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Talc in Plastics

Technical Bulletin 1301

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INTRODUCTION

Pure talc, the softest of all minerals with a Mohs hardness of 1, is an organophilic, water repellent and chemically inert mineral. It is characterised as a hydrated magnesium sheet silicate with the formula $Mg_3 Si_4O_{10} (OH)_2$. Talc consists of a layer or sheet of brucite ($Mg(OH)_2$) sandwiched between two sheets of silica (SiO_2) (see Figure 1).

Weak Van der Waal's forces bond the crystal lattice of talc. Thus, talc undergoes cleavage very readily, is very soft and has a soapy feel.

The term "talc" covers a wide range of natural products. Impurities commonly encountered include magnesite (magnesium carbonate), calcite, quartz and chlorite (a mix of Mg- Al- and Fe-silicate/$Mg(OH)_2$). Among the different modifications of talc, mostly pure and lamellar talc grades are used in the plastic industry.

Talc is usually lamellar (platy), but the aspect ratio can vary considerably. Its high aspect ratio is the most important property for its use in plastics.

Talc is a functional component in paper, paints, plastics, rubbers, ceramics, fertilizers, animal feed, cosmetics, pharmaceuticals and other applications.

In plastics, it is used to stiffen thermoplastics, mainly polypropylene but also polyethylene and polyamide (nylon). Main applications are automotive parts, household appliances and engineering plastics.

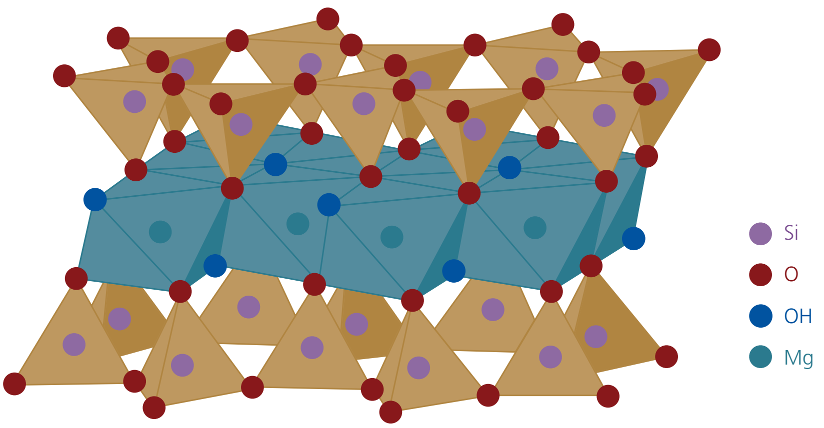


Figure 1: Talc crystal structure

BENEFITS OF TALC IN POLYPROPYLENE COMPOUNDS

1. STIFFNESS (E-MODULUS)

The main reason for incorporating talc in plastics is to increase the stiffness (E-modulus). The degree of rigidity depends on the filling level, aspect ratio and fineness of the talc (Figure 2).

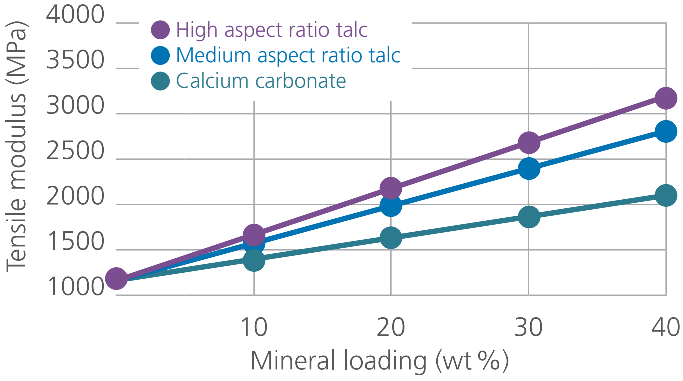


Figure 2: Stiffness of a PP compound with high aspect ratio talc, a mineral with medium aspect ratio, and calcium carbonate

2. THERMAL CONDUCTIVITY

Because of talc's significantly higher thermal conductivity (compared to the polymer), the heat introduced and generated during processing is transmitted through the mixture more quickly (Figure 3). The heat is also transported out of the compound faster during cooling.

