3D printers shown to emit potentially harmful nanosized particles

July 24 2013

A new study by researchers at the Illinois Institute of Technology shows that commercially available desktop 3D printers can have substantial emissions of potentially harmful nanosized particles in indoor air. The study, which was recently published in the journal *Atmospheric Environment*, is the first to measure airborne particle emissions from commercially available desktop 3D printers. Desktop 3D printers are now widely accessible for rapid prototyping and small-scale manufacturing in home and office settings. Many desktop 3D printers rely on a process where a thermoplastic feedstock is heated, extruded through a small nozzle, and deposited onto a surface to build 3D objects. Similar processes have been shown to have significant aerosol emissions in other studies using a range of plastic feedstocks, but mostly in industrial environments.

In this work, assistant professor Brent Stephens and graduate students in his Built Environment Research Group in the Department of Civil, Architectural and Environmental Engineering at Illinois Institute of Technology in Chicago, IL measured ultrafine particle concentrations resulting from the operation of a single type of popular commercially available desktop 3D printers inside an office space. Ultrafine particles (or UFPs) are small, nanosized particles less than 100 nanometers in diameter. The printers were used to print small plastic figures during normal operation. The resulting concentration measurements were then used to estimate UFP emission rates from these printers.

Estimates of emission rates of total UFPs were high, ranging from about

20 billion particles per minute for a 3D printer utilizing a lower temperature polylactic acid (PLA) feedstock to about 200 billion particles per minute for the same type of 3D printer utilizing a higher temperature acrylonitrile butadiene styrene (ABS) feedstock. The emission rates were similar to those measured in previous studies of several other devices and indoor activities, including cooking on a gas or electric stove, burning scented candles, operating laser printers, or even burning a cigarette.

Human inhalation of UFPs may be important from a health perspective. UFPs deposit efficiently in both the pulmonary and alveolar regions of the lung, as well as in head airways. Deposition in head airways can also lead to translocation to the brain via the olfactory nerve. The high surface areas associated with UFPs also lead to high concentrations of other adsorbed or condensed compounds. Several recent epidemiological studies have also shown that elevated UFP number concentrations are associated with adverse health effects, including total and cardio-respiratory mortality, hospital admissions for stroke, and asthma symptoms.

In addition to large differences in emission rates observed between PLA- and ABS-based 3D printers, there may also be differences in toxicity because of differences in chemical composition of the feedstocks and UFP byproducts. Thermal decomposition products from ABS processing have been shown to have toxic effects in mice and rats in previous studies; however, PLA is actually known for its biocompatibility in humans. PLA nanoparticles are even widely used in drug delivery.

Because most of these devices are currently sold as standalone devices without any exhaust ventilation or filtration accessories, the researchers suggest caution should be used when operating in inadequately ventilated or unfiltered indoor environments. They also recommend that more controlled experiments be conducted to more fundamentally evaluate particle emissions from a wider range of desktop 3D printers.

More information: *Atmospheric Environment*, 2013. DOI: 10.1016/j.atmosenv.2013.06.050.