Examples of technical resources

- **TOF-SIMS (time-of-flight secondary ion mass spectroscopy)**: Identification and semi-quantification of the presence of chemical compounds in particles. Agglomerations of particles and individual particles down to 1µm.
- **ICP-MS (inductively coupled plasma mass spectrometry)**: Quantitative analysis of metals and heavy metals.
- **IC (ion chromatography)**: Quantitative analysis, e.g. of chloride and sulphate ions.
- **ESCA (electron spectroscopy for chemical analysis)**: Surface-sensitive analysis of atomic composition. Measurement depth 2-10 nm, depending on the material.
- **Gas adsorption for multipoint analysis of specific surface and porosity**: Measurement of pore size distribution and multipoint BET specific surface.
- **ELPI (electrical low-pressure impactor)**: Real-time measurement of particles in gas, e.g. smoke or outdoor air.
- **DLPI (Dekati low-pressure impactor)**: Characterisation of the mass size distribution of particles.
- **BM dust detector**: Measurement of the degree of dust coverage on a surface.
- **AFM (atomic force microscope)**: For measuring shape, size and force.
- **Air jet sieving**: Determination of granular size.
- **ESEM-EDX (scanning electron microscope with energy-dispersing X-ray analysis)**: Two-dimensional analysis of particles shape and size down to 10 nm. Semi-quantitative element analysis of individual particles down to approx 1 µm.
- **Optical instruments for measuring smoke density and visibility.**
- **GC-MS (gas chromatograph)**: Analysis of organic content.
- **Exposure chamber** for inhalation of wood-smoke particles.
- **Powder production (lab-scale facilities)**: Spray-drying (conventional as well as for meso-porous particles), freeze-drying, freeze-granulation.

TOF-SIMS (Time-of-flight secondary ion mass spectrometry)

Training

SP conducts extensive training activities in most fields. We can also offer tailored courses in many of the areas described in this folder. For further details, please get in touch with one of the contact people listed below.

SP offers a broad train programme in most fields and can provide customized courses in many areas.

Powder Network

In order to broaden the competence of participating companies, SIK (the Swedish Institute for Food and Biotechnology), together with industry, has been running a network in the field of powder technology since 1999. This Powder Network serves as a forum for those who work with powder, whether as raw materials, ingredients or products (visit www.sik.se).

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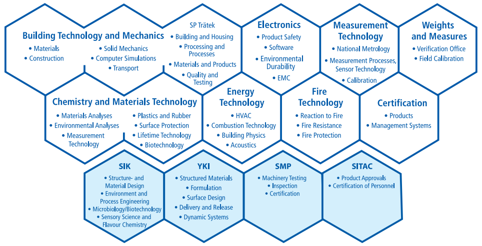
SP Technical Research Institute of Sweden develops and transfers technology for improving competitiveness and quality in industry, and for safety, conservation of resources and good environment in society as a whole. With Swedens widest and most sophisticated range of equipment and expertise for technical investigation, measurement, testing and certfication, we perform research and development in close liaison with universities, institutes of technology and international partners.

SP is a EU-notified body and accredited test laboratory. Our headquarters are in Borås, in the west part of Sweden.



SP is organised into eight technology units and four subsidiaries

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Particles and Aerosols

SP Technical Research Institute of Sweden

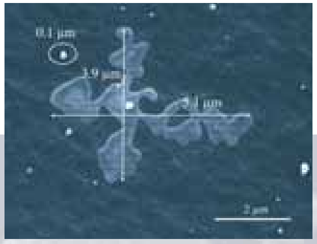
PARTICLES AND AEROSOLS

SP combines broad competence with advanced technical equipment to measure particle concentrations and properties. In many cases, the particles are suspended in gas, e.g. outdoor air or smoke. Particles and gas together constitute an aerosol. SP also offers broad knowledge about aerosols and is thus able to provide services in these fields for most lines of business.

Particles in combustion gases

Particles that arise during combustion can lead to high particle concentrations in the air. At heat and power plants, particles can cause deposits, leading to corrosion and worsened operating economy.

