Sulfate Formation via Photosensitized Oxidation by Incense Burning Particles

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Abstract

Incense burning, a common ritual in Asian cultures, especially in coastal cities, emits significant particles in temples and households. Particulate aromatic carbonyls, key components of incense burning aerosols, contain photosensitizers that can produce oxidants for in-particle oxidation such as sulfate formation from SO_2. Using single particle aerosol mass spectrometry (SPAMS), we observed that sulfate formation in incense burning particles does not solely depend on traditional gas-phase reactions. Instead, it is significantly influenced by photosensitization, which is dependent on various environmental conditions such as relative humidity and UV light exposure. Furthermore, internally mixed incense burning and sea-salt particles are often found in coastal regions. We observed enhanced sulfate production in laboratory-generated droplets containing incense smoke (IS) extracts and sodium chloride (IS−NaCl) over pure NaCl droplets under irradiation, attributable to photosensitization induced by IS constituents. Photosensitizers like vanillin (VL) and syringaldehyde (SyrAld) found in IS samples can markedly accelerate SO_2 oxidation. Moreover, the excited triplet state of the photosensitizer might interact with chloride ions to generate reactive chlorine species. Such synergistic effects between chlorine chemistry and photosensitization could further enhance sulfate formation. Additionally, the aging of IS particles further promoted sulfate production. This is likely due to increased secondary oxidant production driven by a higher proportion of nitrogen-containing species relative to fresh IS particles. Our studies highlight the substantial impact of photosensitized oxidation processes in sulfate production, particularly in areas impacted by incense burning, offering new insights into atmospheric sulfate formation mechanisms. The similarity between incense burning and biomass burning particle mass spectra suggests that biomass burning may also trigger sulfate formation. Using sulfate formation as a tool, we demonstrate that photosensitization of incense burning aerosol can enhance the atmospheric oxidative capacity and promote secondary aerosol formation.

Early Career Scientist

NO, I am not an early career scientist.

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