Journal of Chromatography A, 1378 (2015) 1–7

Contents lists available at ScienceDirect

Journal of Chromatography A

journal homepage: www.elsevier.com/locate/chroma

Application of nonionic surfactant as a new method for the enhancement of electromembrane extraction performance for determination of basic drugs in biological samples

Kobra Sadat Hasheminasab, Ali Reza Fakhari *

Department of Pure Chemistry, Faculty of Chemistry, Shahid Beheshti University, G. C., P.O. Box 19396-4716 Tehran, Iran

ARTICLE INFO

Article history:
Received 14 June 2014
Received in revised form
24 November 2014
Accepted 24 November 2014
Available online 27 November 2014

Keywords:
Surfactant assisted electromembrane extraction
Nonionic surfactant
Capillary electrophoresis
Basic drugs
Hair
Urine

ABSTRACT

This paper proposes for the first time the use of a nonionic surfactant for the enhancement of electromembrane extraction performance. The presence of nonionic surfactant in donor phase promotes ionic analytes efficient migration through the organic liquid membrane. Surfactant assisted electromembrane extraction coupled with capillary electrophoresis was used for the extraction of basic drugs (methamphetamine, ephedrine and methadone) from biological samples. Parameters that affect the extraction efficiency were investigated and optimized for the proposed method. Optimal extractions were accomplished with 2-nitrophenyl octyl ether as the supported liquid membrane, with 125 V as the driving force and 0.2 mM Triton X-100 with pH 5.0 in donor and pH 1 in acceptor solutions. Equilibrium extraction conditions were obtained after 20 min of operation where the whole assembly agitated at 1000 rpm. Under the optimum experimental conditions, good limits of detection (0.90–2.42 ng mL^{-1}), linearities ($R^2 > 0.9995$), and repeatability of extraction (RSDs below 4.4%, $n = 5$) were obtained. Finally, the developed method was applied to drug level monitoring in the biological samples including hair and urine samples and satisfactory results were obtained.

1. Introduction

The assay of drugs in biological fluids can indicate many difficult analytical problems. The analysis of complex matrices and the detection or quantification of the drugs present at very low levels in these samples are two of the main analytical challenges [1]. To obtain reliable data material from bioanalysis, a robust sample preparation technique is crucial. Sample preparation plays an important role in the total analytical process to obtain accurate and sensitive results [2]. It must exhibit satisfactory performance with respect to high enrichment and selectivity [3].

Traditional sample preparation techniques such as liquid–liquid extraction (LLE) and solid phase extraction (SPE) are considered time consuming and involve large quantities of toxic and expensive organic solvents. Because of these disadvantages, during the last decades, microscale sample pretreatment techniques have become an active research field, since they have obvious advantages of efficiency, selectivity, high enrichment, low cost, and possible automation. Liquid-phase microextraction (LPME) is a simple LLE which uses only a few μL of acceptor phase in order to pre-concentrate the target analytes. LPME has been accomplished either by extraction into small water immiscible drops of organic solvent, hanging (single-drop microextraction) [4,5] or dispersed (dispersive liquid–liquid microextraction) [6,7], or into small volumes of acceptor solution inside the lumen of porous hollow fibers (hollow fiber liquid-phase microextraction, HF-LPME) [8]. HF-LPME is an effective method for the extraction of compounds from complicated matrices. To date, many articles have been published using the HF-LPME configurations for the determination of many compounds belonging to different families, and they have been reviewed recently [8]. However, in some cases, the best results were obtained using long extraction times, even up to 6 h [9,10].

Recently, a totally new concept based on electrokinetic migration of charged analytes was introduced [11]. In contrast to most LPME methods, which are based on passive diffusion and mass transfer of the analytes, the electromembrane extraction (EME) is based on electrokinetic migration and an electrical potential difference as the driving force [12]. This technique uses electromigration across artificial liquid membranes for selective extraction of analytes and sample enrichment from complex matrices. The major benefit of this approach is the reduction of extraction time [13],

* Corresponding author. Tel.: +98 21 22431661; fax: +98 21 22431683.
E-mail address: azavareh@sbu.ac.ir (A.R. Fakhari).

http://dx.doi.org/10.1016/j.chroma.2014.11.061
0021-9673/

particularly with small sample volumes. EME has been applied for the extraction of different acidic drugs [14], hydrophobic basic drugs [15–17], hydrophilic basic drugs [18,19], peptides [20–23] and both acidic and basic drugs simultaneously [13]. EME with complicated biological samples like whole blood [24], human plasma [25,26], urine [27,28], breast milk [27,29] and most recently oral fluids [30] has been reported.

Surfactants are amphiphilic molecules that comprise distinct hydrophobic and hydrophilic moieties – a polar or ionic group connected to a long hydrocarbon tail (linear, branched or containing aromatic rings) [31]. Therefore, they have the ability to dissolve in both organic and aqueous phases. Owing to their special structure, there has been a growing interest in their application in sample pretreatment techniques to enhance extraction efficiency. Surfactants were used in cloud point extraction [32], dispersive liquid liquid microextraction [33], ultrasound-assisted emulsification microextraction [34] and HF-LPME [35].

In this research, we decided to use a nonionic surfactant in donor phase for the enhancement of EME performance. To increase the tendency of the target analytes from aqueous sample to supported liquid membrane (SLM), non-ionic surfactant was added to the donor phase. The method was optimized and applied for the preconcentration of basic drugs in biological samples prior to capillary electrophoresis analysis.

