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Assessment of Exposure to Volatile Organic Compounds (VOCs) during 3D Printing in Laboratory Settings at East Carolina University

Background

- 3D printing involves the extrusion of melted thermoplastic feedstock through heated nozzle onto a moving baseplate to create virtually any 3D solid shape.
- Previous studies have shown that both volatile organic compounds (VOCs) and ultrafine particles are emitted during high temperature thermal processing of thermoplastics.
- East Carolina University (ECU) is currently expanding on the use of 3D printing because of its promising application in varying fields of study.

Purpose of the Study

- To measure the airborne VOC concentrations during 3D printing operations in ECU laboratories
- To determine the differences in VOC concentrations by location and the type of feedstock used

Significance of Study

- 3-D Printing is becoming more of a technology commodity, and is being used a lot more in schools. Thus, it is important to ensure the safety of teachers, staff and students.
- The public can easily gain access to 3D printing technologies and, thus, it is also important to ensure safety of the general population.

Methods

- 3D Printer used: Creator Pro™ Dual Pro *(Figure 1)*
- 2 types of feedstocks used:
  - Polylactic acid (PLA)
  - Acrylonitrile butadiene styrene (ABS)
- 2 laboratory room locations
  - Big ventilation room: S&T SZ-148 *(Figure 3)*
  - Small non-ventilation room: S&T 134A *(Figure 4)*
- Real-time total volatile organic compound (TVOC) concentration was continuously measured using a photoionization detector (PID) *(Figure 5).*
- Air samples were collected in TO-15 stainless steel canisters for the analysis of specific VOCs (SVOCs) *(Figure 6).*

