TALC AND PYROPHYLITE GROUP – 2:1 Phyllosilicate

What is Talc and associated mineral

Talc, which is a soft, hydrous magnesium silicate (3Mg0 4Si0 H 0), is used in a wide range of industries including the manufacture of ceramics, paints, paper, and asphalt roofing. The end-uses for talc are determined by variables such as chemical and mineralogical composition, particle size and shape, specific gravity, hardness, and color. Talc is a magnesium silicate mineral with the simplified molecular formula Mg3Si4O10(OH)2. The talc products used by the coatings industry contain the mineral talc, but also accessory minerals in varying amounts. These include chlorite, serpentine, quartz, tremolite, anthophyllite and carbonates such as magnesite, dolomite, and calcite. There is no Source Classification Code (SCC) for the source category.

Talc is practically insoluble in water and in weak acids and alkalis. It is neither explosive nor flammable. Although it has very little chemical reactivity, talc does have a marked affinity for certain organic chemicals, i.e. it is organophilic. Above 900°C, talc progressively loses its hydroxyl groups and above 1050°C, it re-crystallizes into different forms of **enstatite** (anhydrous magnesium silicate). Talc's melting point is at 1500°C.

Morphology

The size of an individual talc platelet (= a few thousand elementary sheets) can vary from approximately 1 micron to over 100 microns depending on the deposit. It is this individual platelet size that determines a talc's platyness or lamellarity. A highly lamellar talc has large individual platelets whereas a microcrystalline talc's platelets are much smaller. The elementary sheets are stacked on top of one another, like flaky pastry, and, because the binding forces (known as Van der Waal's forces) linking one elementary sheet to its neighbors are very weak, the platelets slide apart at the slightest touch, giving talc its characteristic softness.

Related minerals

Talc ores also differ according to their mineralogical composition (i.e. the type and proportion of associated minerals present). They can be divided into two main types of deposits**: talc-chlorite** and **talc-carbonate**. Talc-chlorite ore bodies consist mainly of talc (sometimes 100%) and chlorite, which is hydrated magnesium and aluminium silicate. Chlorite is lamellar, soft and organophilic like talc. It is however more hydrophylic. Talc-carbonate ore bodies are mainly composed of talc carbonate and traces of chlorite. Carbonate is typically magnesite (magnesium carbonate) or dolomite (magnesium and calcium carbonate). Talc - carbonate ores are processed to removed associated minerals and to produce pure talc concentrate. Talc's properties (platyness, softness, hydro-phobicity, organophilicity, inertness and mineralogical composition) provide specific functions in many industries.

Pyrophyllite has a different chemical composition from talc, but the two minerals have some properties in common, such as softness and a light colour. Chemical formula of pyrophylite is $Al_2Si_4O_{10}(OH)_2$

Pyrophyllite.
The physical properties of pyrophyllite and talc are practically identical. The main difference is that pyrophyllite has an abundance of **aluminum** in its chemical make-up and talc has an abundance of magnesium.

Talc.
Talc is a mineral of low to medium grade metamorphic rocks rich in **magnesium**. It is often derived from ultrabasic igneous rocks made up of enstatite and olivine.

Pyrophyllite belongs to the **montmorillonite** (**smectite**) group of minerals. It is remarkably similar to talc, which belongs to the same mineral family, except that magnesium is substituted for **aluminium**. In fact, chemical; tests are often requires to tell the two apart.

Its name comes from the Greek words "**pyr**" and "**fullon**" meaning fire and leaf respectively. The derivation stems from the fact that pyrophyllite breaks or exfoliates into leaves when fired to temperatures in excess of 800°C as a result of dehydration of its structure.

Pyrophyllite is a hydrous aluminum silicate with a structure similar to talc. Such properties as chemical inertness, high dielectric strength, high melting point, and low electrical conductivity make it useful for ceramic and refractory applications.

Occurrence

Pyrophyllite is quite abundant but not particularly common. It is found most commonly found in slate, phyllite and some schists.

The main deposits are found in China and Carolina in the USA. Other notable occurrences are located in Belgium, Switzerland, Mexico; Brazil, Sweden, Russia, and Japan.

Structure

Pyrophyllite has a sheet-like structure consisting of two silicate layers being sandwiched between gibbsite ($Al(OH)_3$) layers.

Key Properties

- Pyrophyllite is quite soft with a Mohs hardness of 1 to 1.5 and can be scratched with a finger nail
- It can be machined to tight tolerances using conventional maching techniques and tools
- It is thermally stable up to about 800°C when it will begin to exfoliate

Applications

Historically pyrophyllite has been used for carving statues and ornaments owing to its relative ease of **machinability**. More recently, this property has seen it used as a machinable ceramic material used for electrical resistors, transducer cores, high vacuum gaskets and insulators in electron microscopes.

Other uses for pyrophyllite are in:

? Ceramic formulations e.g. tile and refractory compositions
? Plastics and rubber as a filler
? Paint
? Insecticides

Detail Applications:

- Refractory raw material with low thermal conductivity, coefficient of expansion, hot load deformation, excellent reheat stability, corrosion resistance and low heating shrinkage. Alumina Silica monolithic refractories, gunning ramming and castable mixes.
- Ceramic raw material partial substitute as a source for feldspar/silica in ceramics. Lowers firing temperature, reduces shrinking and cracking, improves thermal shock resistance. Finished product has a high degree of vitrification and good mechanical resistance.
- Filler in plastics and rubber. Wallboard, mastics, paint, adhesives and roofing resins.
- ***Minphyl D (Phyrophilite)*** has a neutral pH and is inert, non abrasive with good flowability allowing it to be used as a diluents, extender, vehicle and carrier for liquids. Fungicides, Insecticides, herbicides and fertilisers.
- Additive in lubricants.
- Foundry mould coatings.

