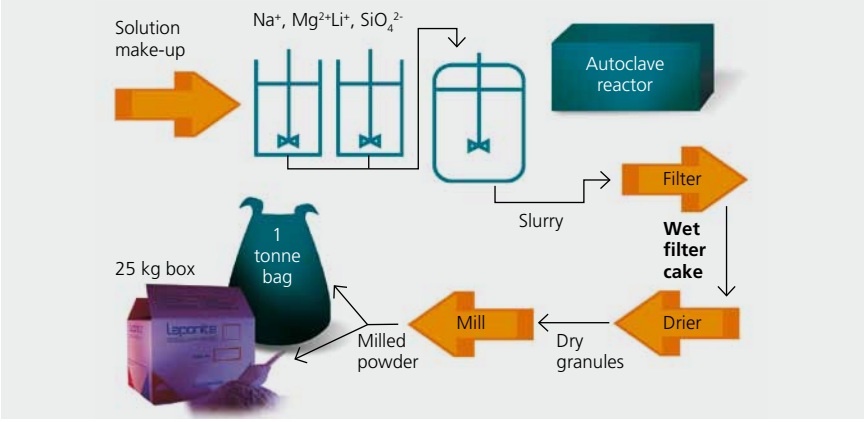


figure 11

Idealised Structural Formula

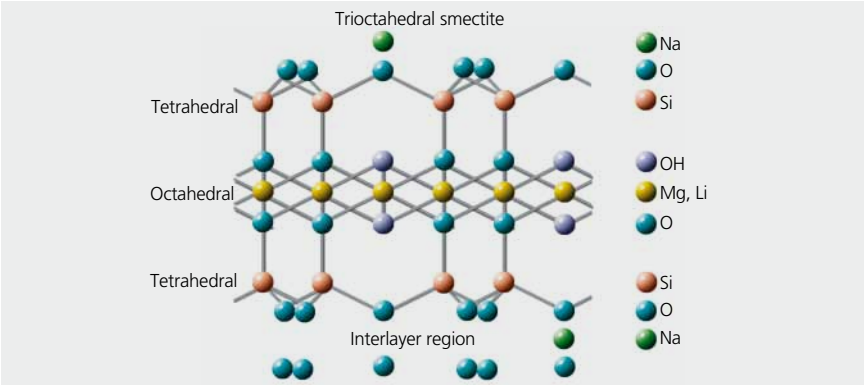


figure 12

Gel Formation

Comparison of Primary Particles

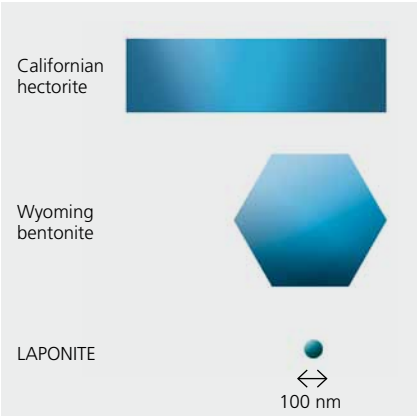


figure 13

Dispersed Primary Particle

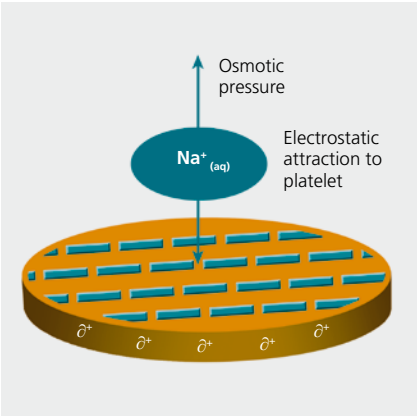


figure 14

Gel Formation-House of Cards

figure 15

Electrostatic attractions draw the sodium ions which go into solution towards the crystal surface and osmotic pressure from the bulk of water pulls them away. An equilibrium becomes established where the sodium ions are held in a diffuse region on both sides of the dispersed LAPONITE crystal as shown in figure 14. These are known as electrical double layers.

When two particles approach, their mutual positive charges repel each other and the dispersion exhibits low viscosity and Newtonian type rheology.

The addition of polar compounds in solution (eg simple salts, surfactants, coalescing solvents, soluble impurities and additives in pigments, fillers or binders etc.) to the dispersion of LAPONITE will reduce the osmotic pressure holding the sodium ions away from the particle surface. This causes the electrical double layer to contract and allows the weaker positive charge on the edge of the crystals to interact with the negative surfaces of adjacent crystals.

The process may continue to give a "house of cards" structure which, in a simple system of LAPONITE, water and salt, is seen as a highly thixotropic gel (see figure 15). This gel consists of a single flocculated particle held together by weak electrostatic forces. A number of features of the rheology support this type of mechanism for gel formation.

