MICROFLUIDICS WITH ON-LINE MASS SPECTROMETRIC METHODS FOR INVESTIGATION OF REACTION MECHANISMS

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ABSTRACT

A measurement set-up using a microchip for on-line mass spectrometric investigations of reaction mechanisms using either electrospray ionization or atmospheric pressure photoionization is presented.

KEYWORDS: On-line reaction monitoring, Electrospray ionization, Atmospheric pressure photoionization

INTRODUCTION

Miniaturized flow chemistry systems exhibit numerous advantages, such as short reaction times, compared to traditional macro size systems. In addition, they are environmentally friendly and allow safer use of dangerous reagents [1]. A simple set-up for reaction mechanism studies combining a microchip on-line with mass spectrometric (MS) detection with two ionization methods is presented (Figure 1).

EXPERIMENTAL

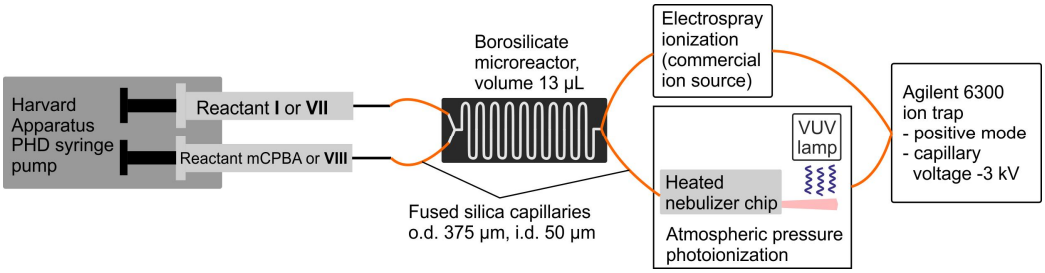
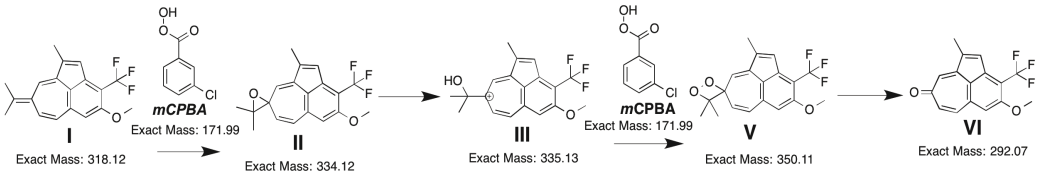


Figure 1: The experimental set-up used in the measurements.

A microchip (Micronit Microfluidics BV, The Netherlands) was used as a microreactor chip. The outlet of the microreactor chip was connected either to a commercial electrospray ionization (ESI) ion source or to a heated nebulizer (HN) chip [2] for atmospheric pressure photoionization (APPI). The concentration of the starting materials (**I** and *meta*-chloroperoxybenzoic acid [*m*CPBA], Scheme 1, and **VII** and **VIII**, Figure 3a) were 100 µg/mL in acetonitrile. For the experiments in Scheme 1, 0.1% acetic acid was added.

RESULTS AND DISCUSSION

Scheme 1 shows the conversion of heptafulvene **I** into tropone **VI** studied using the microfluidic set-up with ESI-MS. The synthesis of the compound **VI** from **I** has been reported previously using traditional methods [3]. A similar reaction has been studied earlier with off-line detection using micropillar array ESI (µPESI) [4]. Here the MS measurements were conducted on-line. Figure 2 shows ESI MS spectra measured for the reaction mixture using flow rates 20 µL/min and 1 µL/min. In both mass spectra, the ions corresponding to the reaction intermediates **II** or **III** (*m/z* 335) and **V** (*m/z* 351) are seen. Compound **V** is an intermediate, which has not been observed before. In the mass spectrum measured using the longer in-chip residence time (Fig. 2b) the reaction product **VI** is seen at *m/z* 293.



*Scheme 1: Conversion of heptafulvene **I** into tropone **VI.***

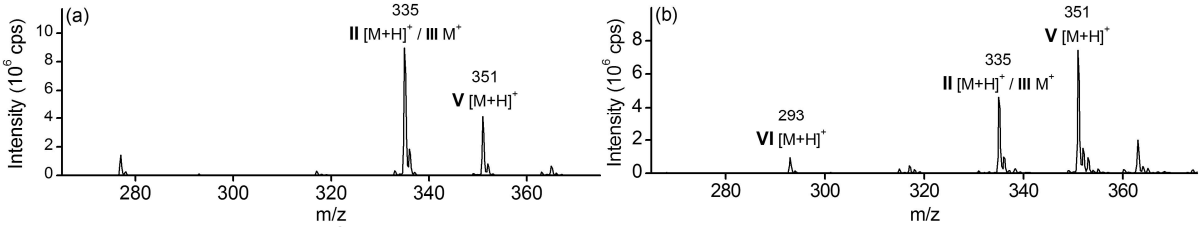


Figure 2: ESI mass spectra for the reaction in Scheme 1. Flow rates were a) 20 µL/min and b) 1 µL/min.

Figure 3 shows an esterification reaction and an APPI MS spectrum obtained for the reaction. In the measured mass spectrum, the starting material **VII** and the reaction product **IX** are seen. These results demonstrate great potential of the HN chips for reaction mechanism studies using microfluidics, since unlike with commercial APPI sources, the HN chips allow the use of flow rates which are typically used in microfluidics.

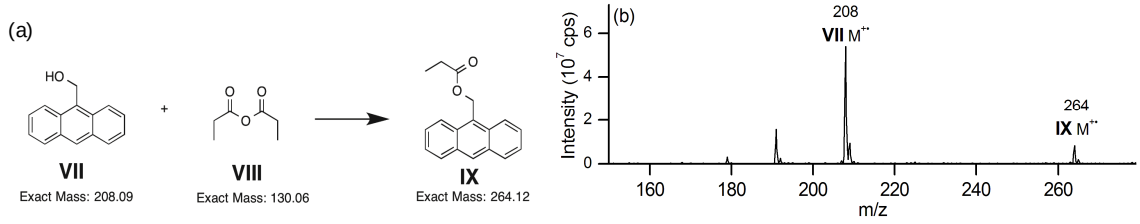


Figure 3: a) The esterification reaction and b) an APPI mass spectrum at the flow rate of 1 mL/min.

CONCLUSION

A commercial microchip was combined on-line with MS detection using ESI or APPI for reaction mechanism studies. APPI was performed utilizing a heated nebulizer chip developed in our group [2]. A new intermediate, **V**, of the reaction in Scheme 1 was observed.

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