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Determination of the overall mass transfer coefficient of Lu(III) in a single hollow fibre pertraction

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Supported liquid membrane (SLM) extraction, also named pertraction, offers the possibility for the separation of the unbound radionuclide from a labeled radiopharmaceutical, after the labeling procedure is completed. The aim of the present study was to investigate the pertraction of Lu(III) from an aqueous phase by applying a single hollow fibre membrane device, as a method which could potentially be applied for efficient removal of unbound 177Lu(Lu(III)) from 177Lu-labeled compound, and to determine the overall mass transfer coefficient of the process.

The overall mass transfer coefficient, $K_a$, is one of the main parameters describing the rate of mass transfer in SLM extraction. In the three-phase membrane extraction performed in the batch mode of operation, $K_a$ can be determined from the time-dependent concentration of Lu(III) in the acceptor phase by maintaining a constant Lu(III) concentration in the donor phase. It could be achieved using a relatively large volume of the donor phase, so that the depletion of Lu(III) in the donor phase is less than 5% [1].

Pertraction of Lu(III) has been performed in a miniaturised single hollow fibre membrane device operated in a batch mode. The effective length of hollow fibres used in this study was 168 or 272 mm. The membrane was impregnated with the organic phase (5% v/v) DEHPA in dihexyl ether) and then the lumen of the fibre was filled with the acceptor solution (2 M HCl). The ends of fibre were bent and wrapped with a piece of Al-foil, in order to prevent the leakage of the acceptor solution. The membrane was then placed in the donor solution (2 mg dm$^{-3}$ Lu(III)) in the 0.2 M sodium acetate at pH = 3.5. After reaching the equilibrium, the membrane was taken out from the donor phase and the concentration of Lu(III) in both phases, donor and acceptor, was determined by indirect voltammetry.

In order to estimate the overall mass transfer coefficient, the donor volume should be relatively large, so that the Lu(III) concentration in the donor phase can be regarded as constant during the pertraction process. Therefore, it was firstly necessary to examine the variations of Lu(III) concentration in the donor phase as a function of the donor volume. The results showed that the variations of Lu(III) concentration in the donor phase during extraction were within 5% for the donor volume greater than 100 cm$^3$ indicating that the Lu(III) concentration in the donor phase could be regarded as a constant under such experimental conditions. For donor volumes above 100 cm$^3$, the drop in Lu(III) concentration in the donor phase is negligible and the overall mass transfer coefficient can be estimated for such donor volumes.

The overall mass transfer coefficient was estimated by measuring the variation of the Lu(III) concentration in the acceptor phase with time at a constant Lu(III) concentration in the donor phase. Linear relationship was obtained on a semilog scale for both membrane lengths and the slope of the two lines was the same. The $K_a$ value was independent on the fibre length and found to be 1.4x10$^{-4}$ m s$^{-1}$.