Zimpure Evaluation on Zortrax M200 with ABS

ABSTRACT

An increasing interest in desktop 3D printers for prototyping, tooling or building commercial objects has been observed during the last past years. These printers are now commercially available, and they are intensively used in closed offices or rooms.

Recently numerous studies have shown that commercially available desktop three-dimensional printers with single or multiple filaments are Particulate Matter (PM) and Volatile Organic Compounds (VOCs) big emitters. The particles emitted are often in the ultrafine mode below 2.5 µm (PM2.5) or ultrafine mode below 1 µm (PM1). The gases emitted have molecular masses up to 180 $g.mol^{-1}$. This complex mixture which is produced during the heating phase and the printing process is particularly toxic and is thermoplastic dependent. During the extrusion and the deposition process of Acrylonitrile Butadiene Styrene (ABS), the average particles concentration found for the 3D printer tested was 373 539 $nb\#.cm^{-3}$ and 78 part per billion (ppb) for the identified gases. The average aerodynamic particle size diameter (AD) has been found to be in the Ultrafine Particle range (HFP, <100 nm).

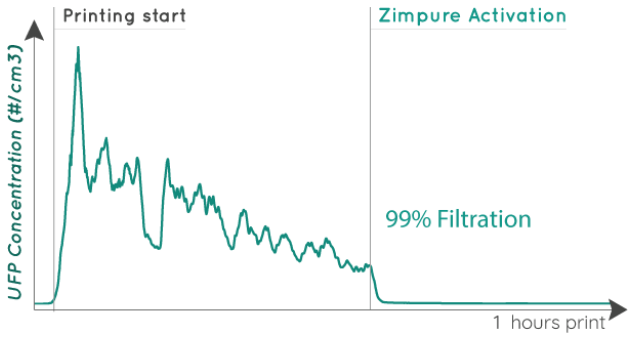
To reduce the health impact and the indoor production of PM and VOCs of these printers, a compact and low-cost filtration device has been developed. This filter combines a total filter coupled with a charcoal membrane. The results obtained have shown that the device removes 99% of the ultrafine particles and more than 90% of the gases. This study suggests that a cleaning process must be implemented in each 3D printer to reduce the health impact of the end user.

Open configuration:

To know if Zimpure filtration and suction was good enough to provide an efficient filtration rate in an open configuration on both UFP and VOC, the nanoparticles counter and the mass spectrometer probes were placed directly above the printer, while the 3D printer was printing.

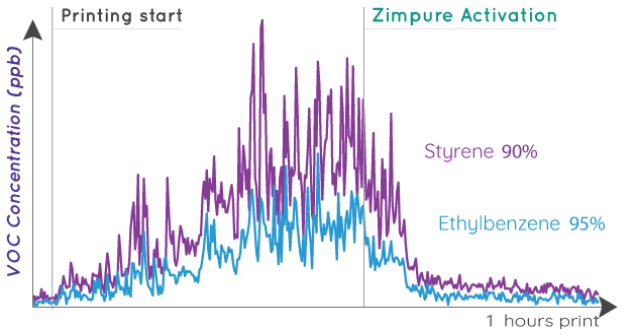
The experience starts without Zimpure, and then Zimpure is turned ON to see its efficiency.

UFP filtration rate



- Average UFP Concentration without Zimpure:
  - UFP: 246 639 (#/cm3)
- Average UFP Concentration with Zimpure:
  - UFP: 2 289 (#/cm3)
- Efficiency:
  - *UFP: 99,07%*

VOC filtration rate



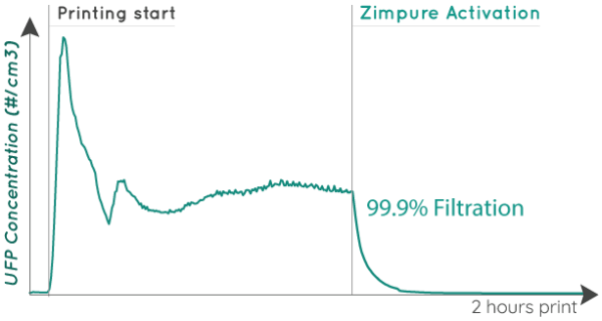
- Average VOC concentration without Zimpure:
  - Styrene: 9.51 (ppb)
  - Ethylbenzene: 7.97 (ppb)
- Average VOC concentration with Zimpure:
  - Styrene: 0.936 (ppb)
  - Ethylbenzene: 0.402 (ppb)
- Efficiency:
  - *Styrene: 90.15%*
  - *Ethylbenzene: 94.96%*

Closed configuration

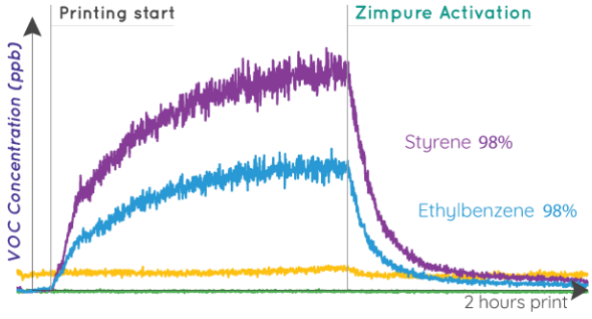
In order to check Zimpure filtering efficiency, life time and stability, Zimpure has been tested in a closed and controlled environment. Zimpure was placed inside a box, with both nanoparticles counter and mass spectrometer probes.

The experience starts without Zimpure, and then Zimpure is turned ON to see its efficiency.

UFP filtration rate



VOC filtration rate



- Average UFP Concentration without Zimpure:
  - UFP: 373 539 (#/cm^3)
- Average UFP Concentration with Zimpure:
  - UFP: 170 (#/cm3)
- Efficiency:
  - *UFP: 99,9%*

- Average VOC concentration without Zimpure:
  - Styrene: 78 (ppb)
  - Ethylbenzene: 45 (ppb)
- Average VOC concentration with Zimpure:
  - Styrene: 1.38 (ppb)
  - Ethylbenzene: 0,79 (ppb)
- Efficiency:
  - *Styrene: 98.2%*
  - *Ethylbenzene: 98.2%*

Settings

All these experiences were made on a Zortrax M200 with ABS filament, with the following print settings:

- Layer height : 0.19mm
- Material: Zortrax ABS
- Nozzle diameter: 0.4mm
- Printer : Zortrax M200

A cube of 32cm^3 was printed in order to have the same extrusion flow during all the printing process.

The complete test report is available here.

CONCLUSION

Considering this study and the numerous other studies published these last five years concerning FFF 3D printers and particles emissions, there are enough scientific contents to be aware of this issue. In the industry, standards and solutions are available for every process of material fusion, included thermoplastic fusion. That's why it is possible to transpose it to personal 3D printers which are manufacturing boxes in the office, at home and even at school. Solutions exist, as you can see regarding the results of this study: Zimpure is a filtering system that can be implemented in each 3D printer, and its efficiency is now proved.

To conclude, 3D printing is a technology which is going to have more and more impact on our society. It has a positive contribution towards medical breakthrough and to the whole industry concerning tooling, prototyping and production. It is also an educative instrument. More and more schools decide to acquire 3D printers in order to develop innovative and stimulating projects with students. This issue must be considered and treated seriously in order not to slow such a revolution. Zimpure is the first 3D printing filtering solution that has been tested to solve this issue, and that could be compatible with all the 3D Printers.