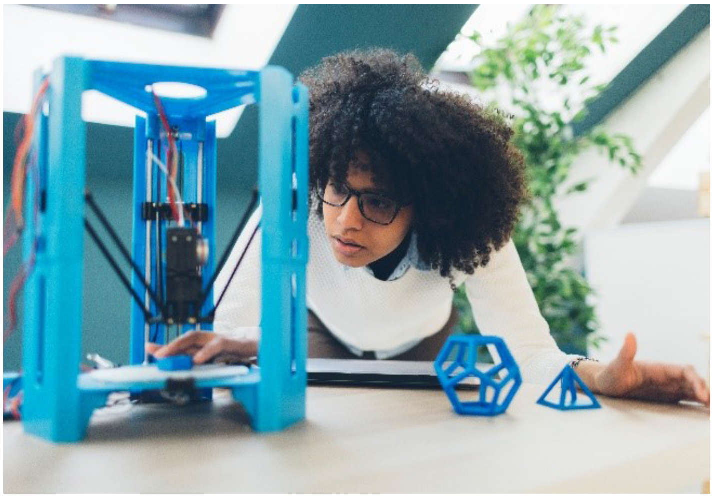
Measuring Byproducts of 3D Printing



Three-dimensional (3D) printers have gained wide popularity, with an estimated compounded annual growth rate of 44%[1], as the cost and size of units has decreased. 3D printing allows for small scale manufacturing and swift prototyping in many different sectors ranging from consumer products, automotive, electronics, medicine, aerospace, and education. With the affordability of the 3D printers being introduced to the market, they are no longer exclusive to industrial applications and are now accessible for manufacturing even in homes and schools. This trend has resulted in more printers being in close proximity to sensitive populations, such as children. The growing number of 3D printers has raised an increased focus on the health effects caused by off-gassing of volatile organic compounds (VOCs) and emitting particulates. A study conducted by the Centre for Research Expertise in Occupational Disease (CREOD) in Toronto concluded that occupants with regular exposure to 3D printers had an increased risk of respiratory health effects with 57% experiencing respiratory symptoms more than once a week in the past year; 22% had physician-diagnosed asthma; and 20% experienced headaches[2].

Three-dimensional printers, in a process also known as additive manufacturing (AM), use a heated nozzle that melts thermoplastic filaments and applies a thin layer across a moving baseplate. Once the layer is cooled, the baseplate moves to the next layer[3]. This process continues until the 3D shape is fully formed. When the printer is initially turned on, they introduce an increased level of particles, primarily nanoparticles (<100 nm in diameter). After this, the concentrations typically stabilize[4]. Nanoparticles can be inhaled into the deepest parts of the lungs causing respiratory and cardiovascular diseases.

Three of the most common thermoplastics used are acrylonitrile-butadiene-styrene (ABS), polylactic acid (PLA)[5], and nylon[6]. When the filaments are heated, they can off-gas VOCs. Many VOCs are irritants that can cause burning of the eyes and throat, headaches, and confusion. In some cases, VOCs are known carcinogens. In one study no less than 200 different VOCs were detected coming from the printers[7].

There are different approaches to reducing the concentration of VOCs and nanoparticles to the occupants. Installing photocatalytic filters will help mitigate VOC emissions. Another recommended practice is utilizing respirators while a 3D printer is in operation. But by far the most common approach is ensuring there is adequate ventilation in the area that the 3D printer is located.

The air quality should be checked in the specific locations and in areas nearby to where 3D printers are being used. Samples of the air can be taken and sent out for laboratory analysis, but this process is expensive and time consuming. Nanoparticle counters can be purchased to measure particulate in real-time, but these units are prohibitively expensive.

The most practical solution for ensuring adequate ventilation is to measure the VOCs with a GrayWolf photoionization detector (PID). These devices will not speciate the individual VOCs present but will show the total VOCs (TVOC) present. GrayWolf TVOC probes offer realtime results and elicit a response from most of the VOCs that are of concern when off-gassed during 3-D printing. Data-logging capabilities allow for tests to be run before, during, and after printing has commenced to detect variations in TVOC concentrations. GrayWolf's software allows recording of "events" to timestamp the data when the printing process was started and stopped. The probes

[1] Alto, P. (2015). Global 3D printing market to reach $20.2 billion in 2019 | Canalys. Retrieved from http://www.canalys.com/newsroom/global-3d-printing-market-reach-202-billion-2019.
[2] Johnson, L. (2018). Are 3D Printers Bad for Worker Health?. Canadian Occupational Safety. Retrieved from https://www.cos-mag.com/occupational-hygiene/35967-are-3d-printers-bad-for-worker-health/
[3] Mendes, L. (2017). Characterization of Emissions from a Desktop 3D Printer. Retrieved from https://onlinelibrary.wiley.com/doi/full/10.1111/jiec.12569
[5] Ragan, S. (2013). Plastics for 3D Printing. MAKE: Ultimate Guide to 3D Printing, 22
[6] MatterHackers. (2015). 3D Printer Filament Comparison. Retrieved from https://www.matterhackers.com/3d-printer-filament-compare
[7] Dvorsky. G. (2018). New Study Details Toxic Particles Spewed by 3D Printers. Retrieved from https://gizmodo.com/new-study-details-all-the-toxic-shit-spewed-out-by-3d-p-1830379464

are quite simple to calibrate prior to a test to ensure confidence in the readings. User cal data, together with factory cal info is easily printed to include with any documentation that might be issued with the testing.

AdvancedSense® Pro with DSII VOC Probe

Easily handheld, the DirectSense II VOC probe may alternatively be wall-mounted, set on a desk or mounted to a tripod. Additional sensors, for ancillary parameters, may also be installed. Further, GrayWolf's companion Cloud Application; GrayWolfLive®, can be utilized to monitor the readings remotely from a web browser, on just about any internet connected device.

WiFi enabled DSII VOC Probe displaying on smartphone via GrayWolfLive®

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