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3D Printing Emissions and Their Impact on Health and Indoor Air Quality

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ABSTRACT

Users of 3D printers are aware of and are showing concerns over 3D printer emissions, especially when used in environments like schools, offices and residences. 3D printing is found to emit particles and volatile organic compounds (VOCs) that can deteriorate indoor air quality and are known to have adverse health effects, which was presented last year. In particular, ultrafine particles, which are nanometers in size, can enter into human bodies and cause adverse health effects; some VOCs emitted from 3D printing are known to be odorants, irritants, toxins, and/or carcinogens.

This talk extends beyond last year's presentation by focusing on particle and VOC emissions from various 3D printing technologies and print materials. Study focus includes consumer level fused filament fabrication 3D printing with various thermoplastics and thermoplastics with additives of colouring dyes, metals, and flame retardants, and desktop vat photopolymerization 3D printing with resins. The emission levels of particle and VOC from various 3D printers and print materials are measured using a standardized test method in a controlled environmental chamber. Emissions are characterized depending on printer type, print material type and specific feedstock additives, and post-processing methods. Other concerning airborne emissions like metals and flame retardants are also analysed. Potential health impacts of particle emissions are estimated based on various toxicity assessment assays. Exposure hazards in different indoor environments are estimated using an indoor air model.

SIGNIFICANCE/IMPORTANCE

This study covers two types of 3D printing technologies and various print materials and additives, which will expand the current understanding on the emission profiles that mainly focusing on fused filament fabrication 3D printing with thermoplastics. The study includes emissions from various newly available print materials associate with metal, carbon fiber, and flame retardants, which have not been studied thoroughly before. Emissions from vat photopolymerization 3D printers have not been reported yet and will be included in this study.

Emissions from 3D printing are specific to the technology and some emissions are newly introduced to non-occupational environments. Ultrafine particles and some VOCs are known to have adverse health impacts, however, the potential health impacts of those emitted from 3D printing are not yet well-known. This study applies in vivo animal exposure, in vitro cellular assays and an in vitro chemical assay to assess potential impacts of exposure to 3D printer emitted particles. Concerning materials, like metals, are also studied to reveal their association with emission levels as well as health impacts. Exposure hazards in indoor environments using 3D printers have not been well understood, this study estimates potential exposure levels of particles and VOCs using a model with different indoor environmental scenarios. Potential health impacts of exposures are estimated based on experimental results and compared to ambient studies and recommendations/regulations for indoor air quality.

BENEFITS/TAKE AWAYS

1. Understand particle, VOC, metal, carbon fiber, and flame retardant emissions resulting from 3D printing and what affects their levels.
2. Understand how to operate 3D printers in the way to minimize exposures.
3. Learn specific chemicals of concern based on health impact and emission levels, that should be eliminated from 3D printing.