2. Experimental

2.1. Chemicals and materials

Methamphetamine ($pK_a = 9.87$, $\log P = 2.07$) and methadone ($pK_a = 9.05$, $\log P = 4.20$) were kindly donated by the Research Center of Antinarcotic Police (Tehran, Iran). Ephedrine ($pK_a = 9.6$, $\log P = 1.1$) was obtained from Tofigh Daru Pharmaceutical Company (Tehran, Iran). All chemicals used were of analytical-reagent grade. To prevent capillary blockage, all buffers and samples were filtered through 0.45 μm PTFE filter membranes (Millipore, Bedford, MA, USA). H_3PO_4, $NaH_2PO_4{\cdot}2H_2O$, Na_2HPO_4, NaCl, NaOH and HCl were purchased from Merck (Darmstadt, Germany). 2-Nitrophenyloctyl ether (NPOE), dihexyl ether, octanol and nitrobenzene were purchased from Fluka (Buchs, Switzerland). Triton X-100 and Triton X-114 were obtained from Merck. Tween-20 was obtained from Sigma (St. Louis, MO, USA). HPLC grade water was obtained through a Milli-Q® system (Millipore, Milford, MA, USA) and was used to prepare all solutions.

2.2. Capillary zone electrophoresis (CZE) conditions

The CZE experiments with UV detection were carried out on a Lumex Capel 105 Capillary Electrophoresis System (Ohio lumex, Twinsburg, Russia). Acquisition of electropherograms was computer-controlled by Chrom & Spec software version 1.5. The electrophoretic experiments were performed in an uncoated fused-silica capillary (Ohio lumex, Twinsburg, Russia) 60 cm × 50 μm I.D. (50 cm effective length). The background electrolyte solution was 50 mM phosphate buffer adjusted to pH 7. The separations were carried out at 20 kV, generating a current level in the range of 140–160 μA. The acceptor solutions were injected by hydrodynamic injection at 60 mbar for 7 s. Detection of the analytes was accomplished at 214 nm.

2.3. Equipment for EME

The electrical equipment consisted in a d.c. power supply model PV – 300 (Mobtaker Aryaei J, Zanjan, Iran) with programmable voltage in the range of 0–300 V, providing currents in the range of 0–1 mA. Platinum wires (diameter 0.2 mm) were used as electrodes with an inter-electrode distance of 5 mm in the sample and acceptor solutions. The porous hollow fiber used for the SLM was a PPQ3/2 polypropylene hollow fiber from Membrana (Wuppertal, Germany) with the inner diameter of 0.6 mm, wall thickness of 200 μm, and pore size of 0.2 μm. It was cut into 6.0 cm segments, cleaned in acetone and dried prior to use. During the extraction, the EME cell was stirred with a stirring rate in the range of 100–1250 rpm by a heater-magnetic stirrer model 301 from Heidolph (Kelheim, Germany) using 5 mm × 2 mm magnetic bars.

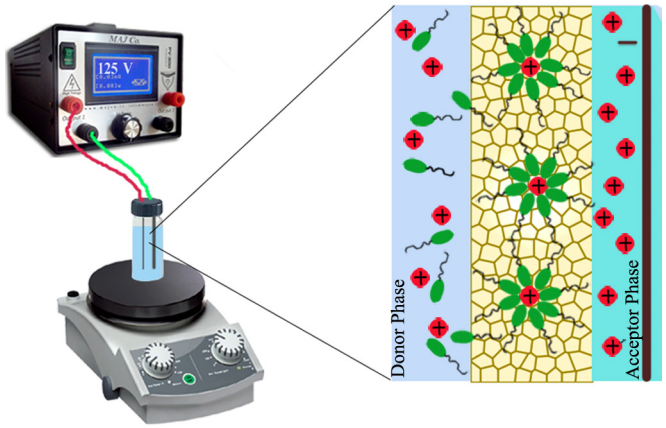

Fig. 1. Schematic illustration of the set-up for surfactant assisted electromembrane extraction (S/EME).

2.4. Procedure for surfactant assisted electromembrane extraction (S/EME)

Fig. 1 shows the schematic diagram of S/EME system. For the experiments, 4 mL of sample solution containing nonionic surfactant was filled into a 4.5 mL sample vial. A 6.0 cm piece of polypropylene hollow fiber was then inserted through the cap of the glass vial and dipped for 15 s in the organic solvent serving as the SLM, and excess of solvent was removed with a medical wipe. Subsequently, 20 μL of the acceptor solution (HCl, 0.1 M) was injected into the lumen of the hollow fiber with a microsyringe and the end of the hollow fiber was thermally closed. The cathode electrode was introduced into the lumen of the hollow fiber. The hollow fiber containing the cathode, SLM and the acceptor solution was afterward placed in the donor solution. The anode electrode was led directly into the sample solution. The electrodes were subsequently coupled with the power supply and the sample compartment was placed on a stirrer. The power supply was turned on and extraction was performed for a prescribed time. After the extraction was complete, the power supply was turned off. The acceptor solution was collected with a microsyringe and transferred directly to a microvial followed by CE.

2.5. Hair samples

Hair samples were collected from a 25 and a 30 year-old male addicted volunteers. These samples (2.0 g per volunteer) were washed at room temperature for 5.0 min with 20.0 mL dichloromethane, 15.0 mL acetone, 15.0 mL methanol and 10.0 mL methanol, respectively, and then they were dried [35,36]. The washed and dried samples were cut into approximately 1 mm pieces and digested with 1 M NaOH and heated at 70 °C for 20 min [37]. The hair was completely digested and the solution was clear. After cooling down to room temperature, the content was transferred into an extraction vial (4.5 mL).