Small angle X-ray scattering (SAXS) can provide quantitative information on internal surface areas, porosity, particle size, void size distributions, surface roughness and fractal dimension of surfaces, interfaces and particles and aggregate structures. Applied in-situ and ex-situ, SAXS even permits to derive kinetic parameters for chemical reactions and transformations. In particular homogeneous systems such as soot can be studied with SAXS, and carbonaceous materials have been widely used to develop this technique. Wide-angle X-ray scattering (WAXS) permits to measure crystallite sizes and to distinguish aromatic and aliphatic structures in carbon materials. WAXS was particularly applied for coal research. I present here studies that were made on diesel exhaust soot for combustion engineering and environmental science, as well as studies on model systems such as glassy carbon (pore size and connectivity evolution) and on aerogels (inclusion of third phases such as metal clusters).

References

Application of small angle and wide angle X-ray scattering for the characterization of carbonaceous materials, aerosols, and particles

A. Braun a, N. Shah b, F.E. Huggins a, S. Seifert b, J. Ilavsky c, G.E. Thomas d, H. Francis e, K.E. Kelly f, A.F. Sarofim f  
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Small angle X-ray scattering (SAXS) can provide quantitative information on internal surface areas, porosity, particle size, void size distributions, surface roughness and fractal dimensions of surfaces, interfaces and particle-like aggregates. Applied in-situ and ex-situ, SAXS even permits to derive kinetic parameters for chemical reactions and transformations. In particular homogeneous systems such as soot can be studied in this way. Small-angle X-ray scattering (SAXS) and wide-angle X-ray scattering (WAXS) permits to measure crystal sizes and to distinguish amorphous and crystalline structures in carbon materials. WAXS was especially applied for coal research. We present here studies that we made on diesel exhaust soot for combustion engineering and environmental science, as well as studies on model systems such as gummy carbon (pore size and connectivity evaluation) and on aerogels (incorporation of third phases such as metal clusters).

Objective

Scattering techniques, including light scattering (LS), provide qualitatively very robust data, complementarity and often super-resolutions to microscopy data. Small angle X-ray scattering (SAXS), when done at synchrotron radiation sources, can provide very fast. At best, a scattering curve can be obtained in a fraction of a second. Small angle neutron scattering (SANS) requires typical neutron run times of about one to two days. A disadvantage of scattering techniques is that they do require some minimal amount of material, such as a liquid, which always means a sample amount necessary for TEM studies, which ultimately reach one tiny particle only. Also, SAXS cannot be applied very well for elastomeric very inhomogeneous systems. However, for soot studies, SAXS is perfect. Wide angle X-ray scattering (WAXS), poorly suited for LS, is a diffraction scattering technique which basically uses particle and layer periodicity for information analysis. It has been extensively applied for small soots with much success.

Thermogravimetric Analysis

Particle and pore size and porosity in diesel soot and GC

Pressure and expansion studies with USAXS

Wide Angle X-ray Scattering

Quantitative data of diesel soot

Pressures of diesel soot in Tesla powder, pressed pellet, and SMPS pellet are measured. Changes of structure are observed. Diesel soot has a semicrystalline structure. SAXS scattering curves for diesel soot as powder, pressed pellet, and SMPS pellet are measured. Changes of structure are observed. Diesel soot has a semicrystalline structure. Wide-angle X-ray scattering (WAXS) permits to measure crystal sizes and to distinguish amorphous and crystalline structures in carbon materials. WAXS was especially applied for coal research. We present here studies that we made on diesel exhaust soot for combustion engineering and environmental science, as well as studies on model systems such as gummy carbon (pore size and connectivity evaluation) and on aerogels (incorporation of third phases such as metal clusters).

Oxidation Studies

Pore size and chord length distributions

Fractality and Roughness

Indistinguishability and Metal Inclusions

References


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