Silica gel technology for tailor-made matting agents

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Matting agents based on silica gels can be produced with very well defined characteristics, including a very high porosity, making them very effective in coatings formulations even at low dosages.

Silica gel technology

Silica gel is a porous amorphous form of hydrous silicon dioxide. It is constituted by randomly linked spheroidal polymeric silicate particles, the primary particles. The properties of silica gels are the result of the size and the state of aggregation of these primary particles and the chemistry of their surfaces [1].

Modern silica gel technology enables the production of highly pure gels that are composed of nearly 100% SiO₂ with tailor-made pore systems and surface properties.

Made from sulphuric acid and sodium silicate

Silica gels can be produced from different raw materials. However, the synthesis from mineral acids, e.g. sulfuric acid, and aqueous sodium silicate is the only industrially relevant process today [2].

Sulfuric acid and sodium silicate are mixed under controlled conditions to build the primary particles of the desired size which polymerise and form the raw gel from which all types of silica gels are made. This glass-like gel is broken down into granules, then washed, aged and dried to produce the highly porous material needed for matting agents.

Via control of the washing, ageing and drying conditions, the important physical parameters such as porosity, pore size and surface area can be adjusted to produce a range of different silica gel types [3].

Ageing and drying conditions determine the quality

The conditions during ageing, e.g. pH, temperature, ageing time and solvent type are key to the pore structure evolution [4]. The most important process that occurs during ageing is the well known Ostwald ripening. Small primary particles are dissolved while larger particles grow, small pores are filled and the formation of the necks between the particles is enhanced [5].

Besides ageing, the drying process, leading to the formation of xerogels, has a high impact on the structure of the final gel. The drying rate and the type of solvent that fills the pores are the main parameters which have an impact on the porosity of the final product. During drying, the arising capillary pressure affects a change in the pore structure of the gel, resulting in a shrinking of the silica network. This process is associated with a decrease in porosity. Because water invariably is the solvent present in the above-described process, the drying time, which can be varied from several seconds up to several hours, is the key variable. Fast drying results in less marked shrinkage compared to slow drying [6].

Silica gels are available in a wide range of particle sizes, each type having a well-defined particle size distribution. Both of these properties highly depend on the type of mill applied during the grinding step and can also be influenced by implementing a classifier into the production process. This allows for the manufacturing of fine-sized products with a cut-off coarse tail of the distribution.

The scheme of the Grace silica gel manufacturing process is shown in Figure 1.

Matting agents

Silica gels are widely used as matting agents in paints and coatings. Important commercial properties of silica gels with respect to incorporation into coatings are:

- good incorporation and dispersion properties
- outstanding rigidity
- high purity
- controlled particle size
- exceptional chemical inertness

Higher mechanical stability than precipitated silica

The mechanical stability of a silica gel particle is higher compared to precipitated silica and thus better resists the shear forces arising during the manufacture and application of the paint.

Synthetic silica gel products are amorphous, non-hazardous substances - in view of both their chemistry and their physical properties - and they are thus not a matter of concern regarding any of the upcoming environmental legislations.

Their matting effect is based on the development of surface micro-roughness, caused by the matting agent particles upon solvent evaporation. The process is depicted in Figure 2.

Low addition levels due to high porosity

The efficiency of the matting agent again depends on the type of silica, its particle size distribution and the porosity of the particle. High porosity, which can be realised for example by strong ageing and fast drying during the production of the silica gel, is a key feature of a modern matting agents, because it enables the formulator to limit the addition level of a matting agent in a formulation.

Unfavorable viscosity effects as well as limitations in surface properties of the coating caused by the matting agent can thus can be avoided. In that, a new milestone in micronised silica gel technology has been reached by achieving a pore volume of more than 2 ml/g.

Today, matting agents for industrial applications are available in a variety of particle sizes [7]. Suppliers also offer organically treated silica gels as matting agents. These products are recommended for use in clear varnishes because they have somewhat better anti-settling, dispersion and mar resistance properties compared to untreated grades.

REFERENCES

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Figure 1: Silica gel manufacturing process
Figure 2: Function of a matting agent

- Film surface micro-roughness created by:
  - film shrinkage / volume reduction
  - size and number of matting agent particles
  - orientation of the particles
  - state of dispersion
  - Interactions with other components: e.g. surfactants, catalysts