A new electrical bi-polar aerosol neutralizer

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Accurate aerosol measurement by electrostatic means requires that the aerosol have an equilibrium charge distribution. The most common method for applying this charge to an aerosol sample is with radioactive sources (eg, Kr^{85+} & Po^{210}), commonly known as neutralizers. Usage of these radioactive sources leads to transport and locality restrictions for researchers and also the possibility of health risks should a leak occur. As such the development of an alternate means for neutralizing the aerosol has received constant attention since the inception of DMA's in the late 70's. Previous examples have utilised bi-polar corona wires and tips (*Stommel and Riebel, 2005)* and most recently surface microplasmas. (*Kwon et. al., 2006)*

The system presented here utilises two corona wires (one supplied with positive voltage and the other negative to a maximum of ± 6 kV) for ion generation and is capable of neutralizing an aerosol of rapidly changing charge loading. Each of the wires sits behind an electrically isolated mesh which can be held at chosen potentials acting as counter electrodes. The sample enters the charging region between these meshes (figure 1) where attachment of the ions to the aerosol occurs. Given the required bi-polar nature of the aerosol for measurement applications, the level of positive and negative ions must be closely regulated to avoid overcharging towards one particular polarity To achieve this an aerosol electrometer (built in-house) on a sample bypass line is used to measure the net charge of the aerosol. In an ideal case the number of positive and negative charges on the aerosol should approximate to zero. Regulation of charge is managed using a feedback loop. The signal from the electrometer is read into a DAQ and a control response is delivered to each of the HV power supplies.

Preliminary testing of the neutralizer has returned encouraging results. Comparison with radioactive neutralizers (Kr^{85+} and Ni^{63}) have shown little variation and production of particles or ozone has not been observed. During testing mono-disperse particles were generated using a DMA (TSI 3081) and passed through the neutralizer. The sample exiting the neutralizer was passed to an SMPS {(DMA (TSI 3081) + CPC (TSI 3025)} where the resulting size distribution was measured. Simultaneously the charge on the aerosol entering the CPC was measured using another FHNW electrometer. Further studies will be conducted to determine the charging efficiency of the neutralizer with respect to particle size.

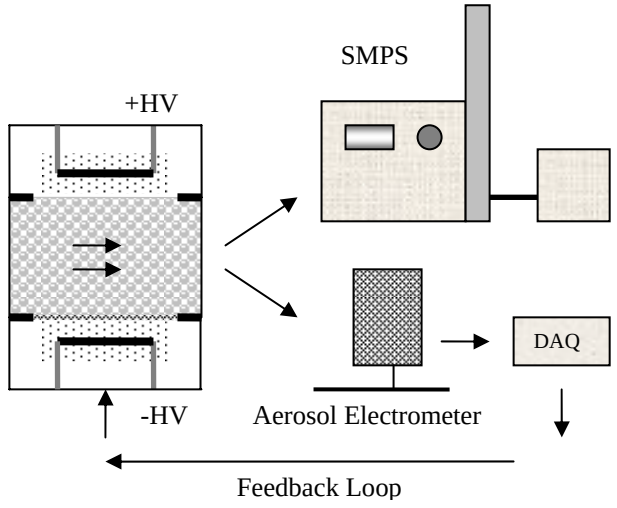

Figure 1. Experimental Setup

The results of a typical test are shown in figure 2 where a 50nm mono-disperse distribution has been passed through both the electrical and Kr85+ neutralizers. As an example the case presented here is for negative particles.

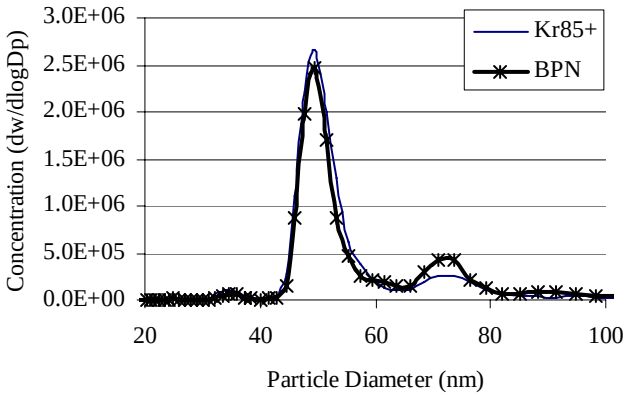

Figure 2 Example size distributions measured when passing a mono-disperse aerosol (50 nm) through either a radioactive (Kr^{85+}) or electrical neutralizer.

Kwon, S.B., Sakurai, H., Seto, T., Kim, Y.J. *(2006) J. Aerosol. Sci, Vol 37, pg 483-499*

Stommel, Y.G. and Riebel, U. *(2005) J.Electostatics, Vol 63, pg 917-921*

A new electrical bi-polar aerosol neutralizer

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A new bi-polar aerosol neutralizer (BPN) has been developed using DC corona voltages. Positive and negative ions create a bi-polar environment in which aerosols having time varying concentration and charge characteristics are charged to a known level. The ion balance in the charging region is monitored using an electrometer as part of a feedback loop. Two methods of control have been investigated and aerosol charging has been observed to be similar to that achieved using a typical radioactive source (Kr85+). The system is capable of creating either symmetrical or asymmetrical charge distributions; both cases are currently being investigated.

