Isotopic constrains on sources and formation pathways of atmospheric nitrate in Mt. Everest

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Studies on the sources and formation pathways of nitrate is crucial to better understand nitrogen cycle and atmospheric oxidation capacity. Tibetan Plateau (TP) and surroundings, referred to as the Third Pole and “Asia water tower”, contain the largest number of glaciers outside the polar regions and are largely experiencing shrinkage. A complete understanding on the source and formation mechanisms of atmospheric nitrate in the TP is important to indicate the impact of human activities on the environment and also crucial to investigate nitrogen cycle in glacier-hydrology systems of this region. Besides, it can supply information on interpreting ice core records to understand the past atmosphere chemistry. Here we collected aerosol samples from the Everest through pre-monsoon (April-May) and monsoon season (June-August) in 2018, and measured for the first time the isotopic compositions ($\delta^{15}N$, $\delta^{18}O$ and $\Delta^{17}O$) of nitrate in this region, allowing insights into their sources and potential formation mechanism. The results show that the seasonal variations in both $\delta^{15}N$ and $\Delta^{17}O$ values have a similar trends with maximum during pre-monsoon season and minimum during monsoon season. The relatively high values of $\delta^{15}N$ in pre-monsoon seasons, maybe indicate the enhanced contribution from fossil fuel combustions in South Asia which can be transported to our sampling sites across the Himalayas by the mountain/valley wind system. The $\Delta^{17}O$ (NO_3^-) value, which is dependent on both the $\Delta^{17}O$ (NO_2) value and the oxidation pathways (O_3 and OH) of NO_2 to NO_3^-, show that the O_3 oxidation pathway is dominant during pre-monsoon season, resulting in higher values of both $\delta^{18}O$ and $\Delta^{17}O$. In contrast, during monsoon season, formation involving HO_2/RO_2 radicals becomes important, producing lower values of $\delta^{18}O$ and $\Delta^{17}O$. To better understand the oxidation process of past atmosphere in the Everest region, observations of oxygen-17 excess of nitrate and sulfate in ice cores collected from this region in the future are recommended.

Keywords: Atmospheric nitrate, the Everest, Isotope, Aerosol, Oxidation pathways

