Nuclear Science and Techniques **20** (2009) 231–234

Preparation of the radioactive source core of iodine-125 seed

HE Jiaheng* JIANG Lin LI Xingliang ZHONG Wenbin
WANG Jing MA Zongping JIAN Yuan

Institute of Nuclear Physics and Chemistry, China Academy of Engineering Physics, Mianyang 621900, China

Abstract Iodine-125 seed is widely used in brachytherapy of intraocular tumors, brain tumors, and prostate cancer. The ^{125}I seed is prepared by depositing ^{125}I on a silver rod. This work was aimed at investigating effects of different parameters on the iodine adsorption, so as to optimize the process for preparing ^{125}I core of the seed. The parameters investigated include kind and concentration of halogenation reagent, halogenation time, adsorption time, pH and carrier iodine quantity.

Key words ^{125}I, Adsorption, Seed source

1 Introduction

Radiopharmaceuticals are widely used in clinical therapy of tumors[1]. Sealed radioactive sources in a variety of shapes, sizes and activity levels are widely used in brachytherapy[2–7]. Among them, ^{125}I seed, a silver rod with ^{125}I sealed in titanium capsules, is used in treating tumors in the eye, brain and prostate[8–12]. Different methods are used for preparing the source core, such as ^{125}I deposition on organic materials, ion-exchange resins, ceramic beads, palladium bars, silver coated beads etc. Although some results of investigations concerning fixing ^{125}I on silver were reported[13,14], little technical details of source preparation are available[15–17]. In order to prepare the radioactive source with ^{125}I deposition, we investigated influences of different parameters on the iodine deposition on a silver rod. The main parameters include kind and concentration of halogenation reagent, halogenation time, adsorption time, pH value and amount of iodine carrier. Instead, we used ^{131}I, which is cheaper and easier to measure than ^{125}**I.**

2 Materials and methods

[^{131}I] NaI at pH≈9 was provided by Sichuan University. The silver wire of *Φ*0.5 mm was of guaranteed purity of >99%. All reagents, obtained commercially, were used without purification.

CRC-15R radioactivity meter, Capintec, USA; S-450 scanning electron microscopy, Hitachi, Japan; SHZ-82 oscillator, Jiangsu Jintan Zhengji Instrument, China.

Silver rods of *Φ*0.5 mm×3.0 mm were made from the silver wire. They were washed with acetone, hot water and tap water successively to clean off possible surface contamination of oil and/or grease. The surface oxide was removed with 100 mL of 3 mol/L HCl. After water washing, the silver rods were dried to constant weight under an IR lamp before storing them in sealed vials.

The precursor $AgCl_2$ layer can be formed in an oxidation-reduction reaction. Three oxidation reagents, i.e. $NaClO_3$, $NaClO_4$ and $NaClO_2$, were used in this work, so as to choose the preferred halogenation reagent. The reagent concentration and halogenation time were optimized.

The halogenated silver bars were ready for ^{131}I adsorption. Acetic-sodium acetate solution was used as the buffer and KI as the carrier. Effects of the deposition time, pH value of the buffer and amount of iodine carrier on ^{131}I adsorption were studied for optimizing the conditions.

Supported by development fund, CAEP (2009B0301028)

* Corresponding author. *E-mail address:* myjhbbljy228318@126.com

Received date: 2009-01-15

3 Results and discussion

3.1 Halogenation of silver wire

3.1.1 Halogenation reagents

Three groups of the silver bars were immersed into 2 mol/L $NaClO_3$, 2 mol/L $NaClO_4$, or concentrated $NaClO_2$ (1.6–1.7 mol/L) and vibrated for 1 h. The halogenation effect was measured in terms of the radioactivity of ^{131}I adsorbed on the silver rods after the halogenation (Fig.1).

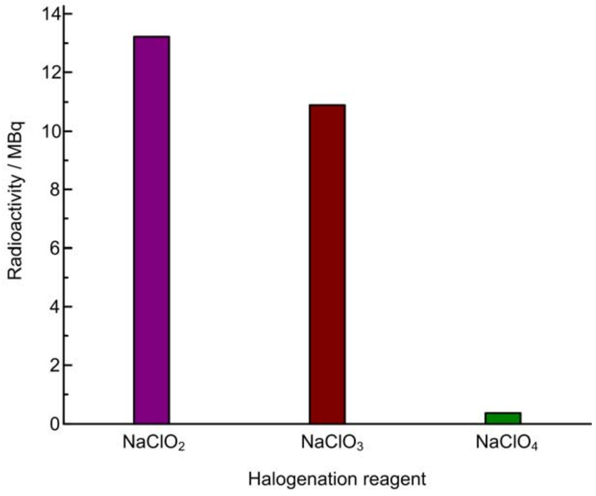

Fig.1 Iodine adsorption of the halogenation reagents.

