Parameter Dependent Studies as Essential Requirement for the Size Control of Metal Nanoparticles

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The interest in metallic nanoparticles is enormous due to their potential for a variety of promising applications based on their unique catalytic, biological and optical properties [1]. Size and shape of the particles strongly determine these particle characteristics. As a result of the broad scientific and commercial interest, research in that field is very vivid since the last 50 years, but mainly focussed on developing or improving nanoparticle syntheses via try and error approaches. In fact, reaction parameters such as reactant concentration and temperature are varied to obtain the required final size distributions. The actual nanoparticle growth mechanisms and in particular the parameters influence are in general unknown. However, knowledge about the parameter influence on the growth might allow the precise control of nanoparticle size. Consequently, the nanoparticle growth mechanism and the corresponding parameter influence are of fundamental interest in the research of colloidal nanoparticles. Thus, in the last 5 years many studies made an effort to reveal these demanded information whereas the underlying mechanisms of the growth processes remain unknown. The decisive factor for this limited mechanistic understanding results from the fact that data have often been obtained by ex-situ analytical methods requiring sample preparation techniques (SEM, TEM, XRD) or via indirect characterization techniques such as UV-Vis spectroscopy [2]. Recently, novel experimental setups applying small angle X-ray scattering (SAXS) provided new insights into the growth mechanism of gold and silver nanoparticles synthesized by chemical reduction [3,4]. For each of these investigated syntheses a sophisticated, yet simple nanoparticle growth mechanism could be deduced. To refine the results of this work, parameter dependent studies were done varying crucial parameters like the reactant concentrations, temperature, ionic strength, pH value but also more uncommon ones like stirring speed or mixing conditions. In-situ and time resolved SAXS measurements reveal the influence of these reaction conditions on the growth. In combination with other methods such as optical spectroscopy and electron microscopy a rounded perception of nanoparticle growth arises. Exemplarily, it is shown how this knowledge can be applied to receive the desired nanoparticles size by the deliberate adjustment of reaction conditions.