Accurate aerosol measurement by electrostatic means requires that the aerosol have an equilibrium charge distribution. The most common method for applying this charge to an aerosol sample is with radioactive sources (eg, Kr85+ & Po210), commonly referred to as neutralizers. Usage of these radioactive sources leads to transport and locality restrictions for researchers and also the possibility of health risks should a leak occur. As such the development of an alternate means for neutralizing the aerosol has received constant attention since the inception of DMA's in the late 70's.

The system presented here utilises two corona wires for positive and negative ion generation; each wire can be supplied with a maximum of ± 6 kV. Ion production occurs behind electrically isolated meshes. The sample enters the charging region between these meshes (figure 1) where ion attachment to the aerosol occurs The residence time in the charging region is of the order of 1-5 seconds for typical sampling flows (0.3 – 1.5 Lpm). The BPN has outer dimensions of 80 x 80 x 60 mm (with the addition of an electrometer and pump which are soon to be incorporated into the block in a miniature format). The net aerosol charge can be monitored, and subsequently regulated, using the electrometer. In an ideal case the number of positive and negative charges on the aerosol should approximate to zero.

Two modes of operation have been investigated, the first simulates the performance of radioactive neutralizers, creating a skewed charge distribution. The second creates a symmetrical charge distribution, in essence a true bi-polar environment. Both cases were investigated for mono- and poly-disperse aerosols. When the radioactive neutralizer and BPN were compared parallel instruments were utilised. A developed explanation of methods employed will be given in a coming manuscript.

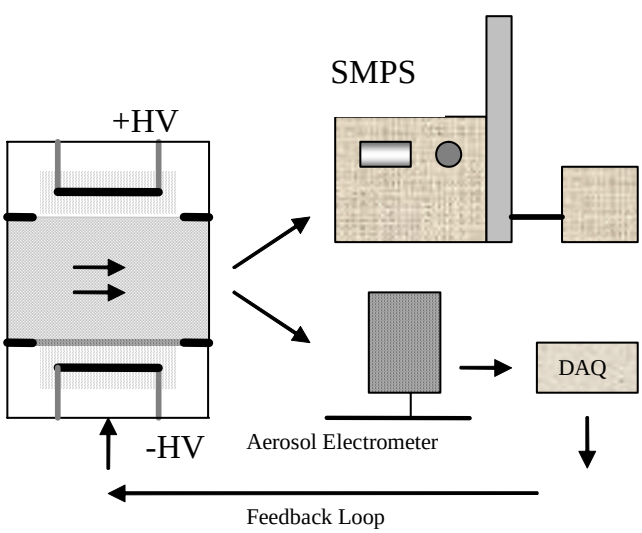

Fig. 1: Typical setup of the BPN. The aerosol passes through the bi-polar charging region after which the flow is directed to an aerosol electrometer and a chosen measurement instrument.

Preliminary testing of the neutralizer has returned encouraging results. Under standard operating conditions little variation was observed between the performance of a radioactive neutralizer (Kr85+) and the BPN. Particle and ozone production do not occur under normal operating conditions and particle losses are limited. Comparison of polydisperse samples using the radioactive and electrical neutralizers provides a good indicator of instrument performance. Distributions were centred around 50 nm were measured as DMA voltage was scanned through both positive and negative ranges (figure 2). The upper and lower black markers represent the positive and negative cases where the Kr85+ source is used. Note that these distributions differ greatly. The blue and pink lines are closely matched and represent the distributions measured using the BPN.

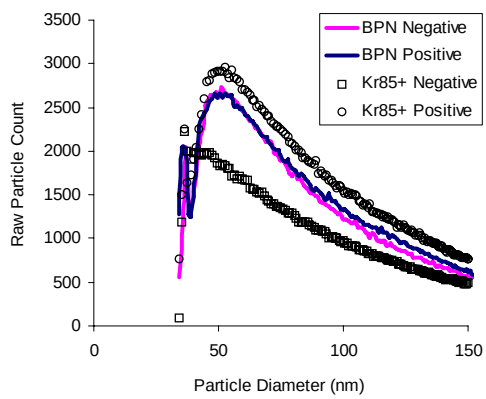

Fig. 2: Size Distributions as measured using the radioactive and electrical neutralizers with the DMA scanning both positive and negative high voltages.

Simulation of the skewed charge distribution indicative of the radioactive sources give comparable particle charging characteristics. Alternately, operating the BPN with it's electrometer held at zero give charge characteristics seen below (figure 3). These characteristics need to be further investigated

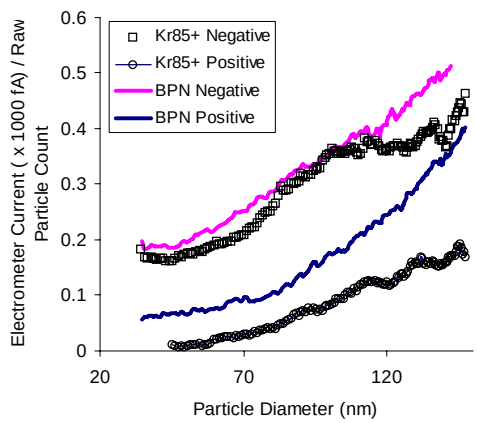

Fig. 3: Comparison of charge per particle vs particle diameter for the Kr85+ source and the BPN.