

## 1. Introduction

Chlorination is the most widely practiced disinfection technique since it has dramatically reduced the incidence of waterborne diseases, and improved the quality of life [1]. However, chlorination of drinking water has been identified as contributing to the formation of a wide variety of disinfection by-products (DBPs). With this has come public concern regarding adverse health effects, since numerous DBPs including some haloacetic acids are toxic and cancer risks [2, 3], leading to the increased regulation of DBPs in drinking water.

Currently, five haloacetic acids (HAAs) are regulated by the US Environmental Protection Agency (EPA) [4]. These are monochloroacetic acid, monobromoacetic acid, dibromoacetic acid, dichloroacetic acid and trichloroacetic acid. A level of  $60 \mu\text{g l}^{-1}$  has been introduced for the sum of these five chemicals, under Stage 1 of D/DBP Rule [5]. Water utilities in the US must comply with ruling or else face heavy penalties. While, there are non-mandatory guidelines in several countries, such as Canada and Australia. In spite of having safe drinking water laws, inadequate funding for enforcement may cause non-compliance, which this is a problem found in several other countries. In addition, the use of additional water purification systems for the post-treatment of chlorinated water is not always helpful for extracting any residual DBPs. Therefore, the use of chlorinated disinfectants in the purification of water calls for the measurement of HAAs as well as other DBPs in drinking water. The traditionally practiced methods for the direct determination of carboxylic acids by electrochemical methods give poor specificity. More sophisticated methods for the specific

determination of HAAs, such as LC-MS, GC-MS and CE, need lengthy procedures, expensive and bulky equipment with a high power demand and well-trained operators for the instrumentation. It is therefore necessary to develop a simple and fast screening method, capable of complementing the established methods; numerous samples can be collected and further verified with established methods for the “positive” samples, so that the number of samples required is reduced. Apart from that, analysts at drinking-water utilities could screen any water having a possible risk of DBPs contamination without high skill levels. For such prospect, the use of sensors seems to be the most promising means to give fast, cheap, simple and continuous measurements.

A sensor is defined as an analytical device incorporating a sensing element that is intimately connected to a transducer, which may be electrochemical, optical, piezoelectric, magnetic or thermometric [6]. To date, many sensors have been developed for determining particular substances, including environmental pollutants and clinical substances. A wide variety of naturally occurring recognition systems (such as cells, antibodies, enzymes, and receptors) are commonly used as sensing elements in sensor technology. Besides these, artificial recognition materials such as molecularly imprinted polymers have also found for the use in sensors [7-10]. A molecularly imprinted polymer (MIP) is a synthetic polymer possessing selective molecular recognition properties because of recognition site within the polymer matrix that are complementary to the analyte molecule in the shape and positioning of functional groups. It is well known that the stability of MIPs is superior to that of biological recognition materials, so that a sensor modified with a MIP is easily stored and operated and has a long lifetime. Recently, a conductometric sensor combining the

specificity of MIP with the high sensitivity of an electrochemical transducer was developed for detection of atrazine and its derivatives [7-9]. The advantages of conductometric sensors that they are simple and relatively cheap because they do not need any reference electrode. Also, they can be simply assembled using membrane technology, which suits them for large-scale production.

The aim of this work was to develop a fast and sensitive screening method based on conductometric sensors for detection of HAAs in drinking water. To explore a sensing element for HAAs, TCAA-imprinted (and non-imprinted polymers) were prepared by either bulk polymerization (BP) or by multi-step swelling polymerization (MSP); both types of imprinted polymer were examined for their recognition ability, using non-imprinted polymers for the control experiments. The selective response of the conductometric sensors having the TCAA-imprinted polymers as sensing elements was investigated. Moreover, the sensor giving high cross-reactivity with the widest range of HAAs was determined in calibration characteristics (sensitivity, operational and linear concentration range and detection determination limits). The constructed sensor was used for the analysis of drinking water. The recovery of the analyte in spiked water samples was scrutinized and the results were verified by liquid-liquid extraction combined with gas chromatography-electron capture detector (LLE-GC-ECD).