We conduct various types of particle measurements. SP is accredited for dust sampling in stack gases from combustion plants. More advanced measurements may include particle mass distribution, particle size distribution or measurements of particle-bound PAH (polycyclic aromatic hydrocarbons). Particle size distribution is measured in the nanometer to micrometer range, and can even be measured in real time. In a number of projects, we analyse collected particles in terms of content and sometimes also geometry.



Many particles are formed during combustion. This picture shows two kinds of particles from the combustion of chips of tree tops and branches.

Real-time measurements of particles in small-scale wood-burning are used to gain understanding of transient combustion processes.

Particles in smoke

How are particles spread in connection with fires? Are highly toxic substances formed? What materials give rise to hazardous substances? These are examples of questions we can answer.

We study particle formation from burning materials and investigate how particles and substances integrate in gas phase. Using lasers, we also measure smoke density and visibility in smoke from different fires. Our areas of research include the health effects of smoke, where particle characterisation plays a key role. We also work with modelling to simulate the dispersion of smoke in the surroundings. After a fire, it may be necessary to measure the chloride content on machinery surfaces etc, e.g. to prevent future corrosion or to check the efficacy of a clean-up. This is done by means of the Bresle method.

Particles in the surrounding air

Traffic and wood fires give rise to particle formation that can adversely impact the environment and health. Outdoor air is governed by quality norms. It is also important to gain knowledge about what types of particles are formed.

SP is conducting several projects relating to particles in the outdoor air and indoor environments. We analyse chemical compositions (organic substances) of particles sampled onto quartz filters via direct heating in a gas chromatograph with mass-spectrometric identification of substances (GC-MS). In one of our research projects we are developing knowledge of how particles in the nanometer range are formed through chemical reactions of gaseous pollutants in indoor air. One example of a special resource for indoor-environment studies is an exposure chamber where test subjects inhale wood-smoke particles.

Enormous quantities of sub-micron particles are generated during a petroleum fire and spread over vast areas.

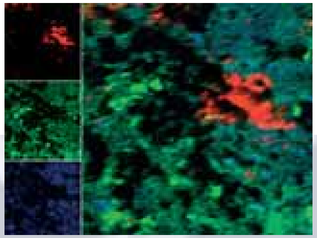
Proper housekeeping can maintain the concentration of particles in indoor environments at a healthy level.

Chemical contents of particles

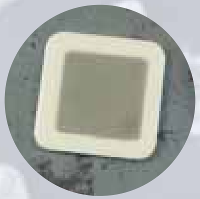
Can combustion particles cause corrosion? Does this dust contain toxins? These are examples of questions we answer. By investigating the chemical contents of particles, we can also pinpoint the sources of emissions, a prerequisite for reducing the particle content in an environment.

Information about the chemical composition of small particles can be obtained by various means. The content of different metals and heavy metals, for example, can be quantified, as can the content of chlorine, sulphates and phosphorous. Detailed information about the chemical content is available via TOF-SIMS (time-of-flight secondary ion mass spectroscopy). A mass spectroscopic image is taken of a sample, enabling determination of the presence of chemical compounds, relative quantities and spatial distribution over the surface. Individual particles down to 1 µm or particle agglomerations can be analysed. The findings can be presented in the form of images showing the spatial distribution of specific compounds over the surface (see picture below; the light intensity indicates the amount) and in the form of diagrams showing the relative amounts of the analysed compounds in the sample.

YKI (the Swedish Institute for Surface Chemistry) uses ESCA (electron spectroscopy for chemical analysis) for surface-sensitive elementary chemical analysis of particles and other solid materials.



TOF-SIMS image showing the distribution of NaCl (red), KCl (green) and $CaCl_2$ (blue) on the surface of a deposit sample from a heat and power boiler. The area of the picture is 100 x 100 µm².



A fluid-filled patch on the surface of a plate is used to measure the chloride content and thus determine the corrosion risk (the so-called Bresle method).

Geometry and specific surface of particles

The pharmaceutical industry needs knowledge about the shape and surface of particles, as these factors can influence how pharmaceuticals are taken up by the human body. Particle shape and surface are also often of interest in studies of indoor environments.

SP uses a number of different methods to obtain valuable information about the geometry and shape of particles. Two-dimensional characterisation of particle size and shape can be done with a scanning electron microscope. By data processing two-dimensional images can be converted to three-dimensional ones. This method is for example used for materials in the manufacture of concrete.