- Solid particles are held within the 3D gel structure and are not stabilised by viscosity alone – this gives excellent suspension properties for materials of all densities.
- As the bonds are ionic, viscosity is not affected by temperature.
- The gel structure is readily broken down on application of shear stress. LAPONITE shows a greater degree of shear thinning than other commonly used thickeners.
- When held under high shear, LAPONITE dispersions show very little resistance to flow and have low viscosity.
- The gel structure takes time to reform when shear stress is removed as the particles must re-orientate themselves back into the house of cards structure.

Addition of LAPONITE to Water (schematic)

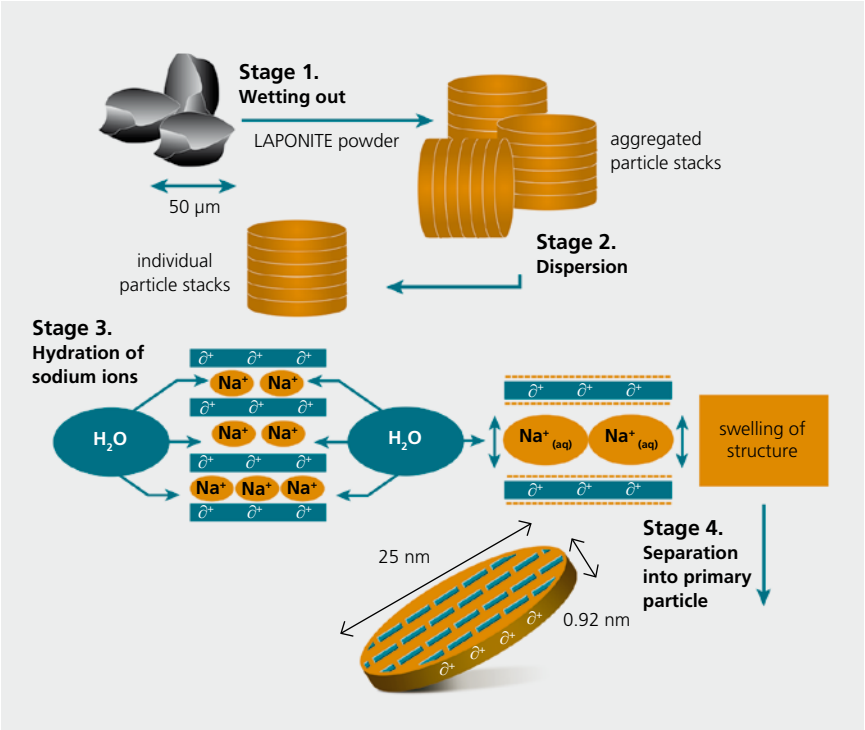


figure 16

Formation of Sols

Firstly, two general textbook definitions:

- A high viscosity colloidal dispersion is termed a gel
- A low viscosity, or liquid, colloidal dispersion is termed a sol

It is possible to modify LAPONITE from a gel forming material to a sol forming type by addition of certain compounds, e. g., condensed phosphates, glycols, some non-ionic surfactants. Optimised sol forming grades of LAPONITE have been developed by combining LAPONITE with a small proportion of tetrasodium pyrophosphate (TSPP) and with other, patented, additives. When a sol forming grade, such as LAPONITE JS is added to water the LAPONITE will disperse as described earlier. As the blended TSPP dissolves, the pyrophosphate $(P_2O_7)^{4-}$ anions become associated with the positively charged edges of the LAPONITE crystal, as shown in figure 17, making the whole particle negatively charged. This is subsequently surrounded completely by a loosely held layer of hydrated sodium ions, whose positive charges cause mutual repulsions between the dispersed LAPONITE crystals. The TSPP has a peptising or dispersing effect on LAPONITE.

When such a sol dispersion of LAPONITE is added into a formulated product such as paint or toothpaste, the dispersing effect is rapidly overcome as the pyrophosphate anions are absorbed by the matrix of e.g., fillers, pigments, binders, surfactants, wetting agents, etc. that comprise the formulation. As this happens, adjacent LAPONITE crystals will begin to interact with each other and the house of cards type structure can form, resulting in viscosity increase in-situ. This unique feature of LAPONITE gives the opportunity to develop a viscosity increase at a pre-selected time during formulation production. It also allows these grades to be used in water-lean formulations and as a post additive or corrective thickener.

