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Elusive Ultrafine Indoor Air Contaminants Yield to Analysis

ScienceDaily (Dec. 7, 2011) — Researchers at the National Institute of Standards and Technology (NIST) spent 75 days on the job carrying out some very important homework -- measurements in a "typical dwelling" of the release, distribution and fate of particles almost as tiny as the diameter of a single DNA molecule. Particles ranging in size from 100 nanometers down to 2.5 nanometers that were emitted by gas and electric stoves, hair dryers, power tools and candles were tracked and analyzed.

Monitoring such tiny particles was made possible by NIST advances in measurement capabilities. Measurements were carried out in weeks of experiments at a 340-square-meter (1,500-square-feet) test house on the NIST campus in Gaithersburg, Md. The researchers used the data to develop a model for predicting changes in the size and distribution of so-called ultrafine particles (technically, particles smaller than 100 nanometers) discharged by tools, appliances and other sources.

The measurements and model will further efforts to explain the dynamics of ultrafine particles, an area of growing interest among environmental and health researchers. They also will advance work to develop accurate and reliable methods for determining how changes in heating and cooling systems, often done to reduce energy consumption, will affect indoor environments.

"If we can understand and predict the dynamics of these extremely small indoor air contaminants, designers and equipment manufacturers can avoid potential negative impacts on the environment inside homes and buildings and may even devise ways to improve conditions and save energy at the same time," explains NIST engineer Andrew Persily.

Utrafine particles are produced naturally -- by forest fires and volcanoes, for example -- as well as by internal combustion engines, power plants and many other human-made sources. Although ever present in outdoor and indoor environments, ultrafine particles have eluded detection, and are not subject to federal or state air quality standards. However, particles with nanoscale dimensions have been associated with a variety of human health problems -- especially heart, lung and blood disorders.

Because we spend most of our time indoors, however, the bulk of human exposure to ultrafine particles occurs in homes and buildings. Typically, releases of the tiny particles occur in periodic bursts -- during cooking or hair drying, perhaps -- but airborne concentrations during these episodes can greatly exceed outdoor levels, according to the NIST team.

The researchers measured the airborne concentrations of ultrafine particles at regular intervals after they were emitted by gas and electric stoves, candles, hair dryers and power tools. With their recently enhanced capabilities, the team could measure particles about four times smaller than in previous studies of indoor air contaminants.

Tests were conducted with the house central fan either on or off, which made a major difference in the behavior of ultrafine particles. With the fan off, these very small particles collide with each other and coagulate -- or combine -- during the first 2.5 minutes following a blast of ultrafine particles from an appliance or tool. In the process, they form successively larger particles, decreasing airborne concentrations of particles. As particles grow larger, they tend to settle on surfaces more quickly.

With the central fan recirculating air, ultrafine particles tend, in roughly equal proportions, to coagulate or settle on surfaces. Under both fan conditions, ventilation accounted for the removal of no more than about 5 percent of ultrafine particles.

Tests also revealed that for many indoor sources, such as stovetop cooking with gas, more than 90 percent of the particles emitted were smaller than 10 nanometers. In turn, emissions of smaller particles result in higher airborne concentrations that dissipate primarily through coagulation.

NIST guest researcher Donghyun Rim is lead author of the new article. Co-authors are Lance Wallace and Persily, both of NIST, and Jung-il Choi, of Yonsei University, South Korea.

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1. Donghyun Rim, Lance Wallace, Andrew Persily, Jung-Il Choi. **Evolution of Ultrafine Particle Size Distributions Following Indoor Episodic Releases: Relative Importance of Coagulation, Deposition and Ventilation**. *Aerosol Science and Technology*, 2011; DOI: 10.1080/02786826.2011.639317

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