Lab scale investigation on the formation of aerosol nuclei by a Wet Electrostatic Precipitator in the presence of SO₂ in a gas stream

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1. Introduction:
One of the counter-measures for the reduction of aerosol nuclei resulting in aerosol based amine emissions is a Wet Electrostatic Precipitator (WESP)[1]. WESP removes particles by means of charging them at a high power input, collecting the particles on an oppositely charged surface and cleaning of the collection surface [2]. Unlike a Dry ESP, a WESP has been shown to be effective in reducing particles below 2.5 µm and H₂SO₄ mist [3]. However, WESP have also shown to be producing aerosols such that it can act as a nuclei for aerosol based amine emission [1], [4], [5]. This is attributed to the highly oxidizing environment in the WESP which converts the SO₂ (g) to SO₃ (g) and, the circulation water providing the humidity to result in H₂SO₄ aerosols of very fine size. These aerosols generated in the WESP have been shown to result in aerosol based amine emissions. Thus, to use WESP without any adverse effect, it is important to understand the interactions between the level of SO₂ in the flue gas and the operating conditions of the WESP.

This paper aims to present a systematic study on the relation between the SO₂ level in the flue gas and the operating conditions of the WESP such as energy input, residence time and design in terms of the particle size distribution and number concentration.

2. Equipment and methods:
The experimental results were conducted using SO₂ from a gas bottle and a lab scale WESP as shown in Figure 1. ELPI+ (Dekati) was used to measure the particle number concentration and size distribution. The results presented here from a pre-test conducted at a SO₂ concentration of 61 ppmv.
3. Results and discussion:

Figure 2 shows the number concentration and size distribution in the absence of SO\textsubscript{2}. In general the number concentration remains at the baseline value of \(10^4\) per cm\textsuperscript{3}. Interestingly, some frequent peaks in number concentration are observed when the voltage is changed, especially beyond 5 kV. These correspond to the lowest size class, i.e. < 6nm. These could be due to spark generated in the gas stream due to the high energy input. These sparks are not stable and give only temporary increase in particles. The peak number concentration too remains below \(10^6\) per cm\textsuperscript{3}.
In the presence of SO$_2$, the particle concentration increases only at 6 kV as shown in Figure 3. At 8 kV, the particle number concentration increases to $10^5$ per cm$^3$. A further increase in number concentration is observed until it reaches a maximum of $2.8 \times 10^7$ per cm$^3$ at 14 kV. Increasing the voltage further reduces the particle number concentration. Beyond 18 kV, the WESP current was not stable.

It is clear from Figure 3b that the produced particles are of extremely small size, i.e. <6 nm and 0.0158 μm, which are the last two stages of the ELPI+. Beyond 10 kV, particles of the size class 0.0307 μm also show some increase in the number concentration, i.e. more than the baseline of $10^4$ per cm$^3$. The decrease in number concentration beyond 14 kV is equally across these 3 size classes.
The stability of WESP is reflected in the measured current. Unfortunately the current monitoring device was not of the correct range and did not have a recording function, so the current values could not be recorded.
4. Preliminary conclusion and future work:
Based on the preliminary tests presented here, the presence of SO$_2$ does lead to high particle number concentration in the range of $10^7$ per cm$^3$. At this high number concentration, aerosol based MEA emissions are extremely likely.

It is important to note that the results presented here are from a pre-test conducted at 61 ppm(v) of SO$_2$ in the flue gas. Further tests are currently being performed at relevant SO$_2$ levels (< 20 ppmv), as obtained downstream of SO$_2$ washer of a capture plant. Further experiments are aimed at varying the SO$_2$ levels, residence time of the gas in the WESP and monitoring the resulting amine emissions from a mobile CO$_2$ capture plant downstream of the WESP.

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6. References