Incorporating talc in a compound increases the thermal conductivity, resulting in faster production rates. Experience with filled polymers is that conductivity depends only on the filler content, within reasonable tolerances.

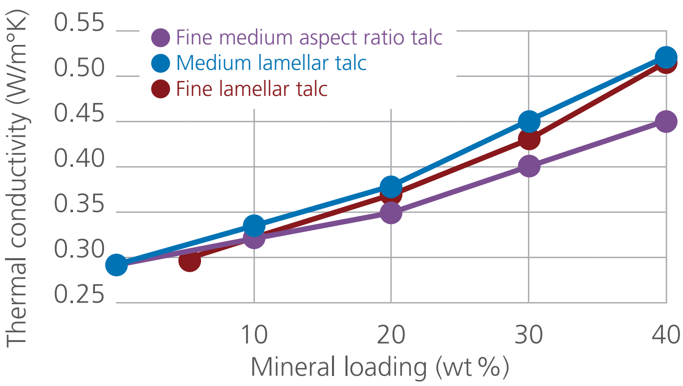
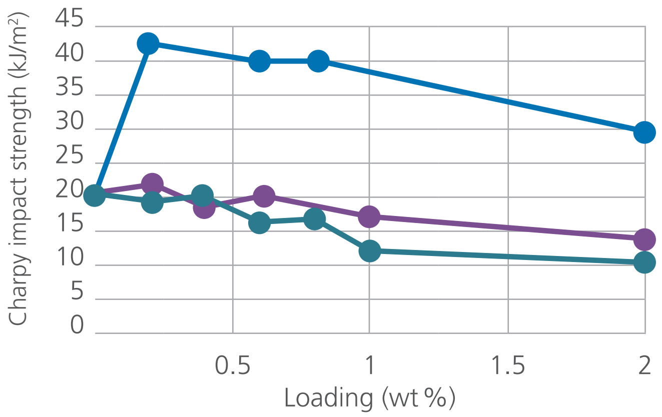


Figure 3: Thermal conductivity of PP compounded with talc

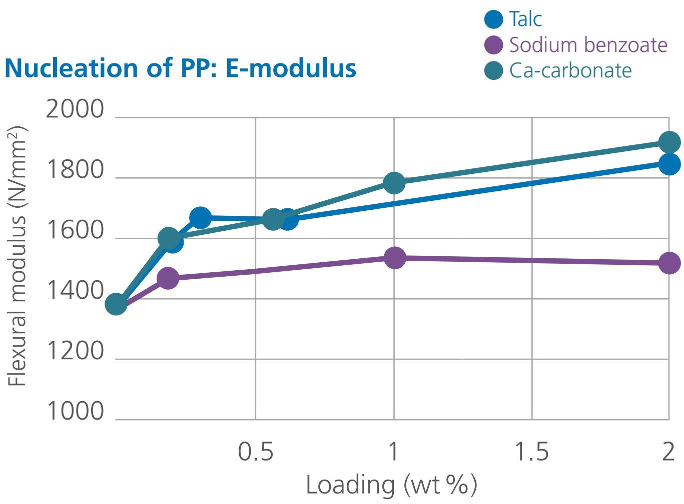
3. NUCLEATION

The crystallisation of polypropylene is promoted by small amounts of preferably fine talc, which acts as a nucleating agent. Crystallisation starts at a higher temperature in the presence of talc, compared to unfilled PP. The impact strength is improved (Figure 4) but this is primarily due to an increase in the crystallisation of the PP and not the mechanical properties of the talc itself. There is also a change in modulus (Figure 5) as a result of the change in crystallinity.

Nucleation of PP: Impact Strength



Nucleation of PP: E-modulus



Figures 4 and 5: Impact and rigidity of nucleated PP

4. IMPACT STRENGTH

Addition of mineral fillers will not generally improve impact strength. There are exceptions, for example the use of fine talc in PP compounds for car bumpers. In the latter case, 5 to 10 % of fine talc is added. Impact strength decreases at higher loadings (Figure 6).

