COMPARISON OF STATIC AND CONTINUOUS HOLLOW FIBRE LIQUID-PHASE EXTRACTION OF LUTETIUM

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ABSTRACT

This work is a comparative study of the efficiency of the lutetium (III) extraction in membrane-assisted liquid-phase extraction (LPE) carried out under static and continuous operation mode using di(2-ethylhexyl)phosphoric acid (DEHPA) as a carrier. The removal of Lu(III) from the donor solution and its recovery into the acceptor phase were compared for the two operation modes investigated. Additionally, the applicability of both systems for purification of ^{177}Lu-radiopharmaceutical was discussed.

INTRODUCTION

Radionuclide ^{177}Lu possesses favorable radiophysical characteristics for therapeutic application in nuclear medicine [1]. One of the main steps in the production process of ^{177}Lu-radiopharmaceutical is the separation of bound from unbound radionuclide. Membrane-assisted LPE offers the possibility of purification of the ^{177}Lu-radiopharmaceuticals, after the labeling procedure [2, 3].

Membrane-assisted LPE operates in a three-phase system and involves simultaneous extraction and re-extraction. The pores of a microporous hydrophobic membrane are filled with the organic phase (extractant) held by the action of capillary forces, while the feed (donor) and the stripping (acceptor) solutions are placed on each side of the membrane. Membrane-assisted LPE can be performed in a miniaturized system under static or continuous mode of operation.

The aim of the present study was to compare the removal efficiency and re-extraction of Lu(III) achieved in a static and continuous flow membrane-assisted LPE system. The systems were investigated with regard to the potential application in purification of ^{177}Lu-radiopharmaceutical.

RESULTS AND DISCUSSION

Lutetium was extracted using two different membrane-assisted LPE systems: (i) static, hollow fibre LPE system (HF-LPE) in the absence of flow of any phase, and (ii) dynamic, HF-LPE system with recirculation of the aqueous donor and acceptor phases. Microporous polypropylene hollow fibre membrane, ACCUREL 50/280 (Membrana GmbH, Wuppertal, Germany) was used in the experiments. The extraction was performed under predetermined optimum experimental conditions [3]: the donor phase

of 2 mg dm^{-3} Lu(III) in 0.2 M sodium acetate buffer at pH 3.5, the organic phase composed of 5% DEHPA in di-hexyl ether and the acceptor phase of 2 M HCl. The membrane wall was impregnated with the organic phase, the acceptor phase was in the lumen of HF, and the donor phase was outside the HF. The efficiency of mass transfer of Lu(III) through the liquid membrane was evaluated using the following parameters: the removal efficiency (*R*) that represents the fraction of Lu(III) removed from the donor phase, the extraction efficiency (*E*) that represents a fraction of Lu(III) initially present in the donor phase that was found in the acceptor after extraction and the memory effect (*M)* that is the fraction of Lu(III) captured in the organic phase.

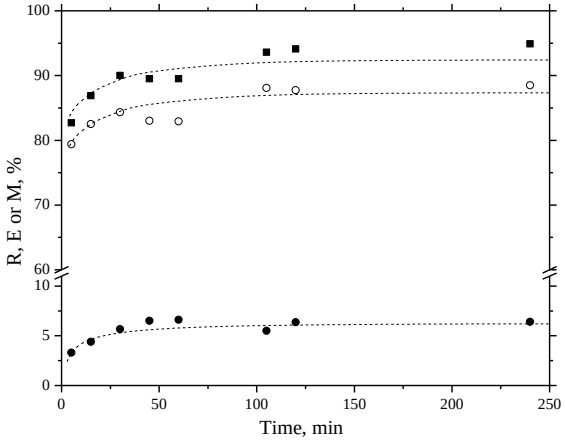

Fig. 1. Time dependence of the efficiency parameters *R* (■), *E* (●) and *M* (○) in the static three phase HF-LPE system

Fig. 1 shows the time-dependent parameters of Lu(III) transfer in HF-LPE under stagnant mode of operation with a volume of acceptor of 0.01 cm^3. As can be seen, the stagnant system was efficient in terms of the removal of Lu(III) from the donor phase, but poorly efficient in terms of Lu(III) recovery from the organic into the acceptor phase. As the acceptor volume increased from 0.01 to 0.06 cm^3 as a result of increased HF length, the extraction efficiency improved from 5 to 15 % but even at the highest acceptor volume, 85% of the extracted amount of Lu(III) remained in the membrane. A further increase of the acceptor volume beyond 0.06 cm^3 was impractical.

Continuous HF-LPE of Lu(III) was carried out in the self-designed membrane contactor containing a single HF membrane. This configuration enables recirculation of both aqueous phases. Fig. 2 shows the time-dependent efficiency parameters in HF-LPE under recirculation of the acceptor phase (3 cm^3) through the lumen of the fibre and donor phase (20 cm^3) outside the fibre. As can be seen from Fig. 2, continuous HF-LPE system enables not only efficient removal of Lu(III) from the donor to the organic phase, but also its recovery from the organic to the acceptor phase. The accumulation

of Lu(III) in the membrane was less than 5%, meaning that re-extraction of Lu(III) was almost complete.

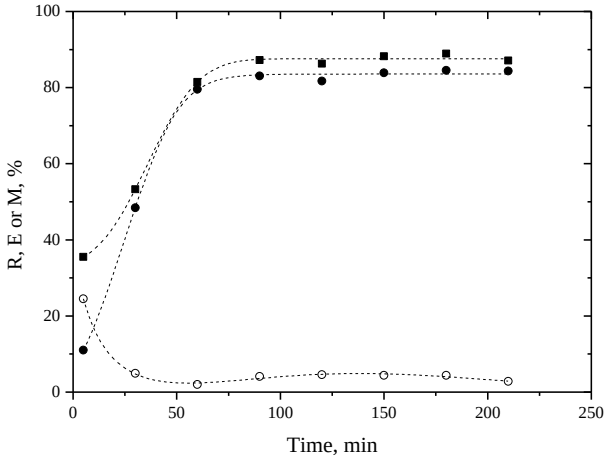

Fig. 2. Time dependence of the efficiency parameters *R* (■), *E* (●) and *M* (○) in the HF-LPE system with the recirculation of aqueous phases (donor flow rate: 5.3 cm^3 min^{-1}, acceptor flow rate: 0.4 cm^3 min^{-1})

CONCLUSION

The removal efficiency of Lu(III) from the aqueous donor solution was very high when both static and continuous HF-LPE were applied, which is of prime importance with regard to the potential application in purification of ^{177}Lu-based radiopharmaceuticals. The main advantage of continuous over static system is almost complete re-extraction of Lu(III) into the acceptor phase.

Considering practical aspects, static HF-LPE is easier to operate, which is very important when working with radioactive material, and more suitable for low volume production, as is often the case in radiopharmaceutical production. Continuous HF-LPE requires higher volumes of donor phase for the operation and there are more potential leakage points that can cause accidental release of radioactive material.

Acknowledgment

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