Generation of sub-Nanometer Atomic Clusters in the Aerosol Phase using Spark Discharge Generation (SDG)

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Spark discharge generation (SDG) is a method to generate highly-pure singly-charged metallic particles of various sizes. Recent studies have shown that this method is also capable of producing atomic clusters, consisting of less than 5 atoms per cluster. The production rates of these small clusters are potentially sufficiently high to enable applications for e.g. catalysis or synthesis of materials with tailored properties. Since their properties depend on the number of atoms, controlling the cluster size can influence the electronic, optical, structural and chemical characteristics of a cluster.

A custom-made SDG operated at low spark energies with a high dilution flow, in order to quench the formation of bigger particles, was employed to generate the atomic clusters. The electrical mobility was measured usinga high-flow/high-resolution differential mobility analyser (Attoui *et al*., 2012, half mini DMA, NanoEngineering corp., FL, USA). To increase the measuring precision and to keep the purity of the aerosol constant along the whole setup the sheath flow in the DMA was recirculating. Three gases (nitrogen, helium and argon) of different purity have been used, in order to investigate the effect of trace oxygen molecules to the atomic cluster production process.

The DMA was first calibrated using electrical mobility standards of bromide ions.

As shown in Fig. 1 the inverse mobility distributions show several distinct peaks for positive as well as for negative clusters. Each peak corresponds to clusters consisting of different number of single silver atoms. The corresponding number of atoms of positive atomic clusters has been identified by comparing the measured electrical mobility with experimental values of silver clusters collision cross-sections reported by Weis *et al*. (2002). The collision cross section scales linearly with the inverse electrical mobility.

The agreement between the mobilities measured in our study and those reported in literature,is within the experimental uncertainty as shown in Fig. 2.The peaks in the spectra shown in Fig.1 correspond to atomic clusters with *n*=1,2,3, and 5 number of atoms.

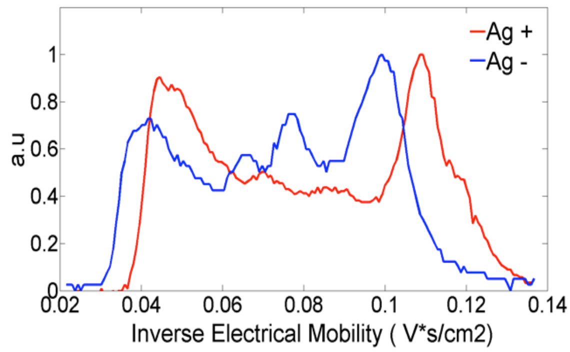

Figure 1. Inverse mobility distribution of positive and negative atomic clusters produced in He gas.

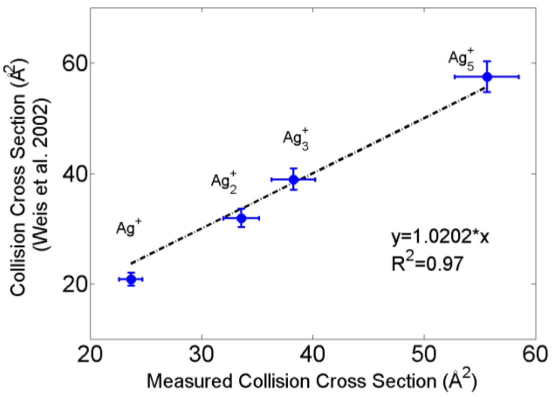

Figure 2. Comparison of the collision cross sections of Ag atomic clusters measurementsin this study and by Weis *et al.* 2002.

Attoui, M., Paragano, J. Cuevas, Fernandez de la Mora, J. (2013) *Aerosol Science and Technology*, DOI:10.1080/02786826.2013.764966

Weis, P, Bierweiler, T, Gilb, S, Kappes, M.M. (2002)*Phys. Rev. Lett.* **355**, 355-364.