# THE PREPARATION OF YTTRIUM-89 TARGET VIA ELECTROPLATING TECHNIQUE FOR PRODUCTION OF ZIRCONIUM-89

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## ABSTRACT

*Positron emission tomography (PET) is becoming a popular modality for cancer detection, staging and therapy monitoring. However, current radiopharmaceuticals are short-lived and are not optimal for tumor imaging. Cyclotron produced zirconium-89 had been proposed for immune-PET imaging due to favourable decay characteristics. The aim of this experiment is to investigate the ability to produce Zirconium-89 by electrodepositing yttrium onto copper substrate in either aqueous, nitric acid, or non-aqueous, ethanol, solutions. The target was bombarded with a low energy cyclotron, purified and measured with a multi-channel analyser.*

## ABSTRAK

*Pemancaran positron tomografi menjadi satu modus popular untuk pengesanan kanser, pengawasan pemeringkatan dan terapi. Bagaimanapun ,radiopharmaceuticals semasa singkat dan tidak optimum untuk pengimejan tumor.Siklotron menghasilkan zirkonium 89 telah dicadangkan untuk pengimejan PET imundisebabkan ciri-ciri reputan yang baik. Tujuan eksperimen ini adalah untuk menyiasatkeupayaan menghasilkan Zirconium 89 oleh yttrium electrodepositing ke atas substrattembaga dalam mana-mana asid nitrik yang berair, atau bukan berair, etanol,penyelesaian. Sasaran telah dibedil dengan siklotron tenaga rendah, tulen danmengukur dengan satu alat analisis berbilang saluran.*

**Keywords:** Positron emission tomography (PET), Cyclotron, Zirconium-89

## INTRODUCTION

With positron emission tomography (PET) imaging becoming widely available to more hospitals, new radiopharmaceuticals are being developed. However, the current issue with commonly used PET

isotopes is that they are short-lived, which gives insufficient time to do studies such as tumour imaging (Veral et al, 2003).

Therefore, studies are being conducted to investigate longer half-life radiotracers and zirconium-89 (Zr-89) had been proposed to be one of the more viable long half-life emitter with a half-life of 78 hours and a good energy of 908.9keV for PET imaging (Infantino et al, 2010). It can be produce in a cyclotron by bombarding yttrium-89 (Y-89) target, where Y-89 can be found in natural yttrium, which makes it cheap to obtain an enriched target material (Infantino et al, 2010). Having a half-life of 78 hours is also very ideal for preparing radio-labelled monoclonal antibodies (mAb) and gives enough time for the tracer to circulate the body for optimum biodistribution and tumour targeting (Holland et al, 2009).

To obtain cyclotron produced Zr-89, the yttrium target must be first prepared. There are a variety of methods for plating the backing of the target, but the method that will be used in research is electrodeposition, where the yttrium will be deposited onto a plate by electrolysis. Compared to other industrial method such as sputtering or electron-beam evaporation, electrodeposition is more affordable. It has also been demonstrated in past studies that electroplated target can withstand at least 600uA 16MeV deuteron beam, which made by electroplating zinc on a copper plate (Nirinckx, 1976). Hence, the efficiency of preparing the yttrium target using the electrodeposition method for more production of Zr-89 will be investigated this in this research. Not only that this method is more affordable, the thickness and morphology of the target can be controlled at low temperature to obtain a uniform target (Tak and Lee, 1999).

The aim of this experiment is to investigate the ability to produce Zr-89 using electrodeposited yttrium targets in aqueous or non-aqueous solutions, which can then be used next aim of the study; separation of Zr-89 from impurities.

## MATERIALS AND METHODS

### *Targets Preparation*

Two copper plates will serve as the anode and cathode were placed together with a 0.5 cm distance to each other.

For *aqueous bath*, 4% HNO3 was used to dissolve 1 mg of yttrium nitrate ($Y(NO_3)_3$). Electrodes were placed into the bath and the power supply ( Lab Power Supply 0-30 V 2.5 Amp Digital Displayl Dick Smith Electronics, Melbourne, Vic Australia) was set to 0.20-0.50 A current. The electrolysis process was left for 60 minutes. After 60 minutes, the electrodes were removed and cleansed with acetone for a minute and left to dry (Kumbhar and Lokhande, 1995).

For *non-aqueous bath*, 1 mg of $Y(NO_3)_3$ was diluted in absolute ethanol and electrolysis was done at 0.01 A current for 60 minutes. Electrodes were removed from the bath and cleansed with acetone for a minute and left to dry (Kumbhar and Lokhande, 1995).

Figure 1 Electrodeposition set-up.

A third target was prepared from collecting 0.45 g of yttrium from the non-aqueous bath and packed into the boat of gold plate target.

### *Bombarding the target*

After targets preparation using electrodeposition, each target was bombarded. The beam setting was 10 uA for 30 minutes.

Figure 2 Yttrium collected from electrodeposition in non-aqueous bath packed into a gold plate target.

### *Obtaining the Zirconium-89*

The targets were dissolved in 3 M hydrochloric acid and eluted with 1 M oxalic acid via a hydroxamate resin column according to previous study done by Iris and colleagues (2003). The eluted zirconium-89 was then analysed in the multi-channel analyser (MCA).