Sol Grades – (schematic)

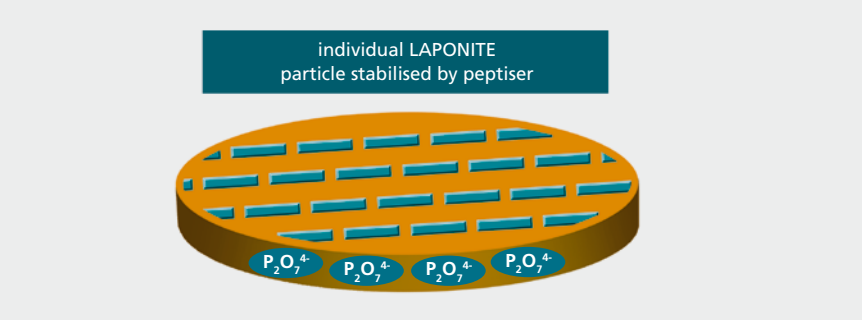


figure 17

Typical Stability of Temporary Sol Forming Grades

Grade	% Concentration of the sol in water			
LAPONITE RDS & XLS	6	7.5	10	11
LAPONITE JS	15	18	19	20
At the concentration shown the grade will be a stable sol for ...	90 days	28 days	3 days	0.5 days

LAPONITE sol stability is a measure of how long the dispersion will remain liquid and is defined as the time in days for which the sol continues to have a viscosity of < 100cP (Brookfield LV, 60 rpm, 25° C)

figure 18

Properties of Sol Grades

There are two groups of sol forming grades- temporary and "permanent".

Temporary Sol Forming Grades:
Under manufacturing conditions, when formulating with LAPONITE RDS, XLS or JS, a sol dispersion should be regarded as a temporary intermediate. The length of time for which a sol can be stored is known as its sol stability.

The pyrophosphate ions which stabilise the LAPONITE sol dispersion are themselves unstable in solution and slowly hydrolyse to produce simple phosphate. The charge density on the phosphate ion is much higher than on the pyrophosphate ion and does not produce a sol stabilising effect.

$$(P_2O_7)^{4-} + 2OH^- \longrightarrow 2(PO_4)^{3-} + H_2O$$

As the edges of the crystals are once more free then particle-particle interactions can occur between positively charged edges and negatively charged faces. This reduces the mobility of the particles within the dispersion resulting in an increase in viscosity – when the process is complete a highly thixotropic gel is formed.

The length of time for which a sol remains stable, at low viscosity, depends upon a number of factors:

Concentration
- as concentration increases then LAPONITE crystals are forced into closer contact with each other and viscosity increase will occur

Storage Temperature
- at elevated temperatures the rate of hydrolysation of pyrophosphate ion is accelerated and sol stability can be significantly reduced

Electrolyte Level/Water Hardness
- concentrated sols show maximum sol stability when deionised or soft water is used- in harder water, sol stability may be reduced

If water soluble compounds (surfactants, polyols, electrolytes) or latexes are added, then in some cases sol stability may be reduced. The addition of larger quantities of electrolyte such as would be caused by addition of the sol to a fully formulated toothpaste or paint will cause almost instantaneous viscosity increase.

Permanent Sol Forming Grades:
LAPONITE grades, LAPONITE S482 (supplied as a power) and LAPONITE SL25 (supplied as a ready-to-use liquid dispersion at 25 % solids content), are modified with patented dispersant additives.

Under normal conditions, sol dispersions of up to 25 % in water, of these grades will remain stable as liquids for over 1 year and can be regarded as "permanent" sols. The patented additives used in these grades form stable complexes at the edges of the LAPONITE crystal, ensuring that aqueous dispersions remain stable at low viscosity for very long periods of time. On addition to a wide range of formulated products, they behave in the same way as temporary sol forming grades- a rapid increase in viscosity will occur.

Product Safety, Storage and Handling

LAPONITE products do not contain respirable crystalline silica.

Product safety data and handling information for LAPONITE can be found on the relevant Safety Data Sheets, which are available in local languages of most industrialised countries. It is recommended that safety data sheets are examined before using LAPONITE.

LAPONITE grades are not classified as Dangerous Substances or Dangerous Preparations under Directives 67/548/EEC and 88/379/EEC. LAPONITE is registered under EINECS (Europe), TSCA (USA), DSL (Canada), ACOIN (Australia) and MITI (Japan).

LAPONITE products are in compliance with the following EU chemicals regulations:

- Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH) Regulation (EC) No 1907/2006
- Classification, labelling & packaging (CLP) Regulation (EC) No 1272/2008

Packaging:

- 25 kg polyethylene lined cardboard cartons.
- up to 1000 kg in polyethylene lined woven polypropylene intermediate bulk containers – "big bags".

Storage:
Store under dry conditions in original packaging. Seal container after use.

Environmental information:
LAPONITE is manufactured from abundant inorganic mineral sources and has a chemical composition analogous to that of naturally occurring smectite clay minerals, such as bentonite and hectorite. It is widely viewed as environmentally neutral.

