Attrition and dustiness of silicon carbide particles in solar energy capture and storage

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Silicon carbide (SiC) powders have been recently adopted as a heat transfer and storage fluid (HTF) for concentrated solar thermal plants (CSP), potentially allowing the plants to generate steam at supercritical levels unlike the conventional HTFs such as molten salts or oil (Benoit *et al* 2015). SiC is used for its favourable physical and mechanical properties of high strength, durability and heat capacity with good availability at relatively low cost.

Particle suspensions used as HTF may undergo different kinds of stresses in a closed loop circulating system including mechanical stresses due to screw feeder or rotary valves and kinetic stresses due to high-velocity jets, conveyors, and collision with tubes, baffles and cyclones. These stresses can cause unwanted attrition leading to change in powder properties and generation of aerosol, which can potentially be released in the atmosphere, in the case of a leak in the circulating loop operating at high pressure and flux rate. Exposure to potentially hazardous SiC dust in occupational settings has been associated with increased rate of chronic bronchopulmonary diseases and bronchial hyper-reactivity in industrial workers (Governa *et al* 1997; Petran *et al* 2000). The dust generated by a powder is related to its physicochemical properties such as particle size, distribution, interparticle cohesive forces among others. Thus, it is important to characterize the powder properties and their role in generating dust particles while selecting novel HTFs such as SiC powders to evaluate the risk associated with control and handling such materials.

In this study, we present the experimental results obtained from the dustiness tests on two different samples of SiC powders with median particle diameters of 36µm and 70µm, using a vortex shaker dustiness tester (Le Bihan *et al* 2014; Morgeneyer *et al* 2013). The mass and number dustiness indices for the SiC powders were measured and compared for the respirable fraction. Both powders were found to release respirable fraction of dust particles when agitated. Figure 1 shows the average particle concentration of the aerosol released in the first hour of vortex shaker operation, measured using the CPC (size range of 4nm to 3µm).

The powders were characterized by their particle size distribution, sphericity and morphology before and after the six-hour vortex shaker duration. Using an APS and a CPC, the number concentration and size of the aerosol generated was measured and evaluated with respect to the change in sphericity of the particles in the bulk sample. The results obtained highlight the effect of particle-particle and particle-wall interaction on the shape of the particles and its role in aerosolization of fine dust particles.

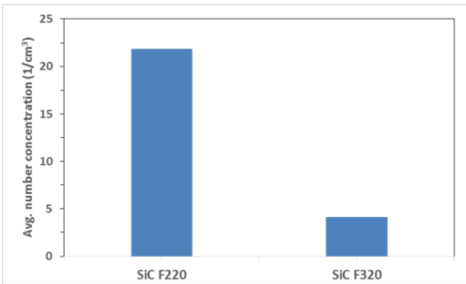

Figure 1. Average number particle concentration as measured by the CPC (for t=1 hour)

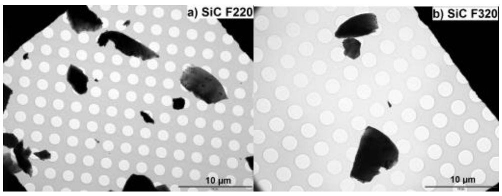

Figure 2. TEM micrographs for: a) SiC F220 (left), b) SiC F320 (right)

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