From Fig.1, $NaClO_2$ and $NaClO_3$ are good halogenation reagent for iodine adsorption, but not $NaClO_4$, with which the adsorption was almost zero. The halogenation occurs when the Cl^- of AgCl is replaced by I^-, i.e.

$$AgCl + I^- \rightarrow AgI + Cl^- \quad (1)$$

However, the oxidation of $NaClO_4$ is so strong that Ag was mainly oxidated into Ag_2O, with little formation of AgCl for I^- replacement reaction.

The $NaClO_2$ treated silver rods adsorbed more ^{131}I than $NaClO_3$ did, but the halogenation releases Cl_2, a harmful gas for human beings and environment. Therefore, $NaClO_3$, which has high halogenation rate but releases no Cl_2, was the preferred halogenation reagent.

3.1.2 Halogen concentration effect

The concentration effect on iodine adsorption was studied with $NaClO_3$ in concentrations of 0.5–3.0 mol/L (Fig.2). The iodine adsorption increased with the $NaClO_3$ concentration up to 2.0 mol/L, where it began to decrease. It showed that the ion-exchange efficiency increased as increasing the concentration of $NaClO_3$ in a certain range. While with further concentration increase, it became decreasing. This indicates that, at this time, the silver chloride covered on whole surface of silver rod was by decreased because of strong oxidation of concentration $NaClO_3$.So the best adsorption occured at 2.0 mol/L of $NaClO_3$.

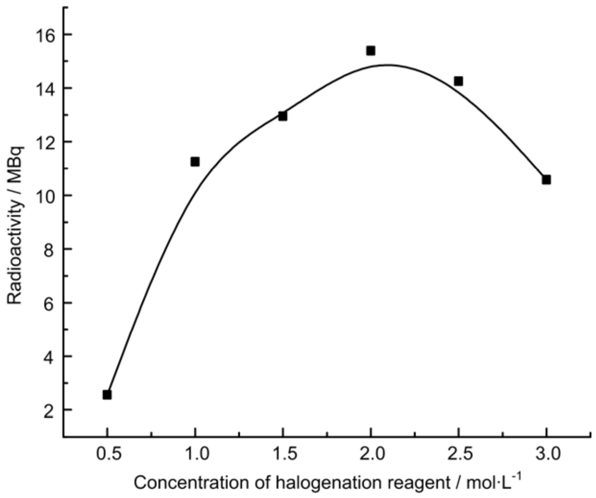

Fig.2 Effects of halogen concentration on the iodine adsorption.

3.1.3 Halogenation time effect

The iodine adsorption was performed with 2.0 mol/L $NaClO_3$ in halogenation time of 30 min to 24 h. Fig.3 shows the halogenation time effect on ^{131}I adsorption of the silver rods. Basically, the ion-exchange efficiency increased with the time from 30 min to 3 h, and became constant after 3 h. This indicates that, the surface of silver rods could be thoroughly covered by silver chloride and the exchange efficiency could reach a maximum value and maintained constant the increase of time, for 2 mol/L sodium chlorate, the suitable chlorination time was 3 hours.

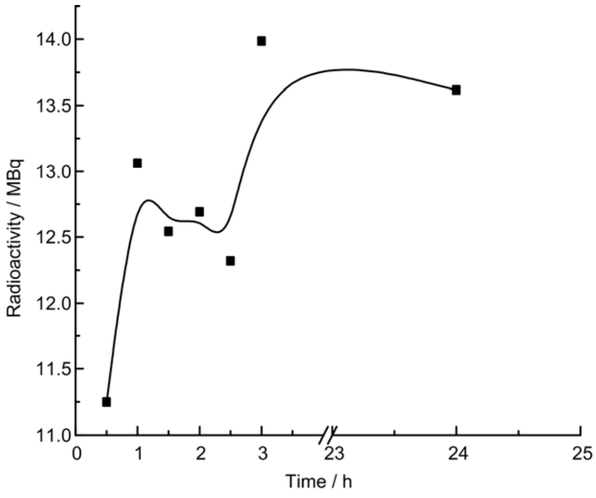

Fig.3 ^{131}I adsorption at different hours of halogenation.

3.2 Optimization of adsorption technology

3.2.1 Iodine adsorbed in different time of adsorption

The halogenated silver rods were immersed in 1.22 mL solution containing 200 μL ^{131}I (about 7.4×10^8 Bq) for 10−150 min at room temperature. The solution had been added with 1 mL acetic-sodium acetate solution (pH≈4) as buffer and 20 μL KI (2 μg in 10 μL) as carrier. The ^{131}I adsorption at different minutes is shown in Fig.4. Prolonging the adsorption time did not improve the ^{131}I adsorption. Instead, it decreased after 20 min. So, the suitable adsorption time is 20 min. But this is a rather strange phenomenon, we will do further experiment to investigate it.

