Article

A Needle Trap Device Packed with Nanoporous Silica Sorbents for Separation and Gas Chromatographic Determination of Polycyclic Aromatic Hydrocarbons in Contaminated Soils

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Abstract

SBA-15 and MCM-41 nanoporous silica sorbents were synthesized and functionalized by amine groups and used, for the first time, for packing a needle trap device (NTD). The characteristics of the synthesized SBA-15 and MCM-41 sorbents were investigated by X-ray diffraction, scanning electron microscopy and Fourier transfer infrared spectroscopy. The NTD coupling to gas chromatography with a flame ionization detector (GC–FID) was carried out to extract and determine polycyclic aromatic hydrocarbons (PAHs) in contaminated soil samples. The performances of the sorbents for the extraction of PAHs were compared under identical conditions and the NH2-SBA-15 sorbent showed superior results. Extraction temperature, extraction time, recycling gas flow rate, sample moisture, desorption time and desorption temperature were evaluated and optimized for the system. Under the optimum conditions, detection limits of 0.0004–0.0035 μg g⁻¹, quantitation limits of 0.001–0.01 μg g⁻¹ and relative standard deviations of 7.4–14.9% were obtained for the PAHs. The results showed the more effectiveness of this sorbent for the extraction of the PAHs compared to that of a commercial sorbent. The method was successfully applied for the extraction and determination of PAHs in polluted soil samples collected from gas stations, with recoveries ranging from 64 to 112%.

Introduction

Polycyclic aromatic hydrocarbons (PAHs) are compounds containing two or more aromatic rings that are welded together to form different isomers (1). These compounds act as pollutants in air, water and soil, and due to their resistance in different environments, they are harmful to human health (2).

Important effects of PAHs on the human body such as mutagenicity and carcinogenicity of some of them including benzo-pyrene can be cited. Therefore, separation, identification and measurement of these compounds have become an important issue in analytical chemistry. The main difficulty in measuring PAH compounds is their low concentrations in environmental complex matrices. So to achieve the sensitivity and selectivity, sensitive analytical devices are required. Various extraction techniques such as liquid-liquid extraction, solid-phase extraction and supercritical fluid chromatography for this class of compounds are employed. Although all of these techniques are based on solvents’ usage for sample preparation and extraction of PAHs, there are some solventless or solvent-free sample preparation and injection techniques for these compounds (3–5).

Needle trap device (NTD) and solid-phase microextraction (SPME) techniques are examples of solventless, one-step sample preparation and introduction methods being developed today (6).