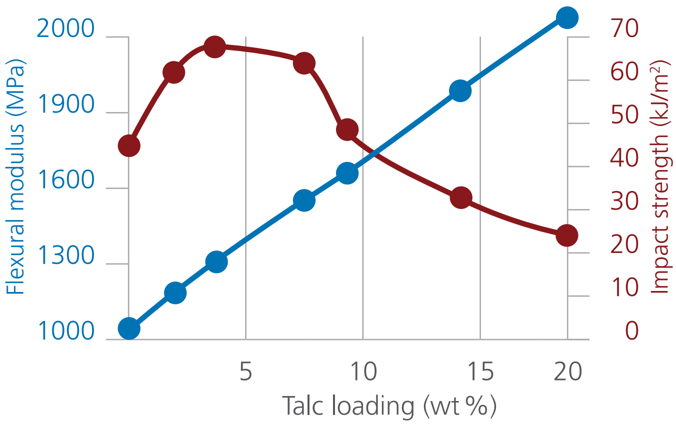


Figure 6: Influence of fine talc on high impact PP

5. DEFLECTION TEMPERATURE

In many applications such as in plastic parts for cars or packaging, rigidity is required at elevated temperatures. The heat distortion temperature (HDT) can be used to demonstrate how a mineral influences the stiffness of a plastic compound at elevated temperatures. Lamellar talc with high aspect ratio improves the deflection temperature of polyolefins to a greater extent than talc with a lower aspect ratio (Figure 7).

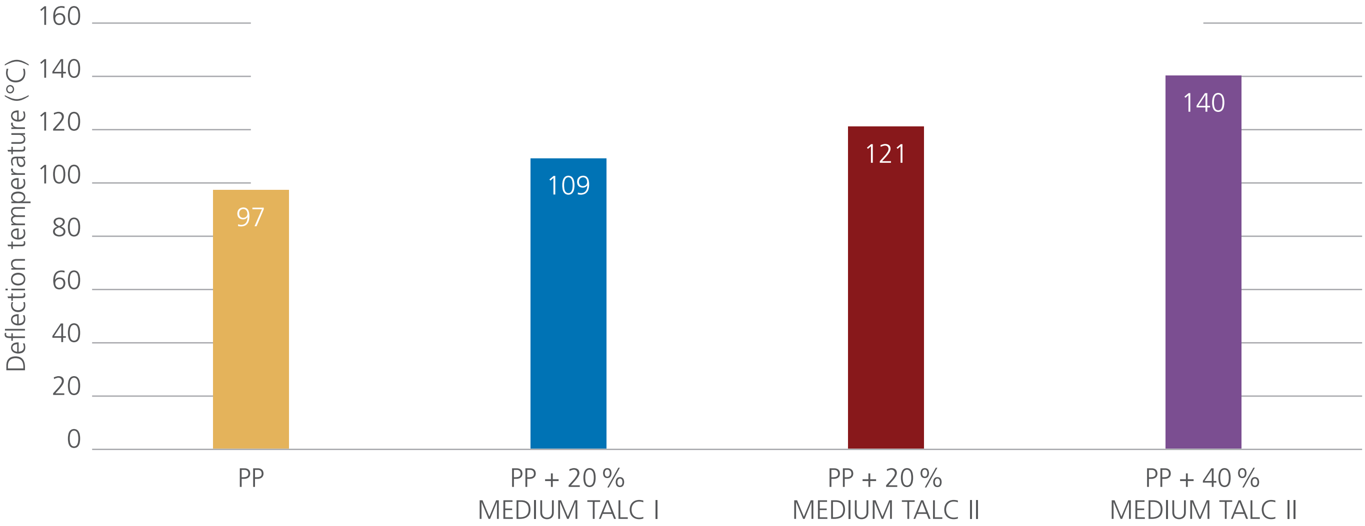


Figure 7: Deflection temperature of compounds with medium aspect ratio talc (I), high aspect ratio talc (II) and unfilled PP

6. CREEP RESISTANCE

Substantial reduction of creep is achieved with filled polymers in comparison to unfilled ones. Best results in our creep tests were obtained with fine platy talc. Various fillers and filler combinations reduced creep as follows:

High aspect ratio talc >
medium aspect ratio talc >
blend of talc and carbonate >
calcium carbonate >
unfilled polypropylene (Figure 8).