Regulatory Information

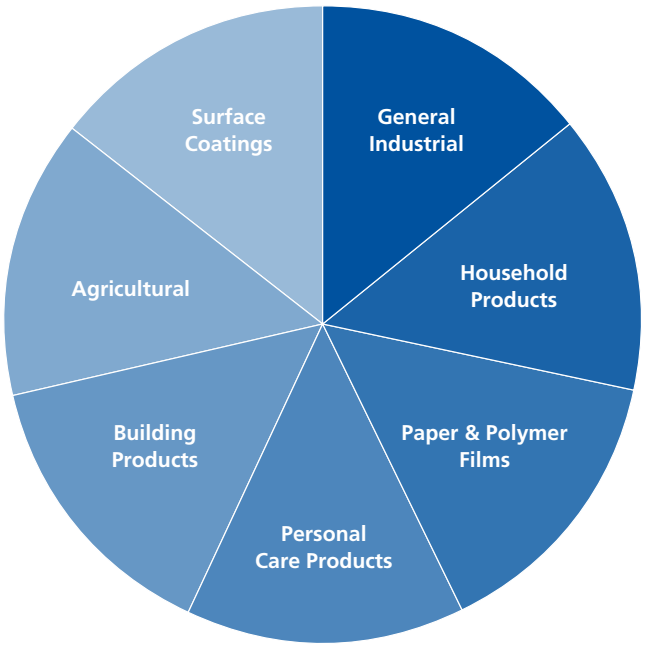
LAPONITE Grade	RD, XLG, D	RDS, XLS	XL21	JS
CAS No	53320-86-8	53320-86-8	64060-48-6	64060-48-6
EINECS No	258-476-2	258-476-2	285-349-9	285-349-9
CTFA and INCI name	Lithium magnesium sodium silicate	Lithium magnesium sodium silicate (and) tetrasodium pyrophosphate	Sodium magnesium fluorosilicate	Sodium magnesium fluorosilicate (and) tetrasodium pyrophosphate

LAPONITE S482, LAPONITE SL25, LAPONITE EP are proprietary compositions of materials listed in EINECS / TSCA and other relevant lists.

figure 19

LAPONITE Applications

Personal Care Products	• Skincare & suncare emulsions • "Emulsifier-free" emulsion systems • Alphahydroxy acid creams • Toothpaste • Colour cosmetics • Gelled skin cleansers • Depilatory creams • Exfoliant & astringent cleansers • Nail lacquers • Shampoos
Paper & Polymer Films	• Static dissipative (antistatic) coatings • Electrographic paper & film • Inert barrier films • Anti-blocking coatings • Paper coating colours • Ink jet coatings • Paper sizing • Industrial speciality papers • Microparticle for retention & drainage systems
Surface Coatings	• Decorative & architectural finishes • Textured coatings • Water-in-water multicolour paint • Automotive OEM & refinish • Clearcoats & varnishes • Industrial & protective coatings • Rust conversion coatings • Water reducible alkyds • Wood stains • Decking stains • Wood varnishes • Printing inks • Artist's & children's paints • Pigment suspensions
Building Products	• Plasters & fillers • Setting retardants • Wood treatment suspensions • Wood adhesives • Tile adhesives
General Industrial	• Mould release suspensions • Children's toys • Processing aids • Grinding pastes • Oil drilling fluids • Ceramic body formulations • Ceramic glazes • Foundry coatings • Rubber latex • Electrorheological fluids



Household Products	• Oven cleaners and degreasers • Gelled bleach cleaners • Sprayable cleaners • Spray-with-cling formulations • Tablet disintegrant • Carpet shampoos • Acidic and alkali toilet cleaners • Hard surface cleaners • Air fresheners • Liquid automatic dishwashing detergents • Antistatic products •Anti-redeposition agent
Agricultural	• Seed germination gels • Plant rooting gels • Agrochemical flowables – herbicides, pesticides • Essential element suspensions

Products and Applications

BYK Additives

Product Range Additives:

- Additives to improve surface slip, leveling, and substrate wetting
- Adhesion promoters
- Defoamers and air release agents
- Processing additives
- Rheological additives
- UV absorbers
- Viscosity depressants
- Wax additives
- Wetting and dispersing additives for pigments and extenders

Application Areas:

Coatings Industry
- Architectural Coatings
- Automotive Coatings
- Industrial Coatings
- Can Coatings
- Coil Coatings
- Wood & Furniture Coatings
- Powder Coatings
- Leather Finishes
- Protective & Marine Coatings

Plastics Industry
- Ambient Curing Systems
- PVC Plastisols
- SMC/BMC
- Thermoplastics

Printing Ink Industry
- Flexo Inks
- Gravure Inks
- Inkjet Inks
- Silk Screen Inks
- Offset Inks
- Overprint Varnishes

Paper Coatings
- Impregnation
- Coatings

Adhesives & Sealants

Construction Chemicals

Pigment Concentrates

Raw Materials for Manufacturing Release Agents

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46462 Wesel
Germany
Tel +49 281 670-0
Fax +49 281 65735

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