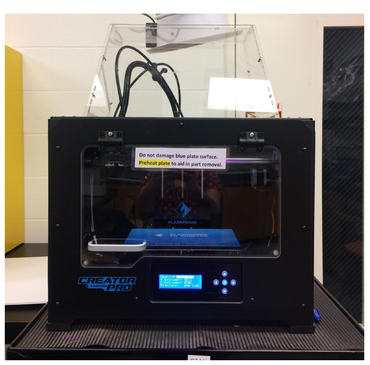

Figure 1. *Creator Pro™ Dual Pro 3D Printer*

Figure 2. *3D-Printed Prototype*

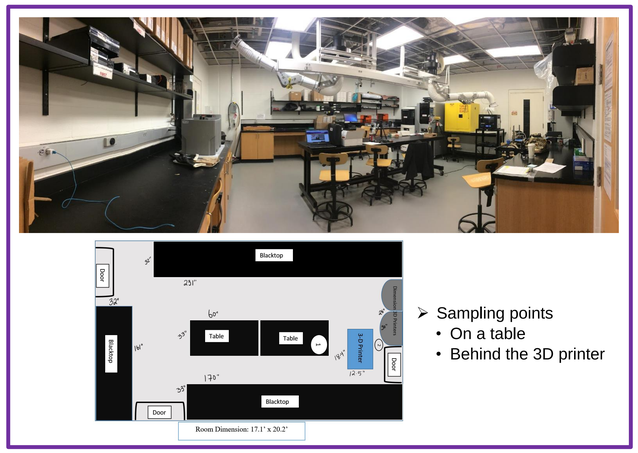

Figure 3. *Lab Room SZ-148*

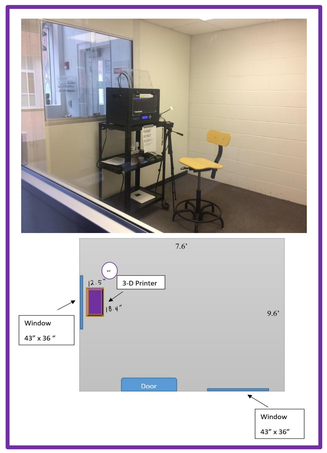

Figure 4. *Lab Room 134A*

Figure 5. *ppbRae photoionization detector*

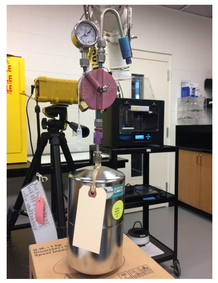

Figure 6. *TO-15 stainless steel canister*

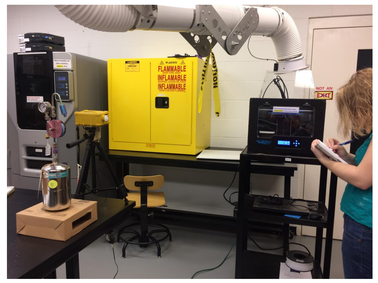

Figure 7. *Sampling set-up at Lab SZ-148*

Results

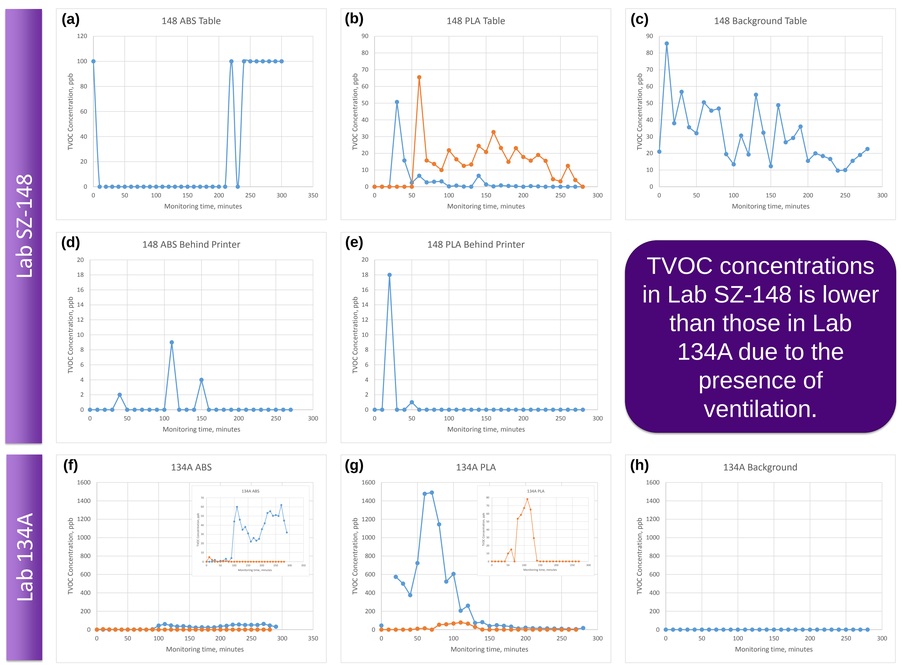

Figure 8. *Total volatile organic compound (TVOC) concentration by location and feedstock type*

Results, cont'd

Lab SZ-148

- TVOC concentrations ranged from 0.0 – 9.0 parts per billion (ppb) when using ABS feedstock, and from 0.0 – 50.7 ppb when using PLA feedstock.
- The background TVOC was not zero, which indicated other sources of VOCs aside from the 3D printer when measured from the table *(Figure 8c)*.
- A peak in TVOC level was observed while monitoring from behind the printer during PLA feedstock pre-heating period (about 18 ppb).
- No ABS chemicals were detected during the use of ABS feedstocks but other VOCs (e.g. isopropyl alcohol, ethanol, acetone) were detected.
- Specific VOCs (SVOCs) measured were well below their corresponding occupational exposure limits (OELs).

Lab 134A

- TVOC levels for both ABS and PLA were relatively low; PLA peak is observed between the 50-100 minute time period *(Figure 8g)*.
- Maximum peak TVOC measurement obtained from Lab 134:
  - ABS feedstock: 62 ppb
  - PLA feedstock: 1491 ppb
- No TVOC was found in the background, which implies that there are no other VOC sources *(Figure 8h).*

Conclusion

- The Creator Pro 3D printer emits VOCs at concentrations lower than existing occupational exposure limits.
- Application to other ECU scenarios
  - Similar scenario to SZ-148 (e.g. library) may not need local exhaust ventilation during the use of 1 3D printer.
  - ECU locations with multiple 3D printing operation (e.g. Innovation lab with 30 printers) need further VOC exposure assessment.
- The use of PLA feedstock may emit VOCs as decomposition products (e.g. aldehydes) during pre-heating.

Recommendations

- Conduct further exposure assessment on:
  - TVOCs during the use of >1 3D printer in SZ-148 and 134A (both using ABS and PLA feedstocks)
  - TVOCs and SVOCs in ECU Innovation Lab (multiple printers)
  - Specific VOCs during 3D printing using PLA to investigate observed TVOC peaks

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