Hems R, Wang C, Collins D, Zhou S, Borduas-Dedekind N, Siegel JA, Abbatt J. 2019. Sources of isocyanic acid (HNCO) indoors: A focus on cigarette smoke. *Environmental Science: Processes & Impacts*, **21**, 1334-1341. DOI: 10.1039/C9EM00107G

Abstract

The sources and sinks of isocyanic acid (HNCO), a toxic gas, in indoor environments are largely uncharacterized. In particular, cigarette smoke has been identified as a significant source. In this study, controlled smoking of tobacco cigarettes was investigated in both an environmental chamber and a residence in Toronto, Canada using an acetate-CIMS. The HNCO emission ratio from side-stream cigarette smoke was determined to be 2.7 (±1.1) × 10^{-3} ppb HNCO/ppb CO. Side-stream smoke from a single cigarette introduced a large pulse of HNCO to the indoor environment, increasing the HNCO mixing ratio by up to a factor of ten from background conditions of 0.15 ppb. Although there was no evidence for photochemical production of HNCO from cigarette smoke in the residence, it was observed in the environmental chamber via oxidation by the hydroxyl radical (1.1 × 10^{7}molecules cm^{-3}), approximately doubling the HNCO mixing ratio after 30 minutes of oxidation. Oxidation of cigarette smoke by O_3 (15 ppb = 4.0 × 10^{17} molecules cm^{-3}) and photo-reaction with indoor fluorescent lights did not produce HNCO. By studying the temporal profiles of both HNCO and CO after smoking, it is inferred that gas-to-surface partitioning of HNCO acts as an indoor loss pathway. Even in the absence of smoking, the indoor HNCO mixing ratios in the Toronto residence were elevated compared to concurrent outdoor measurements by approximately a factor of two.

Environmental Significance

Isocyanic acid (HNCO) can be toxic to humans at high concentrations and has been monitored in industrial settings. However, very little is known about daily exposure to HNCO, its sources, and loss processes in indoor environments. We identify side-stream cigarette smoke as a significant indoor source of HNCO in both laboratory and field settings. Our results suggest that oxidation of cigarette smoke constituents by hydroxyl radicals can further produce HNCO. Measurements inside a residence indicated that higher levels of HNCO, compared to outdoors, were always present and that gas-surface partitioning of HNCO may be an important process indoors.

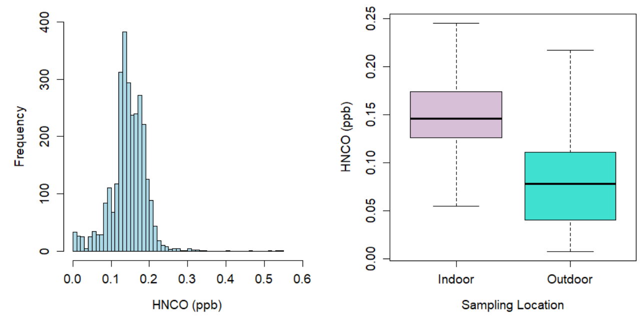
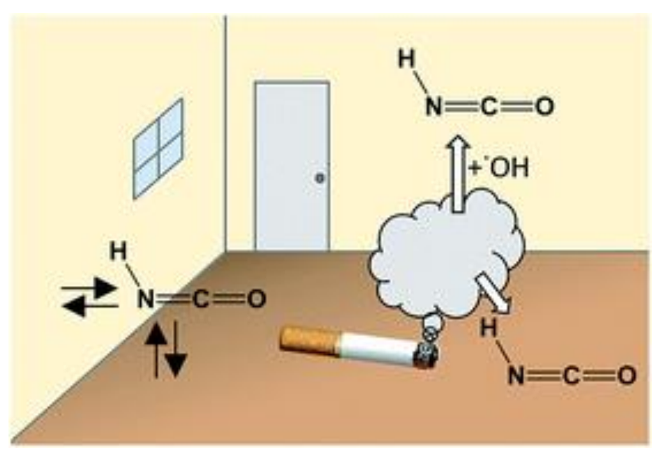


Figure 1. Histogram of the frequency of HNCO mixing ratio measured indoors (left) and box-and-whisker plot of HNCO mixing ratios comparing indoor and outdoor measurements (right). The median is shown as a thick line, the extent of the box shows the 25th and 75th percentiles, and the whiskers show the 5th and 95th percentiles. All data are reported for non-experimental periods (i.e. not during cigarette burning periods).

Source	Emission Ratio (ppb HNCO/ppb CO)
Cigarette side-stream smoke- Toronto Residence (this study)	2.0 (±0.6) × 10^{-3}
Cigarette side-stream smoke - Chamber Experiment (this study)	2.7 (±1.1) × 10^{-3}
Biomass burning – Fire Lab[2]	0.76 (±0.25) × 10^{-3}

Table 1. Emission ratios of isocyanic acid from cigarette side-stream smoke and biomass burning smoke. Error is reported as 1 standard deviation.



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