Mining

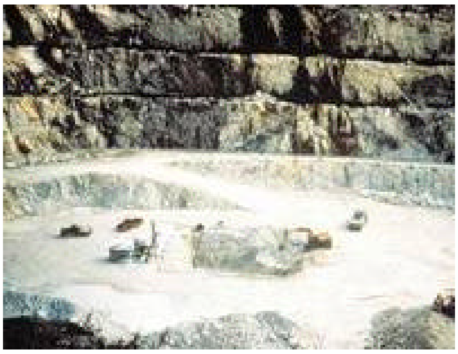
Over 95 percent of the talc ore produced in the United States comes from open-pit mines. Mining operations usually consist of conventional drilling and blasting methods.

Talc Processing

Talc ore generally is hauled to the plant by truck from a nearby mine. The ore is crushed, typically in a jaw crusher, and screened. The coarse (oversize) material then is returned to the crusher. Rotary dryers may be used to dry the material. Secondary grinding is achieved with pebble mills or roller mills, producing a product that is 44 to 149 micrometers (um) (325 to 100 mesh) in size. Some roller mills are designed to use heated air to dry the material as it is being ground. Hammer mills or steam- or compressed air powered jet mills may be used to produce additional final products. Air classifiers (separators), generally in closed circuit with the mills, separate the material into coarse, coarse-plus-fine, and fine fractions. The coarse and coarse-plus-fine fractions then are stored as products. The fines may be concentrated using a shaking table (tabling process) to separate product containing small quantities of nickel, iron, cobalt, or other minerals and then may undergo a one-step flotation process. The resultant talc slurry is dewatered and filtered prior to passing through a flash dryer. The flash-dried product is then stored for shipment, unless it needs further grinding to meet customer specifications. The classified material also may be pelletized prior to packaging for specific applications. In the pelletizing step, processed talc is mixed with water to form a paste and then is extruded as pellets.

Talc deposits mined in the southwestern United States contain organic impurities and must be calcined prior to additional processing to yield a product with uniform chemical and physical properties. Generally, a separate product will be used to produce the calcined talc. Prior to calcining, the mined ore passes through a crusher and is ground to a specified screen size. After calcining in a rotary kiln, the material passes through a rotary cooler. The cooled calcine (0 percent free water) is then either stored for shipment or further processed. Calcined talc may be mixed with dried talc from other product lines and passed through a roller mill prior to bulk shipping.

Pyrophyllite puffin sculpture.
This sculpture was carved from pyrophyllite by Nath Noel, The Stone Garden Gallery, St. John's, NF. It is the property of Frank Blackwood.



A view of Canada's only producing pyrophyllite mine (Newfoundland Minerals) at Manuels.
Note the production benches in the quarry face, development of a new production bench on the quarry floor, and the drill and other mining equipment in operation

TALC (PYROPHYLLITE & MAGNESIUM SILICACEOUS)

Supply	Uses & Application
Industrial	Rubber, paints, coatings, thermosetting & thermoplastic polymers, mould release agents, flow aids
Cosmetic (BP 1998)	Body powders, cosmetic base ingredient, pharmaceuticals, high specification industrial applications
Sterilised cosmetic grade	Tablet manufacture, critical demand paint & general filler/extender applications

The Mineral Talc

Chemistry: Mg3Si4O10(OH)2, Magnesium Silicate Hydroxide

- **Class: Silicates**
- **Subclass: phyllosilicates**
- **Group: Clays and also The Montmorillonite/Smectite Group.**
- **Uses: an ornamental and heat, acid and electrically-resistant stone (soapstone) used as counter tops, electrical switchboards, carvings, etc, used as an ingredient in paints, rubber, roofing materials, ceramics and insecticides. Most commonly known as the primary ingredient in talcum powder.**
- **Specimens**

Talc is an important industrial mineral. Its resistance to heat, electricity and acids make it an ideal surface for lab counter tops and electrical switchboards. It is also an important filler material for paints, rubber and insecticides. Even with all these uses, most people only know talc as the primary ingredient in talcum powder. Mineral specimens are not very common as it does not form very large crystals. However, it often replaces other minerals on an atom by atom basis and forms what are called pseudomorphs (false shape). The talc takes the form of the mineral it replaces. A specimen of what looks like milky quartz is quite a suprise when it not only has a soapy feel but can be scratched by a fingernail.

