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Atmospheric Chemistry at Home: Abundance, Sources, and Fates of Indoor Organic Gases and Particles

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The average American spends 90% of their time indoors, with 70% at home. We breathe an average of 15 kilograms of air per day, far more than the few kilograms per day of food and water that we ingest. From the perspective of human exposure and health, it is critical to understand indoor air quality. From the perspective of fundamental science, it is fascinating to explore the factors that govern the airborne chemical environment in which we spend most of our time living and breathing.

We seek to characterize and quantify volatile organic compounds (VOCs) and semivolatile organic compounds (SVOCs) indoors in a way that enables fundamental understanding of the dynamic processes that influence their concentrations. Do these indoor chemicals originate from outdoor air, human activity, microbial activity, or from building materials? How do these chemical species change in a dynamic indoor environment, where temperature, humidity, and air exchange with outdoors can rapidly change? How do the organic compounds interact with surfaces and oxidants indoors?

Results will be presented from several recent field campaigns in normally occupied residential homes. We applied proton-transfer reaction time-of-flight mass spectrometry (PTR-ToF-MS) to quantify concentrations of hundreds of different VOCs in real time at multiple locations indoors and outdoors. We also utilized our recently developed semivolatile thermal desorption aerosol gas chromatograph (SV-TAG) to acquire hourly SVOC measurements in both the gas and particle phases, including their dynamic partitioning, both indoors and outdoors. This investigation represents the first time that such monitoring has been undertaken in residences under normal occupancy. By collecting extensive metadata, including experimentally determining the air-exchange rates using release of tracer gases, we determined emission rates of hundreds of chemicals at hourly time resolution, identified the locations and activities associated with those emissions, and examined the role of environmental parameters on emissions. We demonstrate that both VOC and SVOC concentrations in indoor air are markedly higher than those outdoors and that their dynamic behaviors indoors are strongly influenced by temperature with episodic enhancements related to human activities such as cooking and cleaning. From ongoing analysis of these field campaign data, we aim to answer important questions about the indoor chemical and physical transformations of VOCs and SVOCs and their implications for human exposure.