

Measured Sulfate Formation Rates Before and After Installation of Scrubbers

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Summary

The principal focus of the study was to determine rates of gas-phase conversion of SO₂ to sulfate in the plume of the Cumberland power plant in north-central Tennessee, and see if those rates had changed significantly since the last time extensive plume measurements had been made in the late 1970s, prior to installation of the SO₂ scrubbers in 1994. It is important to compare the rate of conversion before and after the installation of the SO₂ scrubbers to determine whether the reduction in SO₂ has been accompanied by a proportional reduction in plume-related particulate sulfate levels. The plume of the 2600 MW plant now has a relatively low ratio of SO₂ to NO_y emissions (~0.1 prior to the recent installation of equipment lowering NO_x emissions) compared with a ratio of approximately 2 before the installation of the SO₂ scrubbers. Two series of eight research flights each were performed in the Cumberland plume in the summers of 1998 and 1999 to investigate SO₂ oxidation processes in the scrubbed plume. The light scattering and number and volume distributions of plume excess particles were determined by nephelometry and PCASP optical particle techniques. The Cumberland plume did not mix with plumes from adjacent power plants during two of those sampling flights, enabling a conversion rate to be estimated.

Rate constants for plume conversion were estimated from samples taken in the plume during two flights at three downwind distances. The rate of conversion of SO₂ to sulfate for the SO₂-scrubbed Cumberland power plant plume was then estimated, including corrections for dry depositional losses, yielding removal rate constants (oxidation + deposition) for one flight in 1998 and one flight in 1999. After taking into account dry deposition losses and the fact that SO₂ is not in large excess compared with

SO_4^{2-} , an upper limit for just the conversion rate was estimated based on plume excess aerosol volume. The upper limit value estimated for the 1998 flight is 0.069 h^{-1} , while the equivalent value for the 1999 flight is 0.034 h^{-1} . While the 1999 rate is comparable with values estimated earlier for non-scrubbed plumes, the 1998 value is somewhat higher than expected, suggesting a possible, albeit small deviation from a linear relationship between SO_2 emissions and sulfate formation.

Two major findings were made in addition to the observation that in-plume oxidation rates on cloud-free days were about the same as in previous studies. First, light scattering measurements could no longer be used to locate and follow the plume, and the reason for this was that plume dispersion now occurred at a rate faster than the accumulation of secondary light scattering particles. The greatest benefit of SO_2 reduction on plume excess volume and visibility thus appears to occur far downwind of the source. The cross-plume profile of volume suggests SO_2 -to-sulfate conversion is highest at the plume edges, analogous to, but less pronounced, than the ozone wings associated with ozone formation in point-source NO_x plumes.