PHYSICAL CHARACTERISTICS:

- **Color** is green, gray and white to almost silver.
- **Luster** is dull to pearly or greasy.
- **Transparency** crystals are translucent and masses are opaque.
- **Crystal System** is monoclinic; 2/m.
- **Crystal Habits**: never in large individual crystals, but if found are flattened tabular crystals with a hexagonal cross-section, usually talc is found in compact or lamellar masses. Forms pseudomorphs (false shape) of other crystals such as **quartz**, **pyroxenes**, **olivine** and **amphiboles**.
- **Cleavage** is perfect in one direction, basal.
- **Fracture** is uneven to lamellar.
- **Hardness** is 1 (can leave mark on paper)
- **Specific Gravity** is 2.7 - 2.8 (average)
- **Streak** is white.
- **Other Characteristics:** cleavage flakes are slightly flexible but not elastic and talc has a soapy feel to the touch.
- **Associated Minerals** include **serpentine**, **dolomite**, **magnesite**, **quartz**, **pyroxenes**, **olivine**, **biotite** and **amphiboles**.
- **Notable Occurances:** include many mines up and down the Appalachian Mountains and in California and Texas, USA; Germany; Florence, Italy; Tyrol, Austria; Transvaal, South Africa and Shetland, Scotland.
- **Best Field Indicators** softness, color, soapy feel, luster and cleavage.

The mineral Pyrophyllite

Pyrophyllite is a 2:1 dioctahedral phyllosilicate. Its unit formula is $Al_2Si_4O_{10}(OH)_2$. It has no layer charge due to the lack of atom proxying or isomorphous substitution, and onlyminimal edge charge. It has the simplest structure of any of the dioctahedral2:1 phyllosilicates.

Pyrophyllite crystals are constructed by oriented stackingof individual pyrophyllite sheets to form thicker crystals. It has a monoclinicand triclinic crystal system.

- **Chemistry: AlSi2O5OH , Aluminum Silicate Hydroxide.**
- **Class: Silicates**
- **Subclass: Phyllosilicates**
- **Group: The Clays**
- **Uses: As a refractory mineral, as a filler for rubber, paints and insecticides, as an ornamental stone, as a component of ceramics and as mineral specimens.**
- **Specimens**

Pyrophyllite is an early stage metamorphic mineral and is actually quite common although usually not very abundant as good mineral specimens. It is found as a constituent of slate, phyllite (which is not named after pyrophyllite), some schists and other early stage metamorphic rocks. It is most common in the phyllites were its pearly luster helps give the phyllites their well known shiny luster. Other minerals that contribute to the luster of phyllite include the **micas, sericite, chlorite, graphite, quartz** and **epidote.**

Pyrophyllite gets its name from the Greek words for fire and leaf as in *"fire-leaf"*. Phyllite is named after the Greek word for leaf as well, in allusion to its flaky fracture. But pyrophyllite gets its name from the fact that it exfoliates when water is driven off upon heating, leaving a flaky mass. The flakes are actually the silicate sheets that are a testament to pyrophyllite's structure.

Pyrophyllite is a member of the **phyllosilicates**, or *"**leaf**"* silicates, which have a sheet-like structure. The phyllosilicates form stacks of silicate layers that are composed of **SiO4** tetrahedrons. The sheets are not directly linked above or below to the next silicate sheets.

In pyrophyllite, two silicate layers are sandwiched in between the so called ***gibbsite*** layer. Gibbsite, **AL(OH)3**, is its own mineral and is composed of octahedrally coordinated aluminums surrounded by six hydroxides. The gibbsite layer (**G**) in pyrophyllite is identical to gibbsite's structure except that four of the hydroxides are replaced by four oxygens from the silicate layers (**S**). The overall structure of pyrophyllite can be imagined as stacked **S-G-S** sandwiches. The bonding between these sandwiches is nearly nonexistent and gives rise to pyrophyllite's softness and perfect cleavage.

There are actually two pyrophyllite minerals. One is monoclinic and the other triclinic. Ordinarily they would be treated as two distinct minerals, but their properties are identical and they are often associated and intergrown. Separating them serves no purpose and the two minerals are often considered as one; at least for now.

Pyrophyllite is also identical in physical properties to a quite distinct mineral called **talc.** The two are isomorphous, meaning they share the same *monoclinic* structure but have different chemistries. Talc has magnesiums instead of aluminums and is basically indistinguishable from pyrophyllite without a chemical test for aluminum. The test for aluminum involves applying a slight amount of cobalt nitrate solution on the specimen and then igniting the solution. The specimen should change color; a blue color confirms pyrophyllite, a violet color confirms talc.

A variety of pyrophyllite is called "*agalmatolite* and is used by Chinese artisans as an ornamental stone. Although pyrophyllite loses water and exfoliates, at higher temperatures it is quite stable up to 800 degrees C. This makes pyrophyllite valuable as a refractory mineral and for other applications. Pyrophyllite shares many of the same purposes as talc although it is usually considered inferior to the better grades of talc in all but one use. Pyrophyllite seems to be best as a carrier for insecticides and is often the filler for these products.

Although an ordinary metamorphic mineral in most regards, pyrophyllite is still quite interesting and does form some very attractive mineral specimens. The radiating stellate aggregates that come from Mariposa County, California and North Carolina for example are quite appealing with their bright pearly luster and radiating habit.

