CHEMICAL SEPARATION AND PURIFICATION OF STABLE ^{45}SC FROM CERN-MEDICIS MASS-SEPARATOR COLLECTION FOILS

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INTRODUCTION

Three radionuclides of the chemical element **Scandium** (Sc) - ^{43}Sc, ^{44}Sc, and ^{47}Sc - are valuable in nuclear medicine and **theranostics**.

Scandium

- Low cost and high efficiency
- ^{43,44g}Sc has diagnostic and ^{47}Sc therapeutic application decay properties
- Scandium radionuclides can be produced and decay to the most biocompatible stable chemical elements such as Ca and Ti

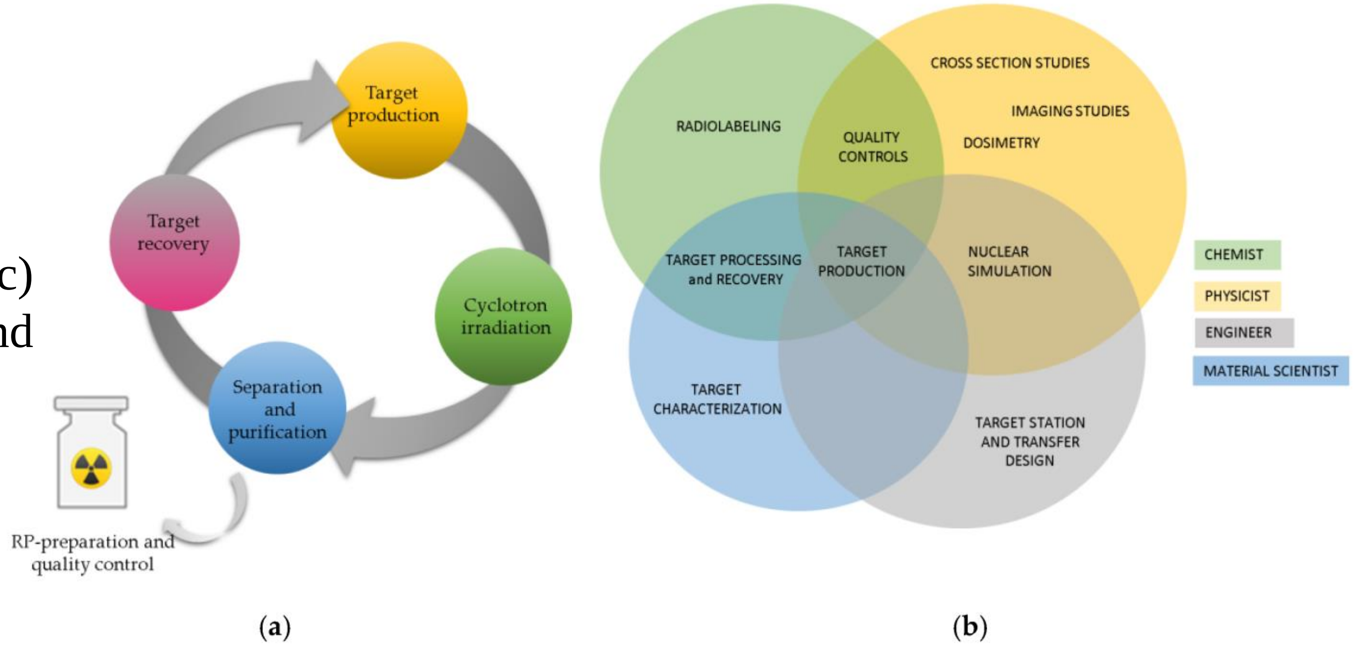


Figure 1. (**a**) Radiometal cyclotron production cycle; (**b**) Involved competence and interrelated tasks and contributions [1]

Theranostics (Therapy and Diagnostics)- refers to the strategy of utilizing radioactively labelled drugs for both purposes:

- Most commonly for cancer treatment;
- Ability to conjugate in the same pharmaceutically active agent

[1]- https://doi.org/10.3390/molecules24030444

MASS SEPARATION

CERN's MEDICIS facility contributes to medical research by producing novel radioisotopes, elements with too many or too few neutrons to be stable.

