New spectroscopic methods for non-invasive pH sensing of aerosols

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ABSTRACT

Airborne particles, or aerosols, originate from both natural and anthropogenic sources, with sizes ranging from a few nanometers to a few micrometers. Aerosols significantly impact human health, contributing to approximately 4.2 million premature deaths annually according to the World Health Organization (WHO). They also influence the climate through direct and indirect radiative forcing and affect terrestrial and marine ecosystems by supplying nutrients. The acidity (pH) of aerosols modulates nearly all of their properties and processes[1]. Despite its importance, aerosol pH has remained virtually unconstrained for decades. Recent developments have led to methods for inferring pH from measurements of gas and aerosol composition. These methods are now used globally but still face significant limitations. As a result, there is a strong need for accurate and direct determination of ambient aerosol pH.

The objective of this study is to propose a non-invasive strategy for monitoring the pH of aerosols. The methodology is based on the deposition of aerosol nanoparticles and microparticles on functionalized pH-sensitive filter surfaces, whose response is monitored via Raman/SERS measurements. The initial method employs a redox-active pH-responsive polymeric substrate, as a sensing material for the quantification of the acidity levels of aerosols (as well as of other environmental contaminants) that deposit on the substrate during normal sampling operations. The polymeric model system under investigation is polybenzimidazole (PBI), which undergoes protonation/deprotonation upon exposure to acids/bases, resulting in structural variations that exhibit distinct Raman fingerprints[2]. In addition, a second method is proposed. It includes low molecular weight pH-responsive molecules as surface modifiers of plasmonic nanostructures. It was found that the structural alterations caused by pH could be traced even at low concentrations through SERS measurements

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