PHYSICAL CHARACTERISTICS:

- **Color** is usually white, colorless, gray, yellow, pale green and/or blue. It can also be stained brown by iron oxides.
- **Luster** is greasy to dull, but pearly on cleavage surfaces.
- **Transparency:** Crystals are mostly translucent to opaque.
- **Crystal System** is monoclinic; 2/m and triclinic; bar 1.
- **Crystal Habits** include the typical fine grained, fibrous and lamellar masses, stellate aggregates and radiating spherules. Individual crystals are rare, but usually have a tabular subhedral or distorted form.
- **Cleavage** is perfect in one direction.
- **Fracture** is uneven or splintery.
- **Hardness** is 1 - 1.5 (soft enough to be scratched by a fingernail).
- **Specific Gravity** is approximately 2.65 - 2.85 (average).
- **Streak** is white.
- **Other Characteristics:** Cleavage sheets are flexible, but inelastic. A distinctive greasy feel to the touch.
- **Associated Minerals:** are numerous, but a short list would include the **micas, sericite, chlorite, graphite, quartz, albite, barite, gypsum, andalusite, kyanite, sillimanite, lazulite** and **epidote.**
- **Notable Occurrences** include Randolph, Guilford and Orange Counties, North Carolina, Chesterfield County, South Carolina; Mariposa County and San Bernardino County, California, Arizona and Graves Mountain, Georgia, USA as well as Belgium; China; Switzerland; Mexico; Minas Gerais, Brazil; Sweden; Ural Mountains, Russia; Korea and Japan.
- **Best Field Indicators** are crystal habit, color, cleavage, softness, aluminum test and feel.

Talc Shape and Form

Talc products are described as platy talc, containing predominately (>90%) the mineral talc; or **tremolitic talc**, most often a natural blend of **talc, tremolite, serpentine** and **anthophyllite**. Platy talcs can be further classified as microcrystalline or macrocrystalline. Microcrystalline varieties are naturally small in plate size and comprise compact, dense ores. Macrocrystalline varieties contain relatively large, higher aspect ratio plates. The term fibrous talc has in the past been used in reference to **tremolitic talc**, but this is a distinct misrepresentation.

Table 1 / Talc Mineralogy by Geography

Region	Characteristic Residual Minerals
Montana, platy, microcrystalline	Chlorite
Texas, platy, microcrystalline	Chlorite, calcite
Vermont, platy, macrocrystalline	Magnesite, dolomite, calcite
Canadian, platy, macrocrystalline	Magnesite, dolomite
Chinese, platy, macrocrystalline	Calcite
New York, tremolitic	Natural blend: tremolite, talc, anthophyllite, serpentine
Canadian, tremolitic	Natural blend: talc, tremolite, dolomite, serpentine

Talc products are also categorized by geographic origin, which reflects characteristic mineralogy (see Table 1). The so-called western platy talcs, from Montana and Texas, are microcrystalline, with chlorite as a characteristic accessory mineral. Eastern platy talcs, from Vermont and Canada, are macrocrystalline, with carbonates as characteristic accessory minerals, as is the Chinese talc that is readily available in North America.

Because talc is a very soft, platy mineral, the residual minerals in platy talc products can have a subtle effect on properties. Carbonates, for example, being nodular and relatively hard, might require more grinding than the softer, platy chlorite in order for a talc product to attain a particular Hegman fineness. Tremolitic talcs exploit the properties contributed by the significant amount of accessory minerals that occur together with the talc.

Table 2 / 4 Hegman Coatings-Grade Talc

Talc, Source	Median ESD, micrometers	Oil Absorption (Spatula Rub-out)
Microcrystalline, Montana	4.8	35
Microcrystalline, Montana, de-fined	10.0	25
Microcrystalline, Montana	4.2	30
Macrocrystalline, Vermont	7.0	35
Macrocrystalline, Canada	4.0	44
Macrocrystalline, China	3.8	41
Tremolitic, New York	6.3	29
Tremolitic, New York, de-fined	10.5	21
Tremolitic, Canada	8.7	32

The platy talcs used by the coatings industry are, in most cases, high in purity in order to use advantageously the platy shape of the talc particles. Some deposits, such as several in Montana, are selectively mined to obtain talc of sufficient quality to preclude most beneficiation steps. Others, such as those in Vermont, require froth flotation to minimize the quantity of residual accessory minerals.

The degree of delamination, particle size and aspect ratio, plus the type and amount of residual accessory minerals, all affect the properties of what otherwise would be considered similar talc grades. For example, Table 2 compares the median equivalent spherical diameter (ESD) and oil absorption of 4 Hegman talc products from various locations. Included are two products that are processed to remove the finest particles, so that oil absorption is significantly reduced for use in high-solids coatings.

Structure

The fundamental structural units common to talc and the related silicate minerals in tremolitic talc are the silica tetrahedron and the magnesia octahedron, as described in the first article of this series. All of these minerals contain a magnesium based octahedral layer bound on one or both sides by a layer of silica rings linked through shared oxygen atoms.

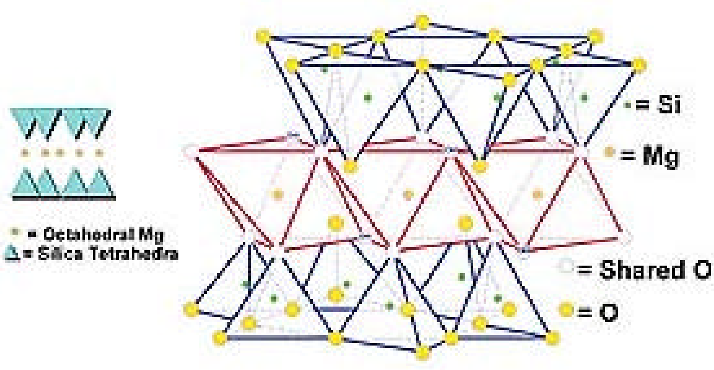


Figure 1 / Talc Structure

Talc

If a continuous sheet of silica rings is attached to both sides of a magnesia layer, the planar talc structure results, as shown in *Figure 1.*