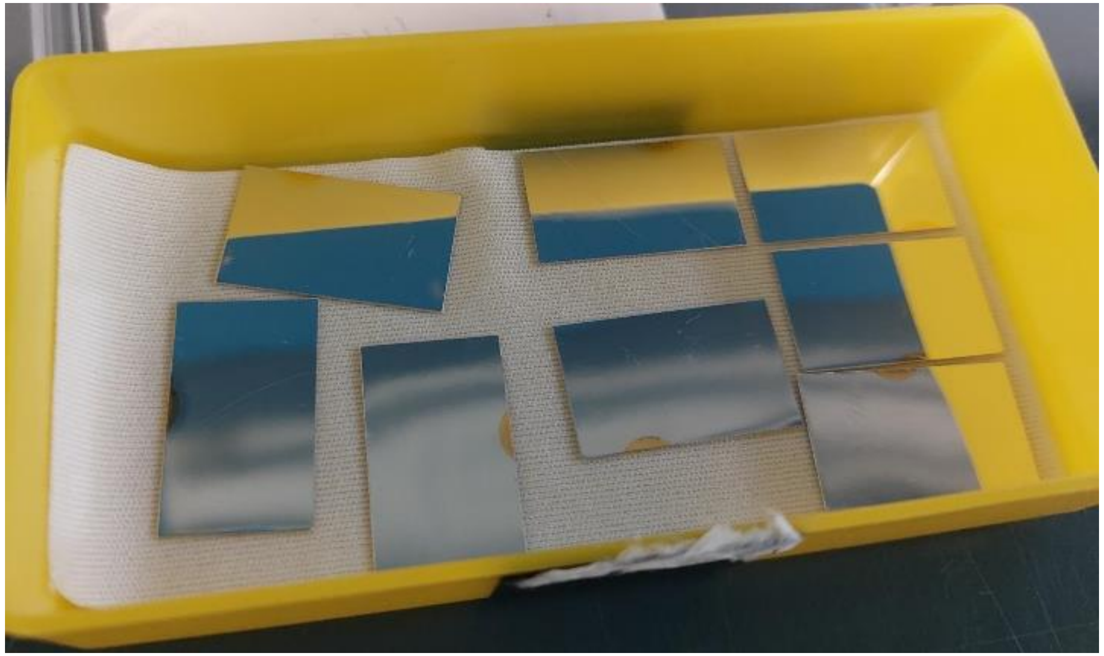


Figure 2. CERN MEDICIS mass separator collection foils

Radioactive nuclei are produced at ISOLDE by shooting a high-energy beam of protons on a target. The interaction of the proton beam with the target material produces radioactive species through spallation, fragmentation and fission reactions. They are subsequently extracted from the bulk of the target material through thermal diffusion processes. The cocktail of produced isotopes is ultimately filtered using one of ISOLDE's two magnetic dipole mass separators to yield the desired isobar of interest.

CHEMICAL SEPARATION – ION EXCHANGE CHROMATOGRAPHY

CERN MEDICIS produces radioactive isotopes by recovering the 1,4 and 1,7 GeV proton beam from ISOLDE before it reaches the beam dump using different types of targets behind the ISOLDE targets. In the end, the isotopes are implanted on a zinc or aluminium- coated gold foil

