硕士学位论文

哈尔滨采暖季无机气溶胶特征及形成过程研究

RESEARCH ON CHARACTERISTICS AND FORMATION OF INORGANIC AEROSOLS DURING A HEATING SEASON IN HARBIN

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中文摘要

以哈尔滨为代表的东北寒区城市大气污染物排放量大、排放系统复杂、气候条件特殊，不仅有别于京津冀等传统大气污染防治重点地区，与纬度相近或纬度较高的欧美城市或地区也不同。因此，其大气环境在世界上是独一无二的。大气细颗粒物（$PM_{2.5}$）是现阶段我国区域性雾霾污染的集中表现。其化学成分和环境影响过于复杂，一直是大气环境研究领域的国际前沿和热点问题。本研究针对东北典型寒冷地区城市的排放特征和气候特征，在哈尔滨市区开展了覆盖整个 2019-2020 采暖季的 $PM_{2.5}$ 长期连续现场观测。

通过化学物种分析发现，无机气溶胶浓度可达 $PM_{2.5}$ 的近一半。哈尔滨采暖季的水溶性无机离子主要有硫酸盐、硝酸盐、铵盐（统称 SNA）和氯离子，可以达到阴阳离子平衡。

通过相关性分析表明，$PM_{2.5}$ 与 SO_2、NO_2 显著正相关，表明对 $PM_{2.5}$ 的贡献中含有燃煤、机动车等多种燃烧源的综合贡献，加上从气态污染物到无机气溶胶的二次转化生成。

而在重污染天气下的分析研究则表明，硫和氮从气态污染物转化为颗粒物的效率 SOR 和 NOR 均与 RH 呈正相关，表明即使在低温条件下，非均相反应也会在高湿度条件下得到增强。本研究结果显示了 $PM_{2.5}$ 的化学成分和变化规律。

关键词：哈尔滨；$PM_{2.5}$；含碳成分；无机气溶胶；重污染日

Abstract

The cities in the northeast cold region represented by Harbin have large emissions of air pollutants, complex emission systems, and special climatic conditions. They are not only different from traditional key air pollution prevention and control areas such as Beijing, Tianjin and Hebei, but also from European and American cities with similar or higher latitudes. Regions are also different. Therefore, its atmospheric environment is unique in the world. Atmospheric fine particulate matter ($PM_{2.5}$) is the concentrated manifestation of regional haze pollution in my country at this stage. Its chemical composition and environmental impact are too complex, and it has always been an international frontier and hot issue in the field of atmospheric environment research. In this study, aiming at the emission characteristics and climate characteristics of cities in typical cold regions of Northeast China, long-term continuous field observations of $PM_{2.5}$ covering the entire 2019-2020 heating season were carried out in urban Harbin.

Through chemical species analysis, it was found that the concentration of inorganic aerosols can reach nearly half of $PM_{2.5}$. The water-soluble inorganic ions in Harbin heating season mainly include sulfate, nitrate, ammonium salt (collectively referred to as SNA) and chloride ion, which can achieve an anion-cation balance.

The correlation analysis shows that $PM_{2.5}$ is significantly positively correlated with SO_2 and NO_2, indicating that the contribution to $PM_{2.5}$ includes the comprehensive contributions of various combustion sources such as coal combustion and motor vehicles, plus the contribution of secondary formation of inorganic aerosols generated from gaseous pollutants.

However, the analysis study under heavy pollution weather showed that the conversion efficiencies of sulfur and nitrogen from gaseous pollutants to particulate matter, SOR and NOR, were both positively correlated with RH, indicating that even at low temperature, the heterogeneous reaction would be enhanced under high humidity conditions. The results of this study show the chemical composition and variation of $PM_{2.5}$.

Keywords: Harbin, PM$_{2.5}$, carbonaceous components, inorganic aerosol, heavily polluted day