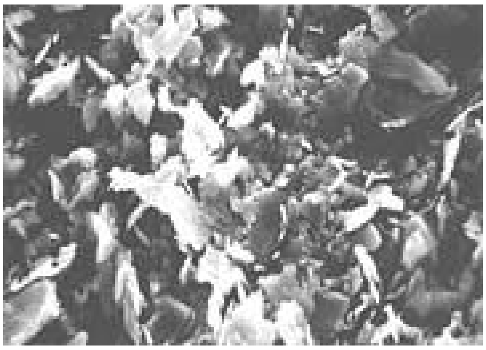


Figure 2 / Platy Macrocrystalline Talc (1700X)

Because both sides of this structure expose an oxide surface, individual talc plates are held together only by weak van der Waals forces. Sliding and delamination are therefore relatively easy, giving talc its characteristic soft, slippery feel. Compared to other silicates, talc is relatively hydrophobic due to the oxide surfaces and the magnesia edges, the latter also accounting for the mineral's alkaline pH. The oxide surfaces do hydrate to a limited extent on exposure to ambient moisture to form silanol groups, which improves the compatibility of talc with aqueous media. Figure 2 is a photomicrograph of a 6 Hegman platy talc.

Tremolite/Anthophyllite

The structure of tremolite is analogous to that of wollastonite, with which it shares hardness, morphological features and certain chemical properties. Wollastonite is comprised of single chains of silica tetrahedra connected by calcium in octahedral coordination. Because of this chain structure wollastonite grows as acicular crystals, in some cases of macroscopic dimensions. The tremolite structure is based on a linked double chain of silica. The double chains form the same type of hexagonal rings as in a continuous silica sheet, but they extend in one direction instead of two. These silica "ribbons" are joined to an octahedral magnesia layer on one side and by calcium on the other.

The schematic view of this structure is shown in *Figure 3* from an end-on perspective. Tremolite can be viewed as offset strips of talc strongly linked back-to-back by calcium ions. The structure is dense, rigid, and of high structural integrity, but with a tendency to fracture lengthwise into blade-like acicular particles. Tremolite is more hydrophilic than talc, due in part to the solvatable calcium. Anthophyllite is similar in structure to tremolite, with magnesium and a minor amount of iron in place of calcium.

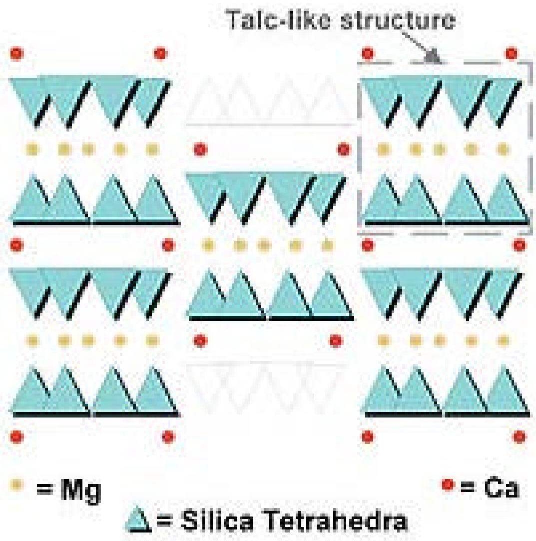


Figure 3 / Tremolite Structure

Serpentine

The serpentine minerals **antigorite** and **lizardite** are clay-like constituents of **tremolitic talc**. They are structurally similar to kaolin clay, which is a platy mineral consisting of a continuous silica sheet joined to a continuous octahedral alumina sheet. Alternatively, they can be considered as a talc-like structure with the silica layer stripped from one side.

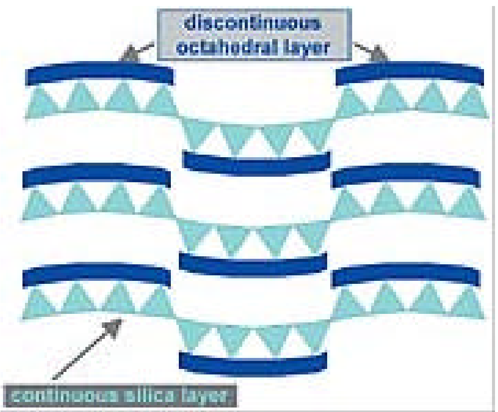


Figure 4 / Corrugated Antigorite Platelets

Antigorite has octahedral magnesia joined to a silica layer, but not without structural stress. The octahedral and tetrahedral layers do not line up very well for the purpose of oxygen sharing. This mismatch is compensated for by a stretching of the apical silica oxygens so that they can form the common oxygen link. This stretching results in structure bending. **Antigorite** is laminar because its tetrahedral silica layer remains continuous by periodically rotating 180 deg . This, however, prevents the continuity of the octahedral layer. The face of an antigorite platelet is therefore corrugated, as illustrated in *Figure 4.*

Lizardite is a closer morphological analogue of kaolin. This mineral remains planar because the strain of the octahedral-tetrahedral mismatch is relieved by the minor substitution of Al^{3+} for Si^{4+} in the tetrahedral layer.

