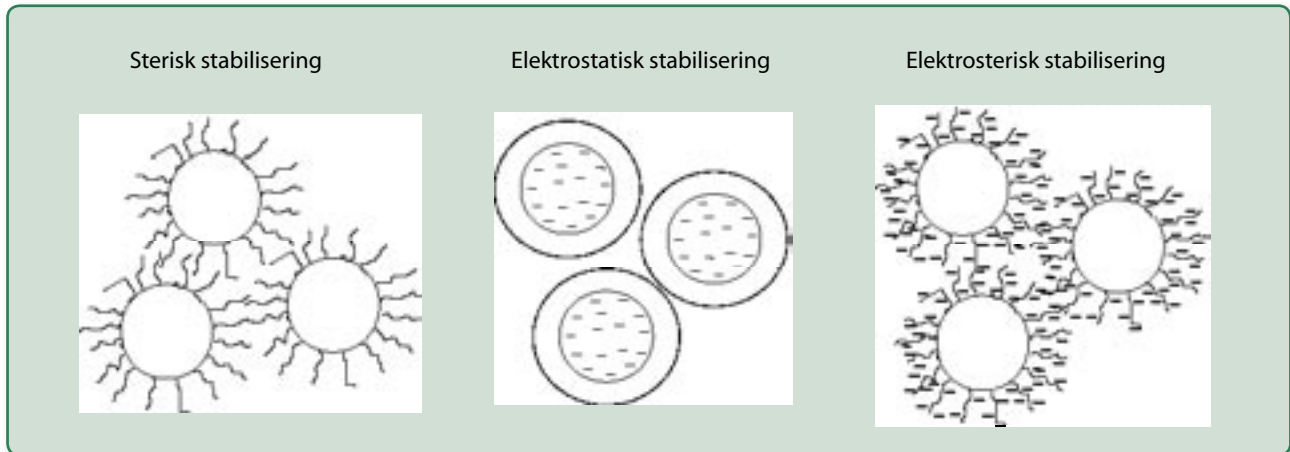


Surface Chemistry and Rheology – Powerful Tools in Process Optimisation



Repulsion between the particles in a powder suspension can be obtained by an adsorption of polymers (steric stabilisation), high surface charge (electrostatic stabilisation) or by a combination of both (electrosteric stabilisation).

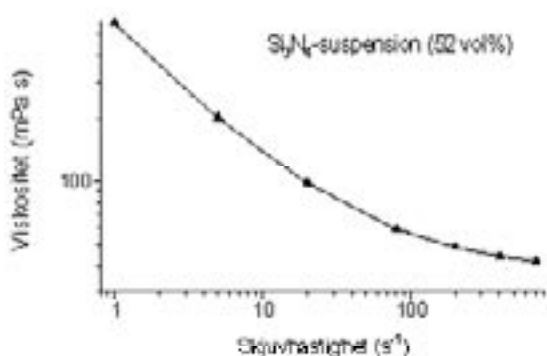
Powder-based forming of ceramics often involves handling of very fine powders ($<1 \mu\text{m}$) and therefore surface forces have a considerable impact on, for example, the properties of powder suspensions. Insights into surface-chemical phenomena are consequently very important in all powder processing. Prior to the forming of ceramic components, for example by slip casting and tape casting, or to a granulation operation, it is desirable to prepare the powder suspensions with high solid loading and proper stability. The stability – the mechanism that keeps the primary particles apart – depends on the degree of repulsive forces between the particles. Therefore, the specific material's surface charge properties in water and/or their affinity to surface active compounds, so called dispersing agents, must be considered. This is especially important in composite systems, i.e. when different materials with different surface-chemical properties are mixed in the same suspension. In non-polar solvents pure *steric stabilisation* can be obtained by the surface adsorption of polymers, which by extended chains give steric hindrance for the agglomeration of particles. Pure *electrostatic stabilisation* can be obtained in water by adjusting the pH to a level at which the particles have a high surface charge, i.e. the surface contains a large amount of ionised groups. Polymers with a large amount of ionisable groups, so called polyelectrolytes, are often used as dispersant in water-based systems. Adsorbed on the particle surfaces polyelectrolytes give an *electrosteric stabilisation*, i.e.

a combination of steric and electrostatic stabilisation.