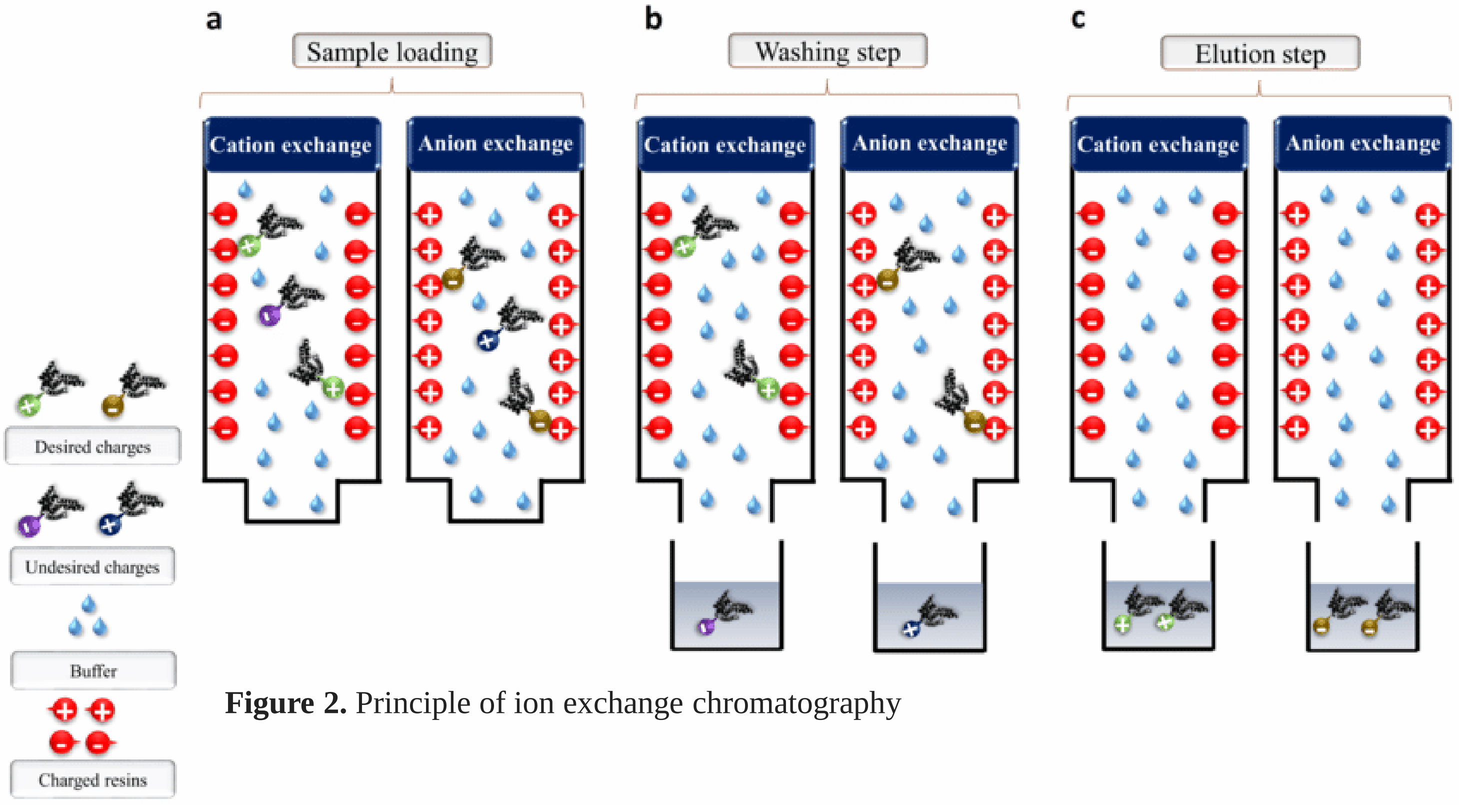


Figure 2. Principle of ion exchange chromatography

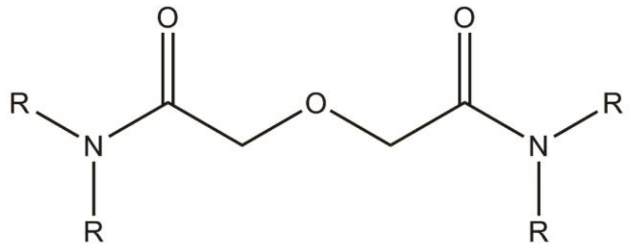
Ion exchange chromatography is one of the most powerful and widely used method for radiochemical separations.

[2]-DOI:10.1016/j.biotechadv.2020.107653

CHEMICAL SEPARATION – COLUMN PREPARATION

In addition to analytical applications, the DGA Resins have been used in nuclear medicine for the purification of ^{44}Sc, ^{47}Sc, ^{86}Y, ^{90}Y, ^{225}Ac, ^{227}Ac, ^{161}Tb, and ^{177}Lu.

FIRST STEP



DGA branched resin

Hydratation with HNO_3

Leave overnight

SECOND STEP

After 24 hours introduce hydrated resin into the ion - exchange chromatography column

Al/Au

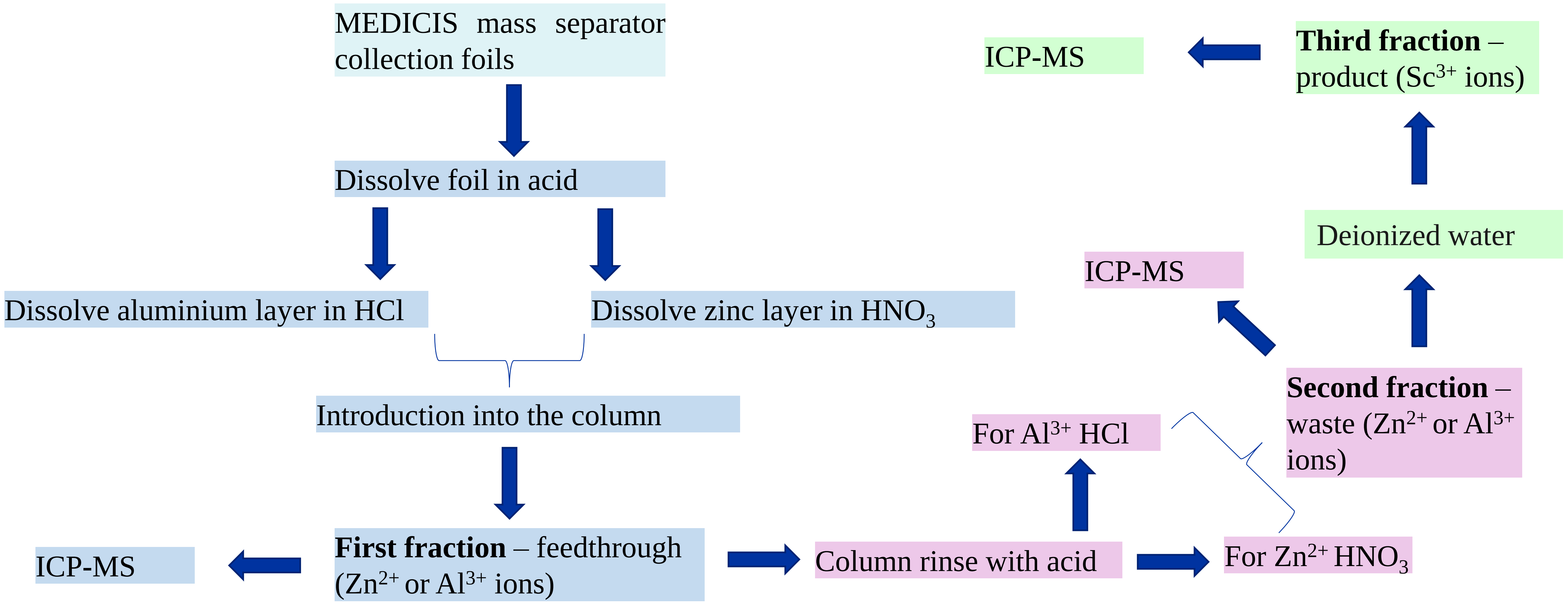
Conditioning column with HCl

Zn/Au

Conditioning column with HNO_3

ICP-MS - Inductively coupled plasma mass spectrometry

CHEMICAL SEPARATION



RESULTS (I): STANDARD SOLUTIONS

Figure 1. Percentage of Scandium and Aluminium ion concentration from standard solution in each sample using HCl