The serpentines are very fine grained and resistant to delamination due to hydrogen bonding between the magnesia hydroxyl face of one plate and the tetrahedral layer oxygen face of the adjacent plate. The exposed hydroxyls of the magnesia octahedral layers make the serpentines more hydrophilic than talc.


Figure 5 / Tremolitic Talc (500X)

Figure 5 is a photomicrograph of a 4 Hegman tremolitic talc demonstrating the multimorphous nature of this natural mineral blend. The blade-like particles are the tremolite cleavage fragments. Because the platy constituents tend to be fine-grained and dense, well delaminated particles are confined primarily to the <5mm size fraction.

Properties and Uses

Talc has been used as a paint filler for more than 60 years, starting with linseed oil house paint, which at one time was its single largest use. Early outdoor testing showed the value of talc in preventing cracking, and exterior house paint remains the major coatings application for talc. Today, the US coatings industry consumes about 180,000 tons/year of talc, which is probably used in a wider variety of coatings than any other single mineral pigment. Talc products serve as functional fillers in solvent- and waterborne architectural, industrial, marine and automotive primers and topcoats, traffic paints, powder coatings, joint cements, crack fillers and caulks.

Table 3 / Summary Comparison of Coatings Grade

	Platy Talcs	Tremolitic Talcs
Dry brightness (GE)	80-90	80-90
pH 10%	8.4-9.5	9.0-9.5
Top size, µm	90-10	90-10
Particle shape	Platy	Acicular, nodular, platy mixture
Oil absorption	25 - 55	20 - 40
Specific gravity	2.75	2.85
Refractive index	1.6	1.6
Relative advantages	Barrier properties	Blister resistance
	Low abrasion	Scrub resistance
	Sandability	Corrosion resistance
	Flatting	Intercoat adhesion
	Rheology control	Color in oil
	TiO_2 extension	Dry hide
		High solids

Platy Talc

The value of platy talc in coatings is derived primarily from its particle shape and surface properties. Although talc is hydrophobic, it disperses easily in aqueous as well as solventborne coatings. Because of its shape, platy talc can have a beneficial effect on paint rheology. It generally contributes to improved brushability, leveling and sag resistance. It is normally self-suspending in paint vehicles and assists in keeping other pigments suspended. When settling does occur, it is generally soft and is readily redispersed.

Platy talcs improve the toughness and general durability of paint films. The talc plates tend to align with the coating's flow so that they are parallel to the substrate in the dry film. This creates a physical barrier to the transmission of moisture, thereby improving water and humidity resistance. This impermeability can aid, however, in the formation of blisters as any moisture or gases leave the substrate. Platy talc reinforces the dry coating film because of its alignment therein and its naturally high aspect ratio. This reinforcement makes the film more resistant to cracking or rupture in response to stretching and flexing, thus better insulating the substrate from the environment. The combination of barrier properties, alkaline pH and reinforcement accounts for talc's contribution to corrosion inhibition.

Its barrier properties also make platy talc well-suited for primers and sanding sealers used on porous substrates to control penetration. In exterior paints, platy talcs tend to chalk more readily than most extender pigments, although less than calcium carbonate.

In liquid coatings, 325 mesh or 4 Hegman talcs are most commonly used. The micronized talcs, 6 Hegman or finer, are used for TiO_2 extension, good low angle sheen and good burnishing resistance. Macrocrystalline varieties are preferred for their excellent flatting.

Tremolitic Talc

Although not soft or platy, tremolitic talc serves as an alternative to platy talc in many coatings applications. The heterogeneous mineral blend accounts for its functional differences compared to platy talcs. The combination of acicular, nodular and platy particles, ranging in size down to the clay-like serpentines, allows for softer settling, easier redispersion and higher loading levels. These factors likewise allow for better light scattering and thus better color in oil and better dry hide. Flatting efficiency is generally inferior to that of platy talcs. The hardness of the non-talc constituents provides greater scrub resistance and durability.5 In primers, the variety of particle shapes provides more micro-roughness than do flat plates and thus better intercoat adhesion.

Tremolitic talc often provides better film reinforcement, but somewhat greater permeability than platy talc. Barrier properties are generally not as good, however this reduces the tendency to blister. For corrosion control, greater permeability is compensated for by greater alkalinity in addition to film durability. In epoxy marine primers, tremolitic talc is preferred for greater corrosion resistance with less blistering. Tremolitic talcs with 4 Hegman fineness are the most widely used grades in architectural, industrial and marine coatings.

Conclusion

Talc products, both platy and tremolitic, are perhaps the most broadly functional of the functional fillers used in the coatings industry. Although platy and tremolitic talcs share certain performance features, the versatility they offer to the coatings formulator stems from their differences. Table 3 summarizes the basic properties and the relative advantages of the platy and tremolitic talcs used by the coatings industry.

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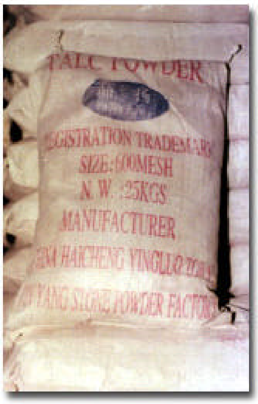
APPENDIX .