An AFM (atomic force microscope) is a microscope with a scanning probe. The probe is sweeping over a surface and registers atomic forces of a few atoms. An AFM can be used to measure the size and structure of individual particles as well as particle clusters. It also enables three-dimensional analysis of objects in sizes from nanometres to micrometres. Moreover, one can measure forces (both adhesion and friction) between particles and surfaces, and between particles, both in air and in fluids. Additionally an AFM can be used to determine the weight and density of individual particles. For larger particles, sizes can as well be determined by use of an optical measurement microscope.

SP also has instruments for measuring specific surfaces, pore size, area, volume and pore-size distribution in particles, e.g. in powders. Pore diameter measurements are possible down to the nanometre level. Such analyses are made in connection with the production of cement and concrete, admixtures and pharmaceuticals.

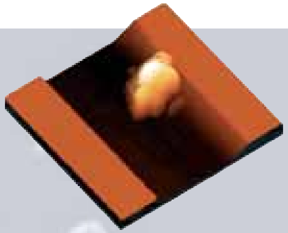


Image of a particle in a calibration standard for AFM. The particle size is about 0.2 µm.

Gas adsorption for multi-point analysis of specific surface and porosity.

Ballast material

Knowledge about ballast material is essential for the economy of construction projects. SP performs numerous types of ballast analysis.

SP uses a hundred or so different methods to study ballast, i.e. the sand, gravel, stones and filler used in construction. For example, grain-size distribution is analysed with an an air jet sieving with a series of square sieves with mesh sizes from 2 mm down to 10 µm. This method can also be used for other materials than ballast, e.g. ash and chalking compounds for treating acidic lakes and waterways.

Dusty working environments

Dust can pose a major problem in the working environment, e.g. at smelting plants, sawmills and storage of biofuels. We conduct many different kinds of measurem ents in dusty working environments.

For comparison with current working environment limit values, measurements are made of “total dust”, “respirable dust” or in some cases “inhalable dust”. This is usually done within the breathing zone of personnel. Specific substances such as quartz dust and asbestos fibres can also be studied in the field, both in the air and as deposits on surfaces. Special types of dust can be determined with chemical methods, e.g. PCB in dust from clean-up work.

We also have an impactor for fractioned sampling, which means that dust is collected in five different size fractions on a filter and the mass of each fraction is determined by weighing. As an alternative and complement, we also use a small portable laser-based particle counter for direct reading of the quantity distribution of different size fractions, from particle sizes of 0.3 µm and upwards. We can even measure fluid aerosols, e.g. oil mist, and the amount of dust coverage, e.g. to measure the quality of clean-up work.

Analysis of grain size distribution in gravel using an an air jet sieving.

Measurement of dust in the breathing zone of a baker.

Filter performance testing

Product tests and measurements let filter manufacturers and others know whether their products meet the relevant standards.

We conduct various types of particle measurements in filters. SP is accredited for testing of air filters for ventilation systems in accordance with EN779:2002. In order to determine the properties of filters in real environments, we perform long-term testing of air filters. We also have equipment for measuring clean rooms down to ISO class 1 (ISO 14644). Optical particle counters are used to measure particle collecting efficiency over filters. Other examples of products we test and evaluate include HEPA filters, motor filters, air cleaners and vacuum cleaners.

Formulation and drying of particulates

How does powder dissolve in a fluid? How does one tailor-make a powder? These are examples of question we help food producers answer.

YKI (the Swedish Institute for Surface Chemistry) has experience in dry formulations of foods and pharmaceuticals, e.g. micro-encapsulation and protein formulation. Research has yielded good knowledge about how particles, especially particle surfaces, are formed during drying processes. This enables selection of composition and processing that to a great extent can determine the properties of the particles, e.g. density, wetting ability and shape. At YKI we have also worked extensively with inorganic powders. Our expertise covers most aspects of powder processing, ranging from synthesis and characterisation of powders, to rheology and colloidal chemistry of powder suspensions and the shaping and drying of powder compacts.

Air filter for separation of particles in ventilation systems.

PARTICLES AND AEROSOLS

Cover picture: Dust particles photographed with a scanning electron microscope.