## RESULTS AND DISCUSSION

The deposited appearance of yttrium onto the copper substrate in the aqueous bath was adhesive, very thin, non-homogenous and brown-grey. After bombardment and elution process, no activity was obtained. This was probably due to metal hydroxides forming the nitric acid and yttrium. However, by adding additional agents that will change the pH or temperature, changing the current density and varying the molarities of the compounds in the bath might allow for better yttrium deposition.

Figure 3 Deposited yttrium from aqueous bath. Adhesive, non-homogenous and dark brown-grey in appearance.

Previous studies demonstrated that by adjusting the bath acidity is an important factor for bath's efficiency and coating physical properties. Increasing the pH will cause hydrogen reduction and sediment of the basic salts on cathode, whereas, enhancing the acidity will lower electroplating current efficiency (Mirzaii et al, 2010). By increasing the temperature of the bath, the mobility of ions will increase and reduce viscosity of the solution, thereby, resulting in concentration polarization and possibly enhances yttrium deposits in the acidic rather than dendrite formations (Mirzaii et al, 2010).

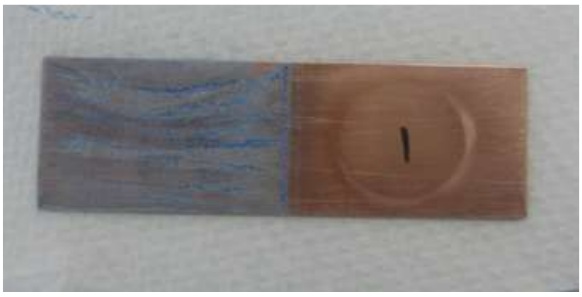

Figure 4 Deposited yttrium from non-aqueous bath. Adhesive, non-homogenous and blue-white in appearance.

For electrodeposition in non-aqueous bath, the deposited yttrium appeared to be adhesive, thin, non-homogenous and blue-white. The yield obtained after bombardment and elution processes was 0.04 Mbq. However, for the yttrium packed in gold plate target, the yield obtain was approximately 7 Mbq. The results show that the deposited yttrium in non-aqueous bath morphology was better than aqueous bath under room temperature and without any additional agents. This was probably due to the absence of hydrogen ions in ethanol forming with yttrium.

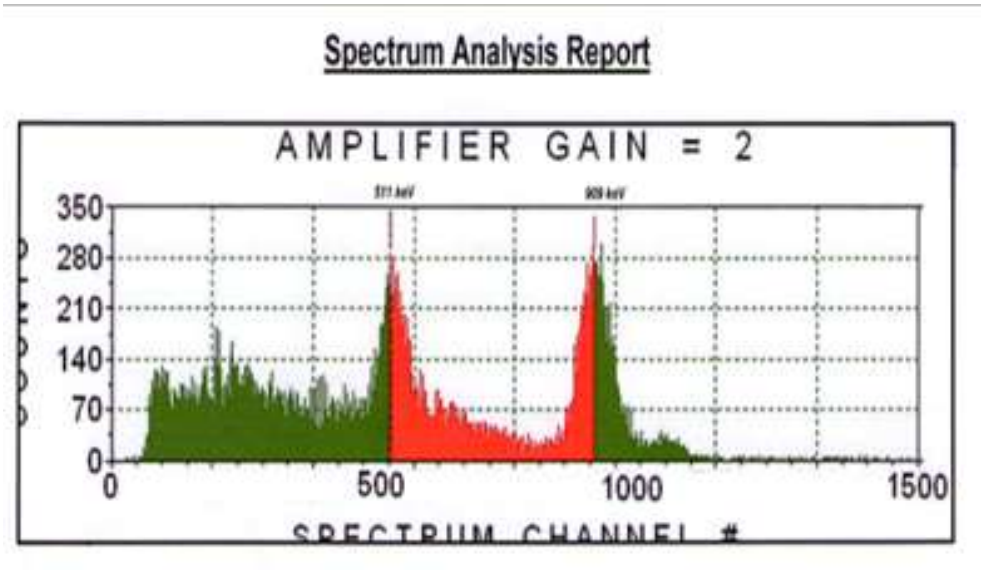


Figure 5 MCA showed the expected peaks for Zirconium-89 from gold plate target, 511 keV and 909 keV, with no other contaminating peaks present and yield of 7 Mbq.

## CONCLUSION AND FUTURE STUDY

The electrodeposition carried out at Peter MacCallum Cancer Center demonstrated that it was plausible to obtain zirconium-89 in a non-aqueous bath. However, due to time constraints and the unavailability of the cyclotron, other factors such as current density, pH and molarities of the compound of the bath could not be investigated.

An alternative to electrodeposition method to prepare yttrium targets is to deposit yttrium layer on a copper substrate by sedimentation (Sadeghi et al, 2010). Sadeghi and colleagues (2010) used this method to prepare their yttrium target by constructing a home-made system. This system was design to hold a mixture of either ethyl cellulose or methylcellulose powder with $Y_2O_2$ and water. They demonstrated that can produce Zr-89 from thick deposited layer of yttrium by sedimentation method. It was irradiated up to 20uA current with 13MeV protons and degradation occurred.

In future studies, the sedimentation technique will investigated using methylcellulose powder to prepare the yttrium target, and compare efficiency and yield of producing Zr-89 to electrodeposition.

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