INDUSTRIAL PRODUCTION – EXAMPLE

Main products are Talc Lump, Talc Grain, Calcspar, heavy calcium powder, Caustic calcined magnesite and Dead burnt magnesite, talc powder etc.

The size of talc powder is between 325mesh-3000mesh, main usages is Paint, Electric cable, Ceramics, Cosmetic, Pharmaceutical-food, Papermaking, Waterproof material, rubber, plastic, sculpture etc. We also can supply super micron talc powder and various talc grain, talc lump according to the customer's request.



PLASTIC GRADE TALC POWDER

Technical specification		Special grade	Products First grade	Products Up to standard
Whiteness % =		95	90	88
SiO_2 % =		61	58	55
MgO % =		31	30	30
CaO % =		0.45	1.00	1.50
Fe_2O_3 % =		0.30	0.40	0.50
Al_2O_3 % =		0.20	0.30	0.30
L.O.I. % =		6.00	8.00	10.00
Volume density (g/cm^3)	Loose density	0.45	0.55	0.65
	Tight density	0.90	0.95	1.00
Moisture % =		0.5	0.5	1.00
Passing through (45µm) % =		98-99.8	99.5	98.5

PAINT GRADE TALC POWDER

Technical specification	Paint 60-10	Paint 60-20	Paint 60-38	Paint 58-15	Paint 57-63	Paint 35-45	PTS 6-30	PTS 8-10	PTS 8-63	PTS 8-38
SiO_2 % =	60	60	60	58	57	35	35	35	35	35
MgO% =	31	31	31	30	30	31	28	28	28	28
CaO % =	0.45	0.45	0.45	0.80	0.80	2.00	2.00	2.00	2.00	2.00
Fe_2O_3 % =	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
Al_2O_3 % =	0.20	0.20	0.20	0.50	0.50	0.50	6-8	8-10	8-10	8-10
L.O.I. % =	7.00	7.00	7.00	8.00	9.00	25.00	14.00	14.00	14.00	40.00
Oil-absorbed g/100g	50-55	30-38	28-35	40-50	20-25	20-25	20-25	40-50	=50	=25
D98	10µm	22µm	38µm	15µm	63µm	45µm	30µm	10µm	63µm	38µm

SPECIFICATION SHEET

Talc

SNOWTALC

Snowtalc is a soft, lamellar inert mineral which occurs typically as magnesium silicate. The ***Snowtalc*** grades exhibit exceptional purity, whiteness, chemical stability and are ideally suited for Pharmaceutical application. These properties render the ***Snowtalc*** grades an ideal carrier and functional extender in cosmetics and pharmaceuticals.

Typical applications include high performance paints and coatings - as a titanium and calcined clay substitute and extender, thermoplastic polymers, waxes, and slip agents.

TYPICAL CHEMICAL ANALYSIS

SiO_2	:	62,2%
Mgo	:	32,4%
Al_2O_3	:	0%
Fe_2O_3	:	0,22%
Na2O	:	0%
MnO	:	0%
TiO_2	:	0%
CaO	:	0.38%
Cr_2O_3	:	0%
V_2O_5	:	0%
P_2O_5	:	0%
Cl	:	0%
S	:	0%
Loss on Ignition	:	4.89%
As	:	Less than 2ppm
Zr	:	Less than 5ppm

TYPICAL PHYSICAL ANALYSIS

	SNOWTALC	SNOWTALC ULTRA
Retention on 53 Micron :	0%	0%
Retention on 25 micron :	<10%	<1%
Specific Gravity :	2.7	2.7
Bulk Density :	270 loose - 270 loose - 330 tapped g/l	330 tapped g/l
Reflectance :	95 typical	95 typical
Refractive Index :	1.58	1.58
Particle Shape :	Platelet (Lammellar);	Two Dimensional
Hardness (Mohs Scale) :	1.0	1.0
Appearance :	White powder	White Powder
Oil Absorption :	37%	39% typical
Toxicity :		Certified BP 1998. Specially suited for cosmetics, medicinals and pharmaceutical dusting powders.
Melting Point :		Heat stable up to ca. 900^{o}C
Packaging :		Packed in 25Kg polypropylene bags.

An example of research

Research in talc filled polypropylene Properties

Motivation

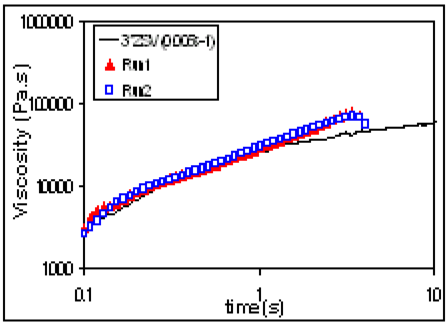
Rheological data for filled polymer melts provides valuable information on how the melts behave during processing. This can allow better material selection and informed choice when selecting processing conditions. Poor filler dispersion within the polymer is detrimental to the final mechanical properties of the blend. Knowledge of how well a filler disperses under set processing conditions will help ensure sub-specification product is avoided during compounding.