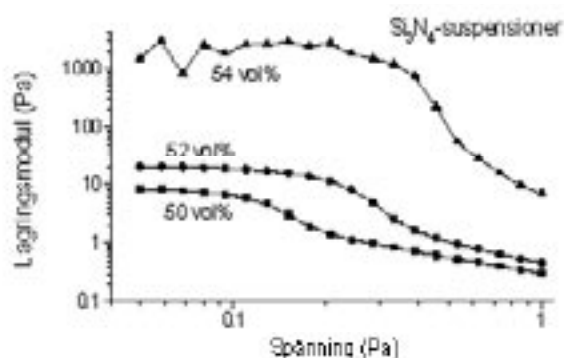
Sometimes maximum stabilisation of a powder suspension is not desirable. A certain degree of flocculation is instead more convenient, for example to give a faster casting in slip casting or to avoid settling/segregation phenomena. Knowledge about surface chemistry is also important when various processing aids, such as binders or sintering aids, are to be added. These additions often give colloidal effects, i.e. they affect the suspension stability, which must be controlled. Rheological measurements are very useful for the study and evaluation of powder suspensions.

Rheology is the science about deformation and flow of matter, and rheological measurements give information on a material's chemical and physical properties. The rheology of a material, in terms of viscosity, viscoelasticity, yield point etc., is often essential for its specific use.

Viscosity describes a material's internal resistance to flow when a stress is applied. For many materials the viscosity is both time dependent and shear-rate dependent, which means that the viscosity varies with time at a constant stress/shear rate and/or with variations in shear rate. Typical for highly concentrated suspensions of inorganic particles (ceramic powders) are the shear thinning properties. The viscosity decreases with increased shear rate because of the break down of structures (created by interparticle forces) and orientation effects in the flow direction.



Powder suspensions often display shear thinning behaviour, e.g. the viscosity decreases with increased shear rate.



Increased particle concentration in a powder suspension results in a higher degree of particle interaction and a more pronounced structure build-up, which is displayed by increased viscoelasticity (storage modulus).

When the particle concentration in a powder suspension increases, the particles come closer to each other and interactions cause a structure build-up as the suspension is in rest. The degree of structure can be studied by oscillating measurements at very small deformations where the viscoelastic properties – the relation between viscous and elastic properties – are characterised. The elastic properties are characterised by the storage modulus.

SCI has a long experience in dispersing and stabilising a large amount of various powder materials, both in water and in organic solvents, with the intention of optimising the properties of the powder suspensions to specific applications. We can therefore

offer you qualified assistance in matters concerning preparation of powder suspensions, give advice when it comes to selecting additives for specific purposes as well as conduct optimisation of suspension properties.

SCI has a rotation-rheometer (StressTech, Rheologica Instruments AB) with which rheological characterisations, such as viscosity, viscoelasticity and yield point, can be conducted. Besides conventional viscometry, oscillatory shear and creep measurements can be done. A wide range of materials can be studied, from low-viscosity liquids to plastic pastes in a temperature range of -15 to +120 °C.

References

SCI has, among other things, published the following papers within the area:

Influence of Magnesia on Colloidal Processing of Alumina, Tari G, Ferreira J M F & Lyckfeldt O, J. Eur. Ceram. Soc., 17, 1341–50, 1997

Processing of Porous Ceramics by 'Starch Consolidation', Lyckfeldt O & Ferreira J M F, J. Eur. Ceramic Soc., 18, 131–40, 1998

Contact us for more information

Do not hesitate to contact us if you want to have more information or have specific questions that you want to discuss. Based on your requests and needs we can provide a quotation.

More information is provided by:

Contact	Phone	E-mail
Ola Lyckfeldt	+46 (0)31-706 62 77	ola.lyckfeldt@ivf.se

The Swedish Ceramic Institute (SCI) is a division of IVF and works with product oriented research and development of ceramics and related materials.

IVF Industrial Research and Development Corp., Argongatan 30, SE-431 53 Mölndal, Sweden
Phone: +46 (0)31-706 60 00, fax: +46 (0)31-27 61 30, www.sci.se resp. www.ivf.se