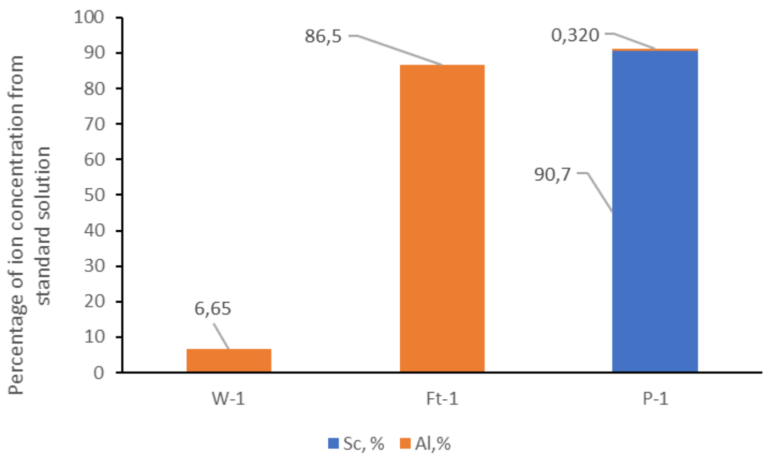


Figure 2. Percentage of Scandium and Zinc ion concentration from standard solution in each sample using HCl

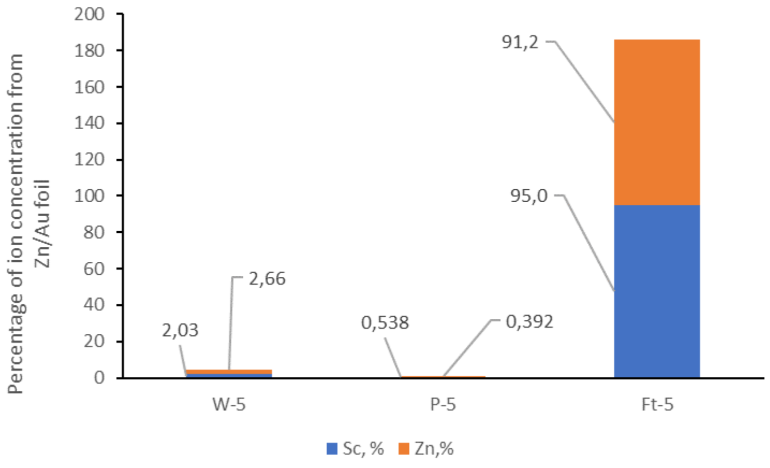
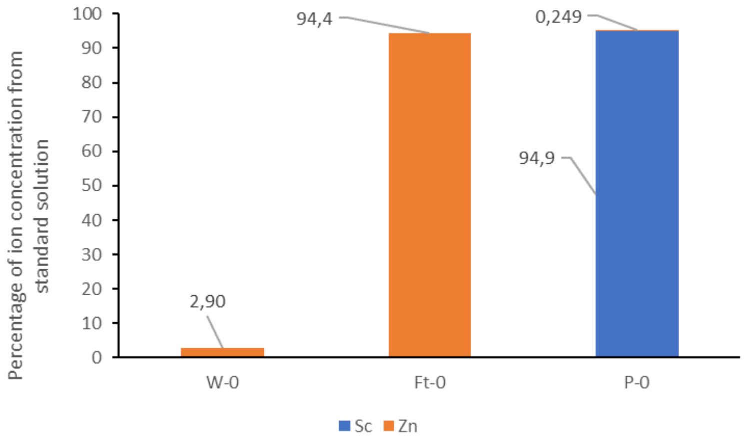
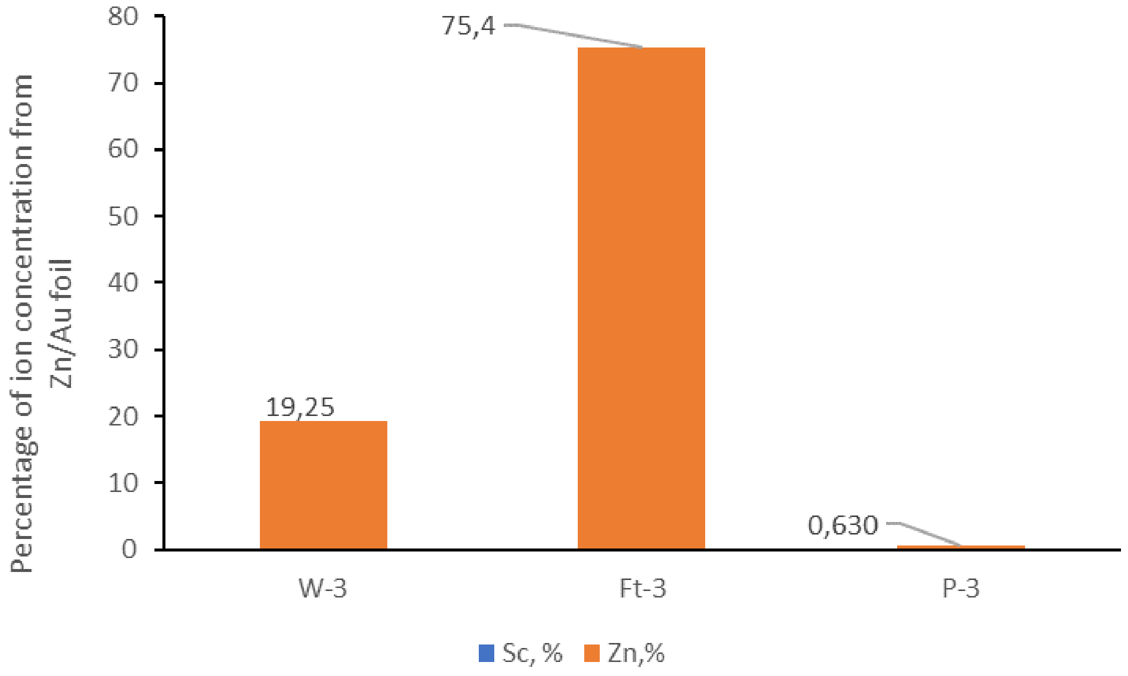


