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MICRO PHOTO IONIZATION DETECTOR FOR BTEX ANALYSIS: REVIEW REPORT OF PERFORMANCE INFLUENCING PARAMETERS

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ABSTRACT

Volatile Organic Compounds (VOCs) are gaseous chemical species emitted from solids and liquids that may cause short and long term adverse health effects. They are present in both outdoor and indoor air. In open environments, automotive exhausts and industrial waste are major sources of VOCs. They are also emitted from building materials, varnishes, paints, solvents, etc. [1]. Within the VOCs, BTEX (benzene, toluene, ethylbenzene, xylenes) are of greatest concern due to their health effects. Benzene, for example, is highly carcinogenic and the World Health Organization reports no safe level of exposure [2].

Gas chromatographs (GC) monitor air quality and can detect VOCs, these equipment are heavy, lab-based and non-portable. In 2016, Nasreddine [3] reported a miniaturized gas analyzer that can detect BTEX at ppb levels and weights 4 kg. In order to further reduce the size of this equipment and the consumption of carrier gas, its main components must be miniaturized and operate under low gas flow rate. The detector is one of the main components of the gas chromatograph, responsible for quantifying the chemicals sampled. This paper is centered on the type of detector named photo ionization detector (PID). The objective of this work is to present the main factors that affect the analytical PID performance. The information summarized here should be used as guidelines to design a future micro PID.

Fig. 1 shows the basic elements of a photo ionization detector. In this device, a gas sample containing the chemicals flows through the ionization chamber, where photons emitted by the ionization source (UV lamp and window) reach the sample molecules. As a general rule, if the ionization energy of the photon is greater than the ionization potential of the molecule, ionization occurs. The electrodes establish then an electric field in the ionization chamber where the ionized molecules generate an ionization current proportional to the concentration of molecules in the gas sample.

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The performance of the PID is affected by design choices at the ionization source, ionization chamber and electrodes. The ionization source is selected according to the desired photon energy output, considering the target compounds to be detected. In theory, an ionization source with energy greater or equal to 9.3 ionizes all the BTEX molecules. However, Driscoll and Duffy [4] suggests to use the 10.2 eV ionization source since it has the highest photon flux resulting in high PID sensitivity. The ionization chamber should ensure uniform flow, otherwise the sensitivity of the PID is reduced [5]. Besides that, the ionization chamber volume should be as low as possible to reduce response time, thereby increasing sensitivity. A small volume also avoids remixing of organic species that have been previously separated in the gas chromatograph and ensures uniform ionization of the sample, contributing positively to the linearity and sensitivity of the signal. The electrodes inside the ionization chamber directly influence the ion collection efficiency, which affects the sensitivity of the PID. Important electrode design aspects influencing the ions collection efficiency are the electric field in the ionization chamber, the area of the electrodes and the position of the electrodes in the ionization chamber [5].

Micro and nanofabrication techniques can be used to miniaturize the PID with the possibility to improve its performance [5,6]. In the future, a micro PID design will be proposed and the most suitable micro and nanofabrication technique for its fabrication will be evaluated. The new design will be based on the major guidelines presented in this work with focus in diminishing both the ionization chamber volume and the associated gas flow rate while maintaining low detection limit. The prototype will be evaluated and compared to commercial PIDs.

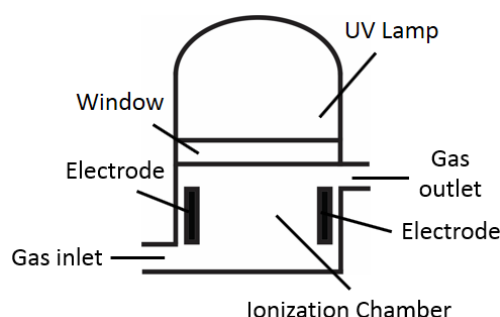


Figure 1: Photo ionization detector main elements.

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