Generation of stainless steel nanoparticles using a spark discharge generator

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The market for engineered nanoparticles is expected to grow considerably during the next decades and the demand to generate these particles in a cheap and environmentally friendly way is expected to grow with the same pace. A highly promising method to produce pure metal aerosol nanoparticles is with spark discharge. It is energy efficient, does not need any chemical precursor, and does not produce any waste (Pfeiffer, 2014). Other advantages of spark discharge are the possibility to produce nanoparticles consisting of complex alloys and of materials that are immiscible in bulk (Tabrizi, 2010).

An interesting complex alloy not yet produced by spark discharge is stainless steel. It has many interesting properties including high strength, good corrosion resistance and useful magnetic properties. Engineered stainless steel nanoparticles have the possibility to contribute to the steel industry in many different ways. An industry of great importance in Sweden since it is world leading in many areas and employs about 50 000 persons.

Here we show, for the first time, the generation of nanoparticles from stainless steel electrodes using spark discharge.

Method

In spark discharge two electrodes, separated by a gap, are being charged until a spark arises between the electrodes. Materials are ablated from the electrodes and nanoparticles are formed by vapour collisions from the ablated material. Several parameters can be adjusted to control the particle formation, including discharge frequency, spark energy, carrier gas composition and the composition of the electrodes (Meuller, 2012). The agglomerates that are formed by the spark needs to be compacted in order to become spherical nanoparticles. This is done by heating these agglomerates above the compaction temperature specific to the material (Messing, 2009).

Two different types of stainless steel (AISI410 & AISI430) have been investigated in this work and we will report the effect on altering several different parameters to obtain controlled properties of the resulting nanoparticles.

Conclusions

Stainless steel nanoparticles have been successfully produced with a narrow size distribution in the size range 30-50 nm and with almost the same composition as the electrodes used. The amount of chromium in the particles showed a clear relation with the amount of chromium in the electrodes used. Suitable parameters for this generation were determined to be 2 mm gap distance and 10 mA charging current when the capacitance was 21 nF. The compaction characteristics of two differently sized agglomerates are shown in Figure 1. This result was obtained using nitrogen as the carrier gas. When, instead, a reducing carrier gas was used (Ar+5%H_2), the compaction occurred at lower temperatures. Further effects on the type of carrier gas will be presented such as composition, structure and purity. We will also present the first results from an investigation where these nanoparticles are mixed together with a metallic micro-powder to enhance sintering and improve the properties of the resulting sintered solid structure.

This method is feasible to produce nanoparticles of any type of stainless steel alloy and, with increased yield, enables many different applications.

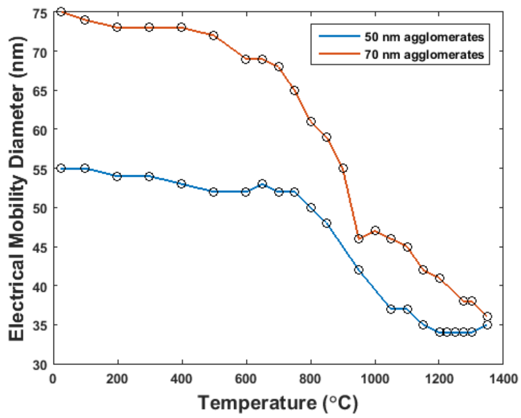

Figure 1. Compaction of differently sized agglomerates into spherical nanoparticles using nitrogen as the carrier gas.

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Pfeiffer, T. V. (2014), *Adv. Powder Technol.*, **25**, 56-70
Tabrizi, N. S. (2010), *J. Nanopart. Res.*, **12**, 247-259
Meuller, B. O. (2012), *J. Aerosol Sci. Technol.*, **46**, 1256-1270
Messing, M. E. (2009), *Gold Bulletin*, **42**, 20-26