

研究论文

## 快速测量挥发性有机物的膜进样-飞行时间质谱仪的设计和应用

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摘要

研制了一种膜进样-微型飞行时间质谱仪, 该仪器使用双层50  $\mu\text{m}$ 硅橡胶膜作为大气压下直接进样的接口. 实验结果表明, 随着样品流速的提高, 膜富集效率信号强度呈线性提高. 双膜中间具有真空差分系统, 富集得到的样品被迅速抽走, 进样系统中样品无记忆效应. 样品在膜中的响应时间为100 s, 而打开差分系统后仅需10 s信号即下降为平稳状态. 与毛细管直接进样相比, 双层膜的富集作用显著, 在相同的实验条件下使用膜进样技术测定 $10 \times 10^{-6}$  (体积分数)苯、甲苯和对二甲苯的信号强度分别提高了280, 370和600倍. 膜进样系统与真空紫外光软电离方式联用, 对于苯的检出限已经达到了 $25 \times 10^{-9}$  (体积分数), 线性范围为3个数量级. 由于采用了软电离方法, 无碎片离子产生, 所以能够根据分子量进行快速定性分析. 将该仪器应用于香烟主烟气中可挥发性有机物的在线分析, 得到50多种可挥发性的有机物. 实验结果表明, 膜进样-飞行时间质谱将在在线分析(特别是环境监测)方面具有广泛的应用空间.

关键词 [膜进样](#) [飞行时间质谱仪](#) [快速分析](#) [软电离](#)

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## Design and Application of Membrane Inlet-Time-of-Flight Mass Spectrometer for Rapid Analysis of Volatile Organic Compounds

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**Abstract** This article describes a membrane inlet-miniature time-of-flight mass spectrometer. Double silicone sheet membranes with a thickness of 50  $\mu\text{m}$  was used as interface for the atmospheric pressure direct sample inlet. The experimental result indicates that the enrichment factor of membrane is increased with the increase of the flow speed of the sample, and the signal intensity is almost linear with the gas flow. There is a vacuum differential system between the double membranes and the enriched sample is pulled out quickly, there is almost no memory effect in the membrane inlet system. The response time for benzene, toluene and o-xylene is about 100 s, but it only takes 10 s to get the steady condition after opening the vacuum valve.

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e. Comparing with the capillary sample inlet, the enrichment of double membrane is quite effective, the signal intensity for  $10 \times 10^{-6}$  (volume fraction) benzene, toluene and *o*-xylene is enhanced 280, 370 and 600 times, when the membrane inlet was used under the same experimental conditions. Combining with vacuum ultraviolet soft ionization, the detection limit of the membrane inlet mass spectrometer is  $25 \times 10^{-9}$  (volume fraction) for benzene, and the linear dynamic range is about three orders of magnitude. The soft ionization is fragment free and qualitative analysis quickly according to the molecular weight of compounds. The instrument was used to on-line analyze volatile organic compounds (VOCs) in mainstream cigarette smoke, more than fifty compounds of VOCs on a mass spectrum were observed. The results indicate that the membrane inlet-time-of-flight mass spectrometer will be useful for a wide range of field application, particularly for environmental monitoring.

**Key words** [Membrane inlet](#) [Time-of-flight mass spectrometer](#) [Rapid analysis](#) [Soft ionization](#)

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