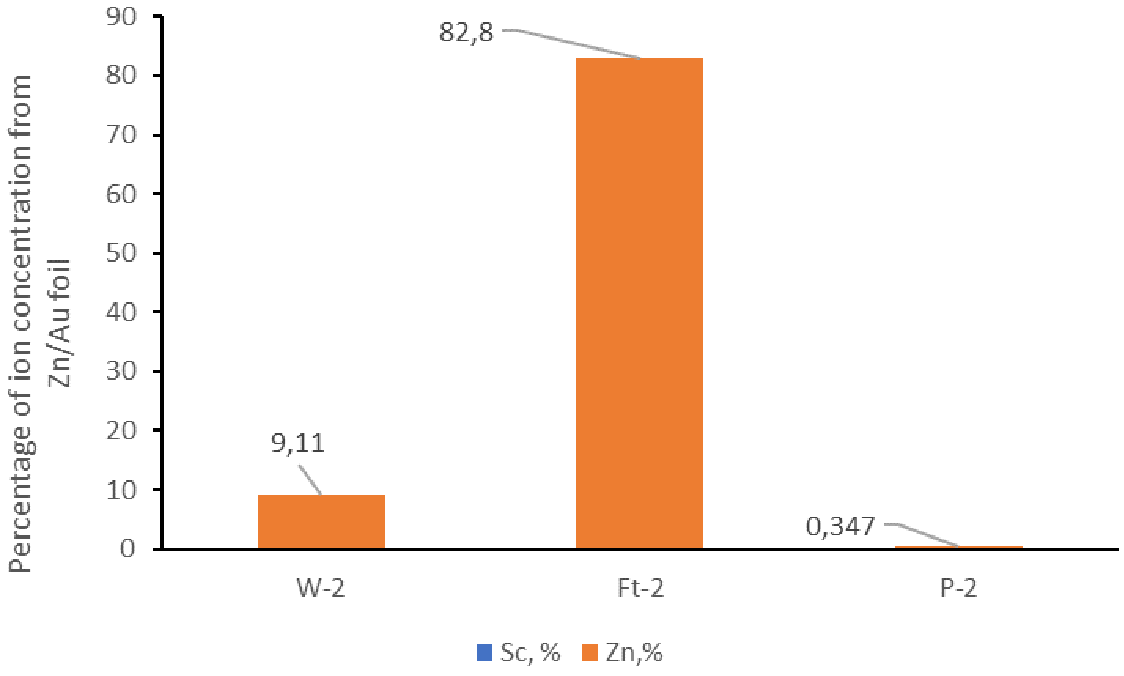
Figure 3. Percentage of Scandium and Zinc ion concentration from standard solution in each sample using HNO_3



