PREPARATION OF CARRIER-FREE RADIONUCLIDES FROM CYCLOTRON TARGETS BY CONTINUOUS ELECTROPHORESIS, I

SEPARATION OF $^{55}$Fe FROM MANGANESE, $^{54}$Mn AND $^{56, 57, 58}$Co FROM IRON, $^{66}$Zn FROM COPPER, AND $^{110}$Cd FROM SILVER TARGET

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Continuous electrophoretic separation of the components of the manganese, iron, copper and silver cyclotron targets bombarded with deuterons is described. The rates of separation were: manganese target, 4.4 mg Mn/hr; iron target, 1.5 mg Fe/hr; copper target, 1.7 mg Cu/hr; and silver target, 6.7 mg Ag/hr. The radionuclides were separated in carrier-free form and were of high radiochemical purity. The results are represented by radioautographs of the continuous electrophoretic processes, and by diagrams showing the distribution of the target material and of radioactivity along the collecting glasses. The radiochemical purity of the separated radionuclides was checked by the gamma spectra, by estimation of the beta-energies, and by evaluation of the decay curves.

Introduction

Continuous electrophoresis is primarily a method for preparative separations, but it also allows qualitative and quantitative analyses of mixtures. This technique is considered to make possible the separation of carrier-free radionuclides, and seems to be very useful both in qualitative and quantitative radiometric analysis of a radioactive mixture.

The apparatus, the theory and application of continuous electrophoresis have been described by PUČAR, and a review of separations of inorganic ions by paper electrophoresis has been given by BAILEY and YAFFE. The possibility of application of electrophoresis in radiochemistry was discussed by BAILEY and by KONRAD-JAKOVAC. Some of the given data can be useful also in continuous electrophoretic separations.

The continuous electrophoretic separations of mixtures of rare earths, fission products and some other radionuclides were described in the literature.

In this series of papers, the continuous electrophoretic separations of carrier-free radionuclides from cyclotron targets are described in order to evaluate the possibility of application of this procedure for the preparation of carrier-free radionuclides in high radiochemical purity.
Experimental

Preparation of targets. The cyclotron targets were 76 x 26 mm, and the thickness of the plates was 2.5 mm. The iron and copper targets were machined to fit the dimensions, and mounted on the cyclotron target holder. Cooling of the targets was provided by circulating tap water. The silver target consisted of an aluminium plate with an oval shaped hole (15 x 5 x 1) in the middle of the plate, in which the target metal was pressed in, and the surface of the metal polished.

The manganese target was prepared by electroplating of a copper plate with manganese. The electroplating solution contained 100 g/l MnSO₄, 75 g/l (NH₄)₂SO₄ and 50 ml/l of glycerol. The pH of the solution was between 2.5 and 3.0, the electrical current density 2.5 A/dm², and the temperature of the bath 25°C.

Cyclotron. The bombardments of the targets were performed in a cyclotron built in this Institute. It is a 16 MeV nominal deuteron energy cyclotron. Its basic data are: pole diameter 1400 mm, weight of the electromagnet iron 61 t, nominal magnetic flux density 1.4 T, accelerating voltage 160 kV, maximum power output 80 kW at a frequency of 10.6 MHz, and total energy consumption 630 kVA.

Bombardment of targets. The deuteron beam intensity varied between 20 and 100 µA, depending on the melting point of the target material. The total flux was about 100 µAh.

Treatment of radioactive targets. Prior to treatment radioactive targets were allowed to cool for a certain period of time in order to eliminate radionuclides of short life time such as ⁵⁵Co, ⁵⁶Mn, ⁶⁵Zn, ⁶⁸Cu, ¹⁰⁷Cd and ¹⁰⁸Ag. The bombarded surface areas of the targets were scraped off and dissolved in an appropriate acid.

Manganese (about 250 mg) or iron (about 120 mg) was dissolved in 40 ml of 0.5 M HCl, or HNO₃, respectively, and precipitated with NaOH, in slightly warm solution. The precipitate was centrifuged and washed several times with water. It was then dissolved in 1 ml of 5 M lactic acid, heated under an infrared lamp, and 9 ml of water was added. After cooling, some manganese lactate crystallized. The manganese solution contained 22.5 mg Mn/ml, whereas the iron solution contained 11.3 mg Fe/ml. The specific radioactivity at the moment of the electrophoretic separation was 800,000 cpm/ml for the manganese, and 1,300,000 cpm/ml for the iron target. The radioactivity of the final solutions was 98% of the initial radioactivity of the hydrochloric and nitric acid solutions, respectively.

Copper (about 70 mg) or silver (about 140 mg) was dissolved in conc. HNO₃, evaporated to dryness, and the residue dissolved in 7 ml of 0.2 M lactic acid. The solution contained 10 mg Cu/ml, or 20 mg Ag/ml, and the specific radioactivity at the moment of the electrophoretic separation was 520,000 cpm/ml, and 300,000 cpm/ml, respectively.

In the separation with oxalic acid, the silver (about 100 mg) was dissolved in conc. HNO₃, evaporated to dryness, and the residue dissolved in 7 ml of water. To this solution 3.0 ml of 0.5 N oxalic acid was added, the silver oxalate precipitated, and centrifuged. The specific activity of this solution at the moment of the