Information obtained from short-term tests of PP can be extrapolated to predict properties over a longer period of time at a constant temperature. The conventional short-term modulus is replaced in formulas by the creep modulus. The creep modulus, which is important for expected service life under load, can be calculated from creep tests. The figure below applies to a five-year period (Figure 9). Typical products where creep has to be taken into consideration are buried plastic pipes (e. g. for sewage water).

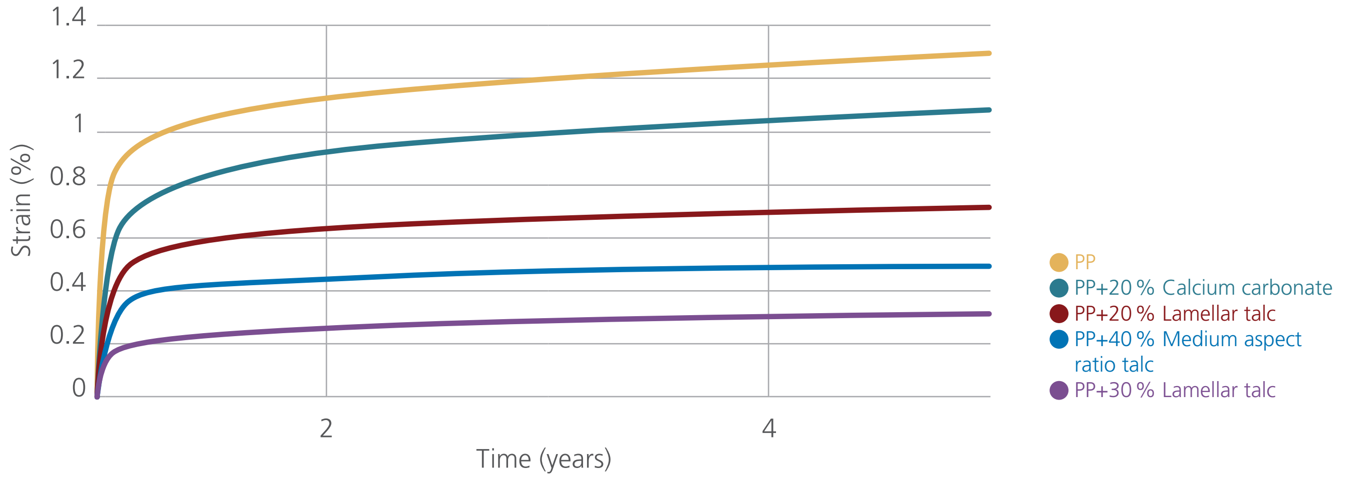


Figure 8: Creep of PP and filled polypropylene

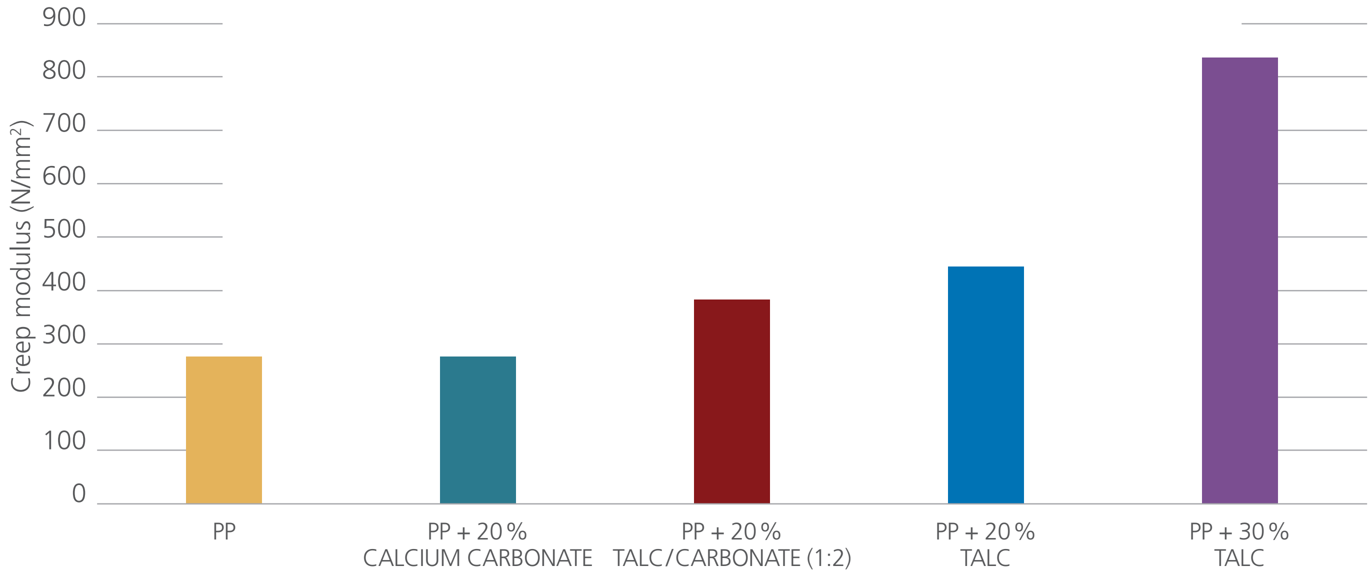


Figure 9: Creep modulus (for five years)

7. BARRIER PROPERTIES

Water vapor and oxygen transmission are important factors to control in food packaging. They directly influence the shelf life of the food contained inside. Talc provides the opportunity to reduce transmission rates for water vapor (Figure 10) and oxygen (Figure 11). The lamellar talc particles are mostly orientated in films and will constrain the water vapor and oxygen on its way through the packaging.