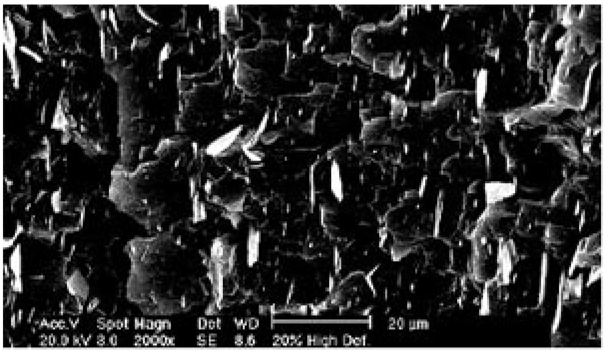
Objectives

- Produce accurate and reproducible data on the steady shear rheology of talc filled polypropylene.
- Investigate the melt strength and drawability of talc filled polypropylene within a range of processing conditions.
- Establish a suitable technique for checking talc filler dispersion in polypropylene.
- Develop an understanding of the characteristics of the filler and polymer which determine the dispersability of the filler within the polymer.

Quantifying Filler Dispersion in the Polymer Samples

Dispersion is evaluated from electron microscopy of the polymer surfaces and the degree of dispersion of the filler is characterised with the dispersion index.





Pyrophyllite

Pyrophyllite is a silicate of aluminum. The sample above left has the labeled composition $AlSi_2O_5(OH)$.

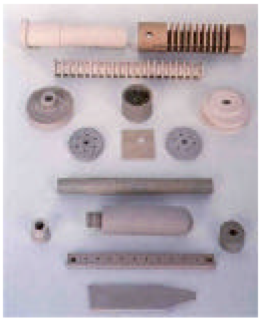


Fig 1 **Fig 2** **Fig 3** **Fig 4**

Fig 1
Large Insulator top right 300mm high, 175mm dia. 13mm wall thickness. - application special purpose muffle 1100°C.
Bottom right - former for embedding electrical resistance spiral - 90mm dia. 75mm high.
Top left - Camera demist heater former - high altitude photography.
Centre left - flanged tube R.F. Zone hardening jig.

Fig 2
Top right - Transmitter HF. Power choke former 125mm X 30mm dia.
Third row down top left hand side - Toothed insulated clutch component 15 KV.
Bottom Centre - Semi-conductor brazing fixture and R.F. Silver soldering 'Holding finger'.

Fig 3.
Max. size top row 40mm dia. - bottom row 8mm dia. Applications range from Laser support "V" blocks to transducer cores, high mechanical stability over wide temperature range. Plug gauges, etc.

Fig 4.
Centre piece - 125mm dia 12mm thick Gasket for high vacuum applications demanding insulation between sections. Electron microscope insulators. Threaded male and female insulating bolts.

Lack of money is no obstacle.
Lack of an idea is an obstacle.
--Ken Hakuta

Material Properties
Pyrophyllite

Property	Unfired	Ceramit 10 Fired (800-1000°C)	Ceramit 14 Fired (1300°C)
Density			2.4-2.55 g/cm^3
Colour	Grey	Pink to dark brown	Pink to dark brown
Mohs Hardness	2.5	5	7
Porosity	1.8-2.0%	2.66±0.02%	0.01%-nil
Softening Temp	-	1600°C	1600°C
Max Service Temp	-	1000°C	1100°C
Thermal Exp. Co-eff. (20-600°C)	-	2.9-3.5x10^{-6} m/m/°C	6-8 x10^{-6} m/m/°C
Compressive Strength KN/cm²	-	10.3	15.16
Cross Bend Strength KN/cm²	1.13-1.58	3.37	18.27
Tensile Strength KN/cm²	1.03	2.34	3.44
Volume resistivity			
20°C	-	Same as Ceramit 14 when dry	10^{14}MΩ/cm^3
300°C	-		10^{9}MΩ/cm^3
500°C	-		10^{6}MΩ/cm^3
700°C	-		10^{5}MΩ/cm^3
900°C	-		10^{4}MΩ/cm^3
Dielectric Strength (using a 5mm test piece)	-	-	24Kv
Power factor	-	-	.01-.13 @1mHz tanδ x 10^4
Permittivity	-	-	5.2
TE Value	-	-	700°C
Loss Factor	-	-	.05 @ 1000KHz
Thermal Conductivity		1.5 W/m.K	1.9 W/m.K

Polypropylene – PP 40% Talc Filled

Polymer Type

Thermoplastic

Advantages

Improved stiffness, dimensional stability and reduced creep compared with 20% Talc filled PP.

Disadvantages

Slightly reduced tensile strength and elongation at break along with increased specific gravity compared with 20% Talc filled PP.

Typical Properties

Density (g/cm^3)	1.25
Surface Hardness	RR85
Tensile Strength (MPa)	30
Flexural Modulus (GPa)	3.2
Notched Izod (kJ/m)	0.03
Linear Expansion (/°C x 10^{-5})	5
Elongation at Break (%)	8
Strain at Yield (%)	4
Max. Operating Temp. (°C)	100
Water Absorption (%)	0.02
Oxygen Index (%)	18
Flammability UL94	HB
Volume Resistivity (log ohm.cm)	16
Dielectric Strength (MV/m)	20
Dissipation Factor 1kHz	0.006
Dielectric Constant 1kHz	2.6
HDT @ 0.45 MPa (°C)	130
HDT @ 1.80 MPa (°C)	80
Material. Drying hrs @ (°C)	NA
Melting Temp. Range (°C)	240 - 290
Mould Shrinkage (%)	0.7
Mould Temp. Range (°C)	30 - 50

Applications

Automotive "under bonnet" applications. Electrical housings.