RESULTS (II): MEDICIS MASS-SEPARATOR COLLECTION FOILS Zn/Au/Sc

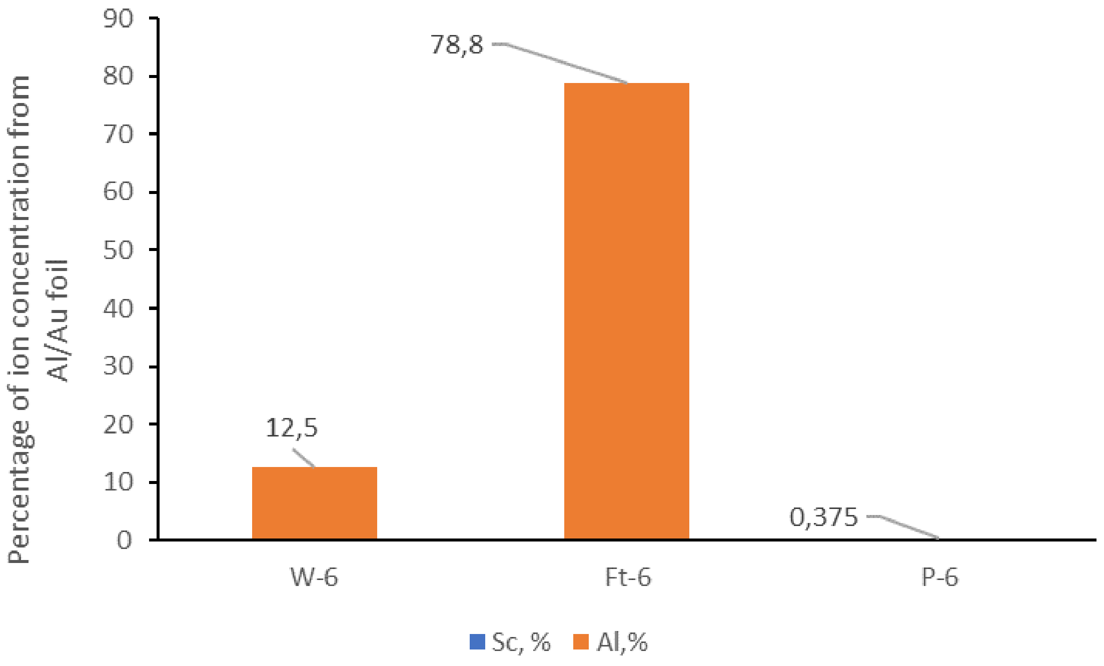
Figure 4. Percentage of Scandium and Zinc ion concentration from mass-separator collection foils

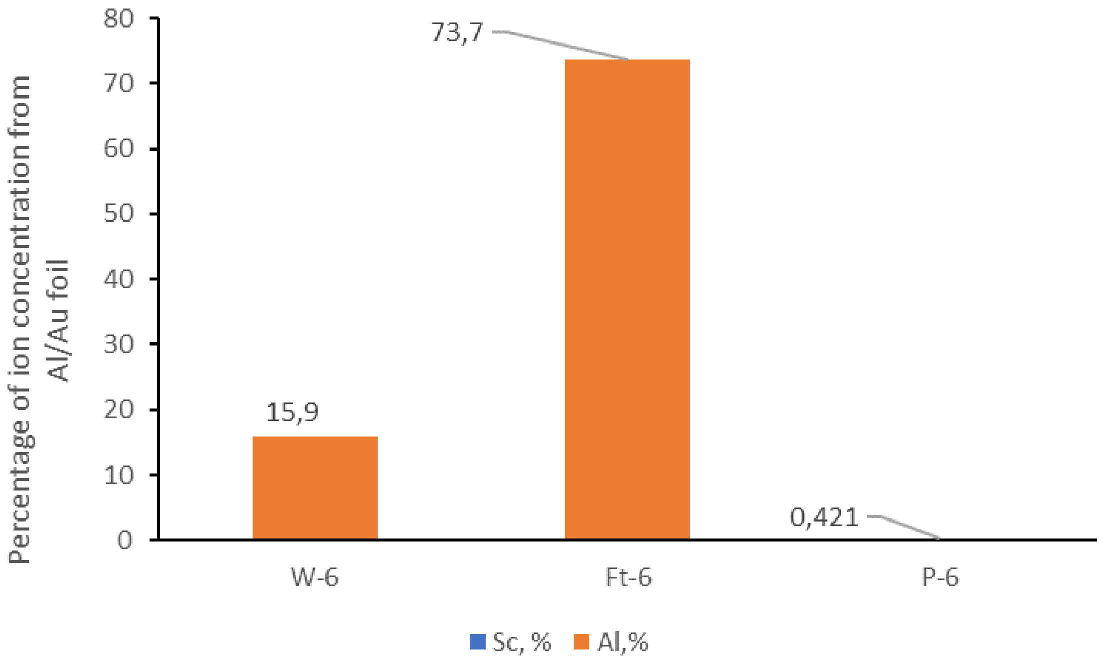




RESULTS (III) : MEDICIS MASS-SEPARATOR COLLECTION FOILS Al/Au/Sc

Figure 5. Percentage of Scandium and Aluminum ion concentration from mass-separator collection foils





