

# CHAPTER 1

## INTRODUCTION



### 1.1 Volatile Organic Compounds (VOCs)

Volatile organic compounds (VOCs) are organic molecules with vapor pressure greater than or equal to 0.01 KPa at 25<sup>0</sup>C (0.1mmHg at 20<sup>0</sup>C) that easily vaporize at room temperature, and are a concern as air pollutants [1]. Compound having boiling point below the ambient temperature such as ethane and acetylene are included in this class, as well as those which are volatile liquids at room temperature, such as, benzene and acetone. The class includes liquids which boiled in the vicinity of 250<sup>0</sup>C. They are known to be toxic, carcinogenic, mutagenic and harmful to human health. They may cause eyes, nose and throat irritation, headache, nausea, loss of co-ordination and damage to liver, kidney and central nervous system. VOCs consist of both aromatic and aliphatic hydrocarbon. Aromatic compounds such as benzene are known as human carcinogens. Moreover, VOCs are also ozone precursors which participate in photochemical reactions in the atmosphere resulting in smog formation [2-3]. Smog causes environmental damage, respiratory problems and lead to global warming. In 1990, The United States Environmental Protection Agency (US.EPA), and the Clean Air Act Amendments (CAAA) classify many of them as hazardous air pollutants [4]. The effects of VOCs exposure depends on several factors including type, amount of VOCs and duration of exposure. There are several major sources of VOCs, such as fossil energy use, automobile exhaust and industrial activities. The VOCs generating chemicals are used in various industrial processes such as ingredient in plastic, cleanser, disinfectants, cosmetics, pharmaceutical, and paints manufacturing [5]. Improper handling and disposal deteriorate

the environment by their contamination in air, soil and water. Therefore, the measurement of trace level VOCs in air, soil and water are of significant importance.

Normally, the measurement of trace VOCs in water include sample preparation followed by either Gas Chromatography Flame Ionization Detector (GC-FID) or Gas Chromatography with Mass Spectrometry (GC-MS). . The conventional sample preparation techniques for VOCs in water include static head space analysis (HS), dynamic head space extraction (P&T), and solid phase micro-extraction (SPME). These conventional methods provide excellent analytical results, however purge and trap is the most widely used because of its low detection limit and high precision. The disadvantage of this method is mainly used as laboratory method, it can not be used for continuous, on line monitoring.

## **1.2 Research Objectives**

The objective of this research was to develop an on-line purge and trap system for continuous monitoring of VOCs in water. The requirement was to able to monitor trace levels of VOCs. The motivation behind such a development is to eliminate contamination and other errors that can be introduced during sampling and transportation. This approach is attractive for process control to detect and correct problems at near real time. The on-line system eliminate the problems of storage and transportation of samples during sampling and analysis. On the whole, this technique is simple and inexpensive. In this research the purging is carried out continuously while the microtrap is used for on-line concentration and injection. The P&T is a faster technique because it does not need to reach equilibrium. Consequently, it is more suitable for a continuous, on-line system. The microtrap has been developed as an on-line, sample preconcentration and

injection device for continuous monitoring of low level organics. It has been used in both air and water analyses.

The other objective of this research was to evaluate novel microtrapping materials, such as, carbon nanotubes. The CNTs can be synthesized by laser ablation, electric arc or chemical vapor deposition (CVD). CVD was selected as the technique of choice because it was good for a direct self-assembly. The microtrap could be fabricated by the deposition of the CNT film on the wall of a steel capillary. The deposition could be done by a chemical vapor deposition (CVD) from either CO or C<sub>2</sub>H<sub>4</sub> as the precursor. The application of self-assembled CNT film in the nanoscale adsorption/desorption of VOCs is investigated. This technique was aimed at developing a microtrap which could be used in the purge and trap mentioned above, or similar applications. Trace (parts per million, ppm) levels of organics are allowed to be adsorbed and concentrated on the CNTs, and then desorbed for detection. This technique was expected to be simple and inexpensive.

In summary the objective of this research was for three folds:

- . To develop on-line purge and trap for continuous monitoring of VOCs in water.
- . To develop a microtrap by deposition of CNT film on the wall of a steel capillary.
- . To evaluate the CNT microtrap.

### **1.3 Scope of study**

The focus of this research is two fold. . The first one is to develop an continuous, on-line purge and trap system. Purging chamber was designed to run in a continuous, on-line mode. This designed chamber was connected with microtrap which acted as a preconcentrator and injector device. The purging part was connected with microtrap by

ten-port valve. The operating conditions were optimized and system was tested with synthesis water samples.

The second part was to improve the efficiency of microtrap by development of CNT microtrap. The CNT microtrap was made from self-assembled carbon nanotube as a thin film on the inside wall of steel capillary. CO and C<sub>2</sub>H<sub>4</sub> were selected as carbon sources. The optimum conditions for synthesis of CNT was characterized by SEM and the performance was evaluated using VOCs mixtures.