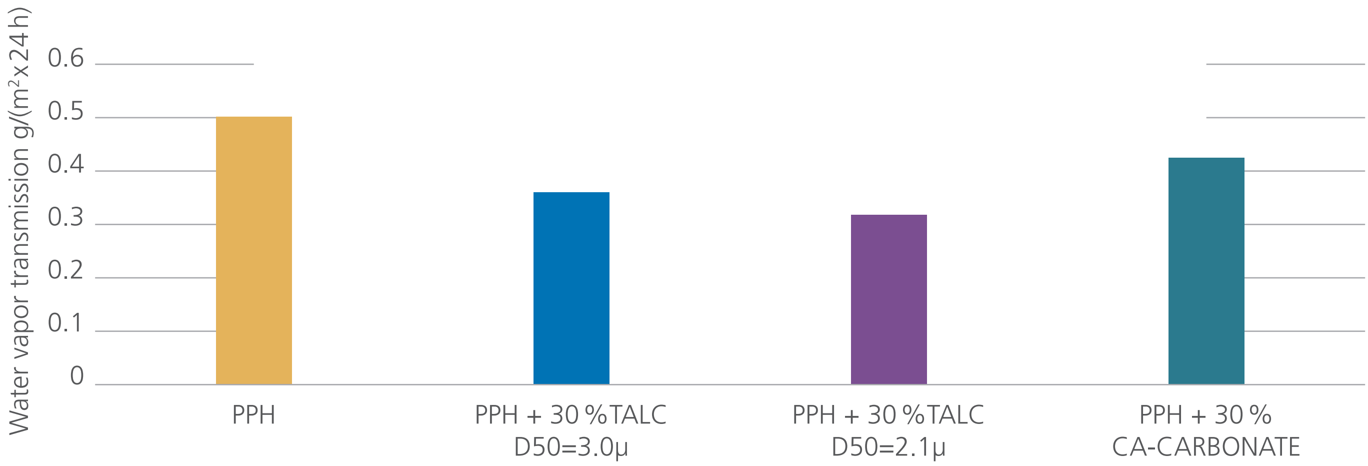


Figure 10: Reduced water vapor transmission in polyolefin food packaging by talc

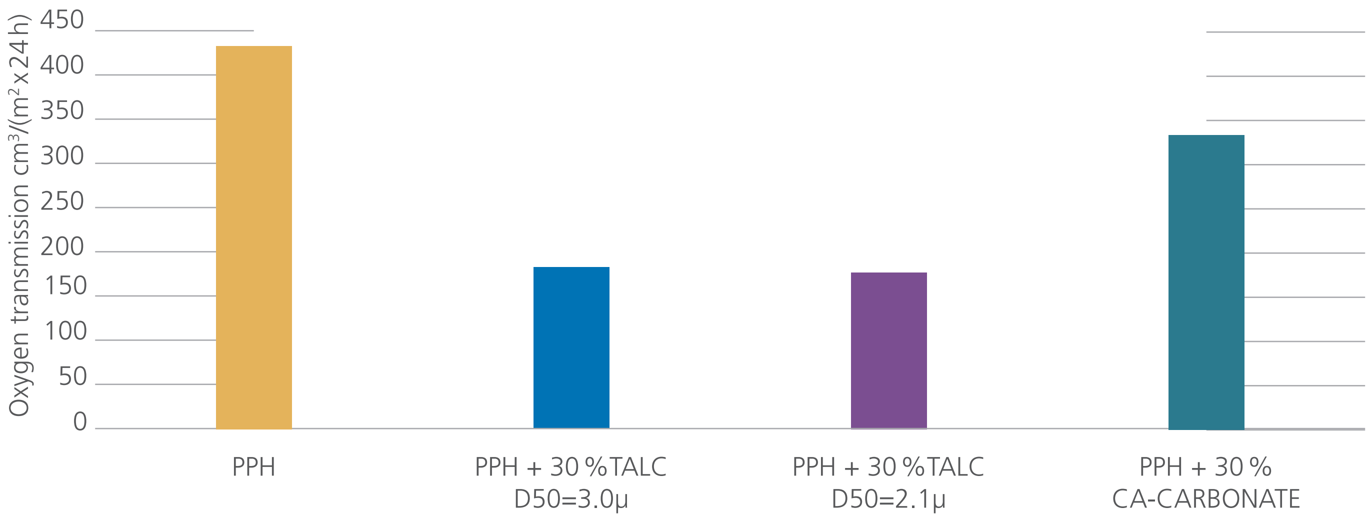


Figure 11: Reduced oxygen transmission in polyolefin food packaging by talc

8. CHEMICAL RESISTANCE

Talc is water repellent and chemically inert. This is very important for the direct contact of mineral filled packaging material with food-stuffs. Migration tests are done with different simulants (distilled water, 3 % acetic acid, 10 % ethanol and rectified olive oil).

Even with 3 % acetic acid, overall migration requirements can be fulfilled (< 10mg/dm² sample). (Figure 12)

EN 1186-5:
Test methods for overall migration from plastics into aqueous food simulants by cell.
Simulant 3 % acetic acid
Test conditions 10 days, 40°C
The overall migration limit is 10 mg/dm²

SAMPLE	OVERALL MIGRATION mg/dm² SAMPLE
PP homopolymer + 30 % Ca-carbonate (EXH1 SP)	79 – 128
PP homopolymer + 30 % Talc d50 = 3.0 µm	0.4 – 1.0

Figure 12: Overall migration of PP/Talc, simulant 3 % acetic acid

NEW MARKETS FOR TALC-FILLED POLYMERS

The automotive and domestic appliances markets are still the dominating users of talc-filled compounds, but new markets are being developed. Their growth depends partly on the extent to which end-users actively seek alternative materials to PVC and PS. Markets of interest here include profiles, pipes and food packaging.

In replacement of PVC for plastic pipes, there is a need to compensate for the lower ring stiffness of polyolefins, but also to reduce undesirable long-term properties of unfilled polypropylene and polyethylene, such as their tendency to creep (deform under long-term strain). Talc is the preferred additive in this application, as it imparts high stiffness, which allows a reduction in wall thickness. Impact resistance at sub-zero temperatures is unimpaired.

Talc-filled polypropylene is also finding new markets in food packaging applications. Migration requirements according to EN 1186-5 can be met, and higher rigidity and barrier properties (e. g. reduction of oxygen permeability) are imparted. Talc improves output in extrusion and shortens cycle times in thermoforming, due to crystallisation and better heat transfer.

These benefits make talc compounds very competitive for food packaging, so there is considerable potential in this application.

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