Sc SEPARATION FROM Ti/Al/V/Ca IMPURITIES

Standart solution mix

↓

Evaporation

↓

Rinse beaker wih HCl acid

↓

Introduction into the column

↓

First fraction – waste (Ti^{4+}, V^{5+}, Ca^{2+} Al^{3+} ions) → ICP-MS

→ Column rinse with water

→ Column rinse with acid

→ **Second fraction** – product (Sc^{3+} ions) → ICP-MS

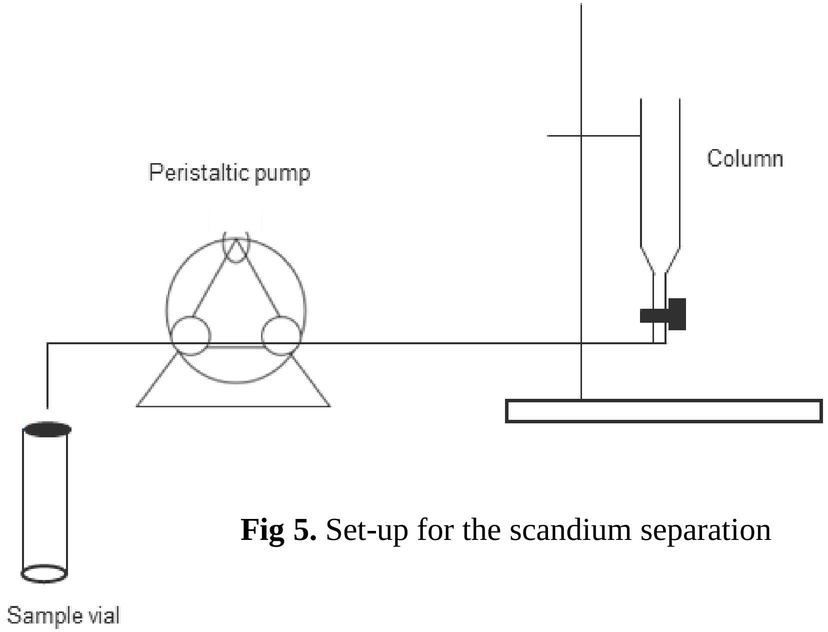
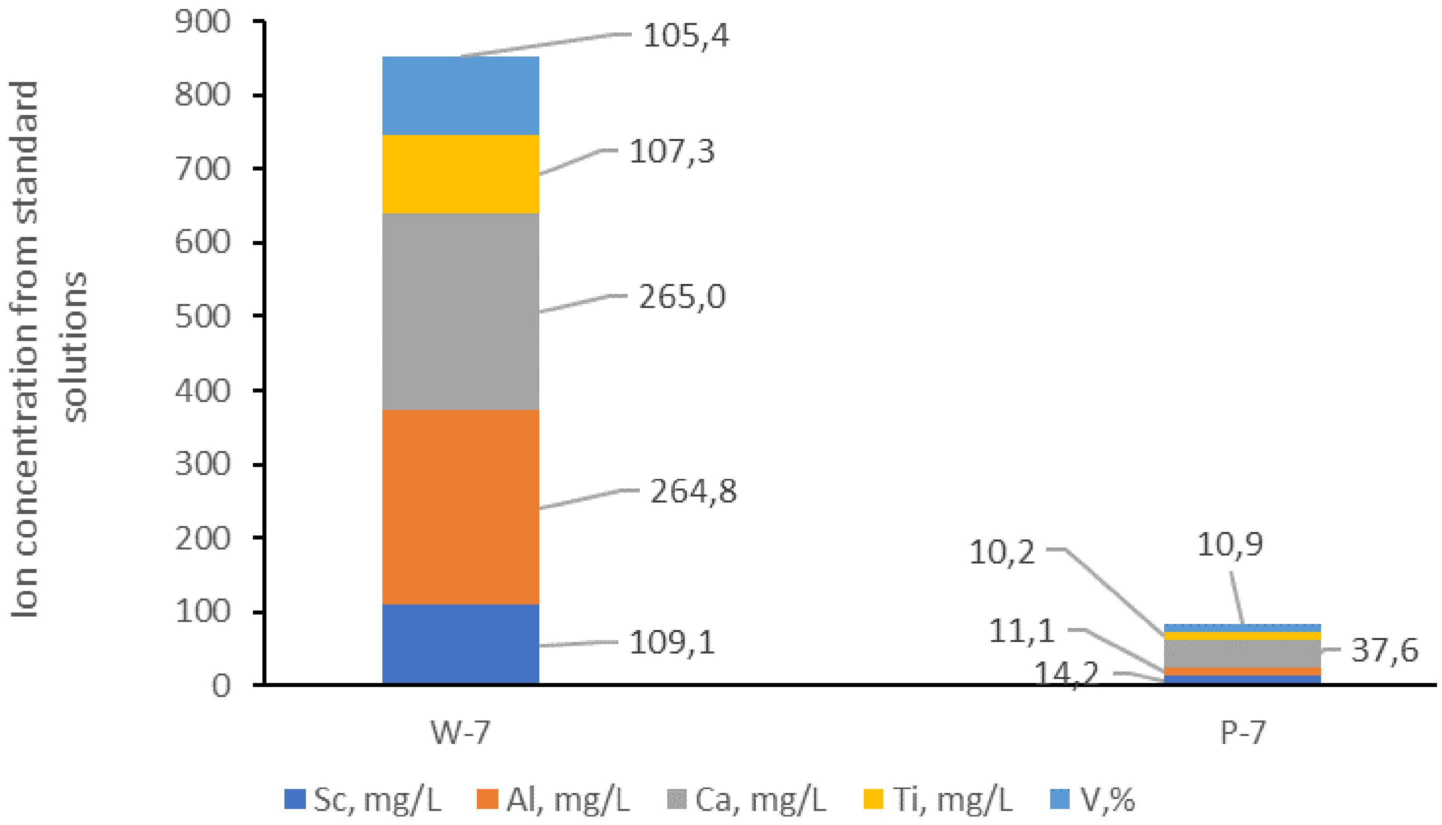


