Objective of the project

The aim of the proposed research is to develop a comprehensive method for real-time monitoring of volatile organic compounds emission during 3D printing, and to identify the compounds generated during the melting of 3D printing filaments in order to assess the user's exposure. The emission rate of the particular identified volatile compounds throughout the printing process will also be determined.

Rationale behind choosing the research topic

Desktop 3D printers are increasingly popular among amateur users, making their way to households and classrooms, where proper ventilation standards are not always enforced. They use polymer material, usually in the form of filament spools, which is melted as it is passed through a heated extruder and then solidifies upon deposition in strata to gradually form the desired object. The temperature of the extruder can be regulated to match the melting point of a particular filament, and can reach 280°C. This process has enabled end users to manufacture complex polymer objects at home and within a relatively short period of time, hence the increasing popularity of this technology. However, there is very little information regarding the potentially harmful volatile organic compounds which are emitted due to the printers operation. Both the nature and the volume of particular chemicals generated during 3D printing remains mostly an unknown, and so there is no good way to assess the user's exposure and the long-term impact of 3D printing on human health. This is due to the fact that there are no reliable methods which would enable real-time monitoring of the emission of particular compounds during the melting of plastic filaments. The development of an analytical procedure which could be used to monitor changes in the composition of fumes emitted during 3D printing would allow a better understanding of the formation of volatile compounds in this process.

The solution could be to use a device which allows the monitoring of concentration of a wide range of volatile organic compounds in real time, without the need for sample preparation and characterized by high sensitivity. The proton transfer reaction mass spectrometer coupled with time-of-flight analyzer is precisely such a device. However, proton transfer reaction mass spectrometry has some limitations, the most important being the lack of accurate identification of chemical compounds. To solve this problem, in this project comprehensive multi-dimensional gas chromatography coupled with time-of-flight mass spectrometry will be used. With it, it will be possible to determine the exact composition of the fumes generated during 3D printing. The developed methodology will enable a comprehensive assessment of the user's exposure to potentially harmful chemical substances during 3D printing using a variety of materials. The tandem use of both analytical techniques will enable simultaneous, qualitative and quantitative determination of volatiles in real time.

The results of this project will facilitate the development of new 3D printing materials and printer designs that limit the user's exposure to volatiles. The collected data will be of use in applied research areas such as medicine (long-term exposure risk assessment) or manufacturing (new 3D printing materials). The filament manufacturers have focused on improving the structural and mechanical properties of the materials and not on minimising the user's exposure risk not because they are unaware of the potential hazards, but because of the lack of data regarding the emission of volatile organic compounds during printing and methods to assess it.