Fig 5. Set-up for the scandium separation

RESULTS (IV) : STANDARD SOLUTIONS

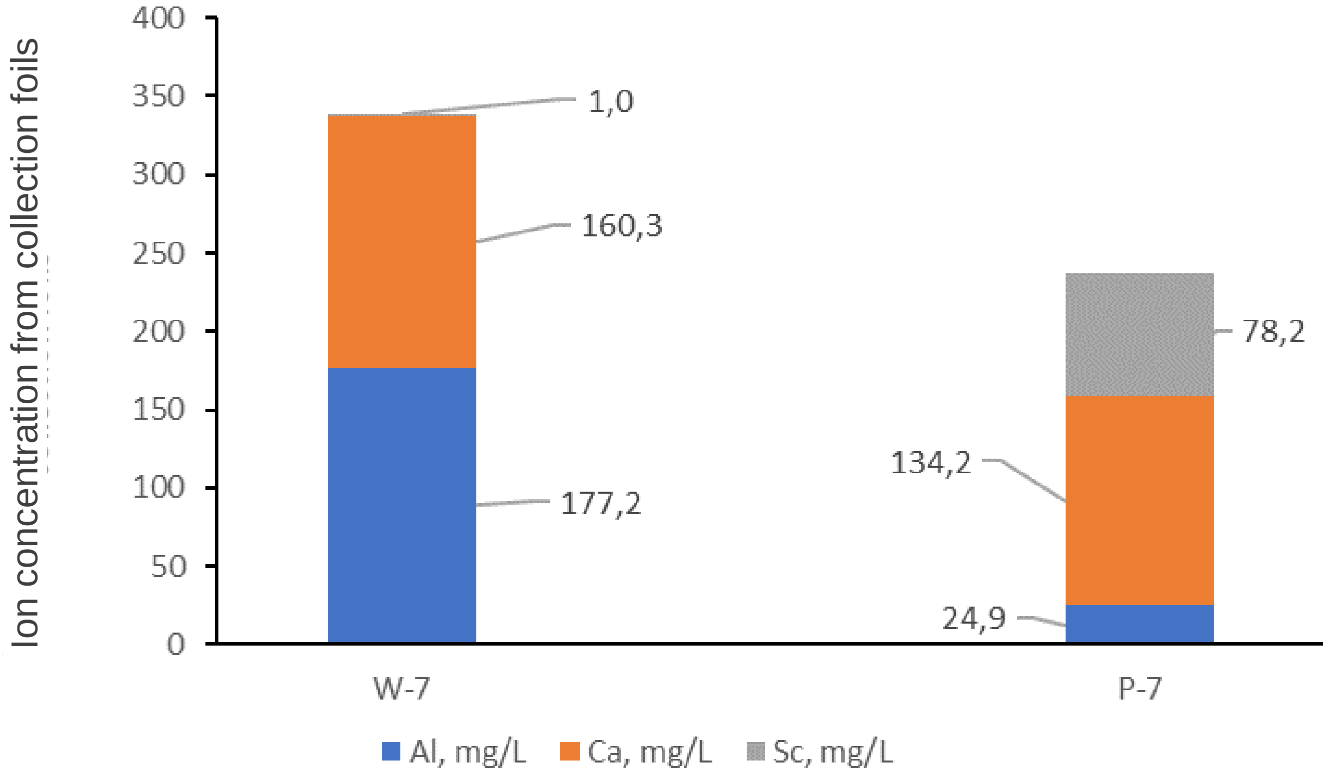
Figure 6. Separated ion concentration from standard solutions



Separation was not successful, as the reason could be column parameter changes

RESULTS (V) : MEDICIS MASS-SEPARATOR COLLECTION FOILS Al/Au/Sc

Figure 7. Separated ion concentration from collection foils



Separation was not successful, as the reason could be column parameter changes

Scandium implantation into medicis mass- separator collection foils was successful

SUMMARY

1. Efficiency for Scandium separation from Zinc and Aluminium ions using a DGA resin (50-100 μm) is more than 90%.
2. For Scandium separation from Al/Au foils it is neccessary to use HCl but for Zn/Au – HNO_3
3. Method is suitable for Zinc and Aluminium separation from CERN-MEDICIS mass- separator collection foils.
4. For the developed, time-optimized method, it is necessary to perform additional optimization for the resin quantity, diameter and height, as well as the flow rate.

Acknowlegments : Nr. lzp-2021/1-0539 „Novel and efficient approach of medical 43Sc, 44Sc and 47Scradionuclide separation and purificationfrom irradiated metallictargetstowards radiopharmaceutical development for theranostics”

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