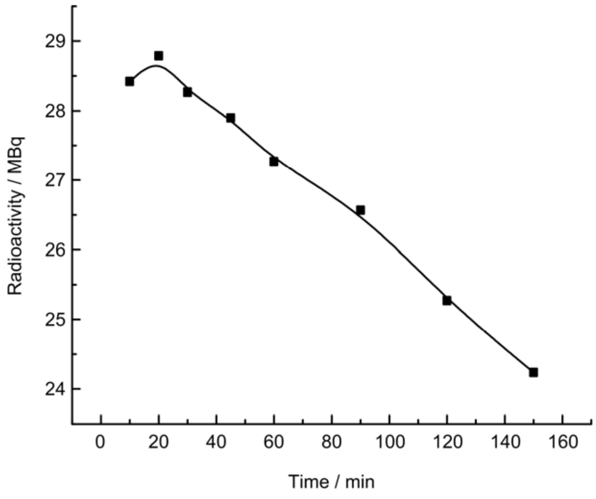

Fig. 4 Iodine adsorbed in different minutes of adsorption.

3.2.2 Effect of the buffer pH on adsorption

Under the optimized experimental parameters, the iodine adsorption was performed with the buffer of different pH values from 3 to 9 (Fig.5). The silver rods adsorbed more ^{131}I in the solution with the buffer of lower pH value. Perhaps further lowering the pH value (e.g. pH=2) would be more effective for the iodine adsorption. But taking into account that the volatility of the strong acid solution will cause environmental pollution, pH value of about 3 was selected.

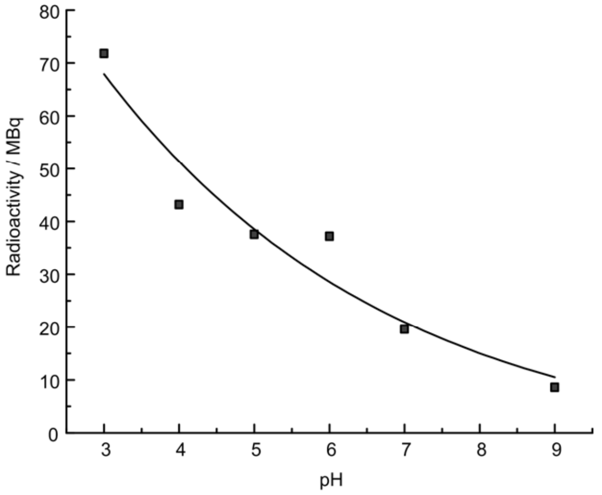

Fig.5 ^{131}I adsorption *vs.* pH value of the buffer.

3.2.3 Influence of carrier iodide quantity on adsorption

The adsorption experiment was conducted with the potassium iodide carrier of different quantities from 0 to 60 μg in a 1 mL reaction volume, while the other optimized experimental parameters were kept constant. Radioactivities of the adsorbed ^{131}I in Fig.6 show that the carrier concentration played an important role in the deposition of ^{131}I on the silver rods. The carrier iodine is necessary in that it reduces the ^{131}I attachment to the reactor wall, and produces a more uniform distribution of ^{131}I on the silver rod surface. The radioactivity of silver rods with around 25 μg of the KI carrier is about 10 times larger than the rods with out the carrier. The carrier quantity we chose was 35–40 μg.

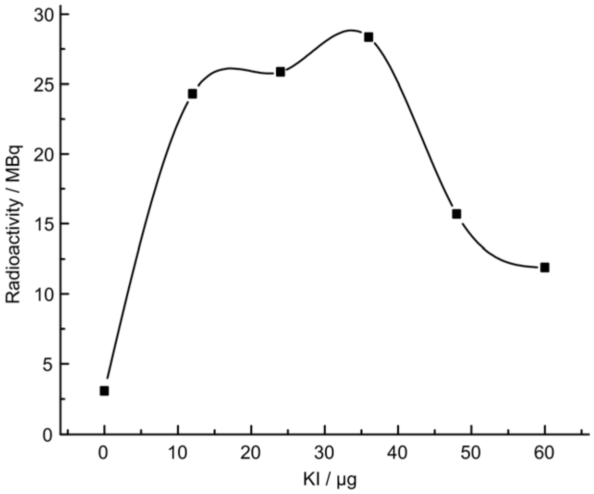

Fig.6 ^{131}I adsorption *vs.* quantity of KI carrier.

4 Conclusion

Among various methods to fix ^{125}I on a silver rod, the ion-exchange technique is simple and effective. Effects of different parameters, including the kind and concentration of halogenation reagent, halogenation time, adsorption time, pH value of the buffer and carrier iodine quantity, on the iodine deposition, were investigated. The optimized conditions are:

(1) Halogenation of the silver wires, 2 mol·L^{-1} $NaClO_3$ for 3 hours.

(2) Iodine adsorption on halogenated silver rods, 36–40 μg KI carrier at pH≈3 for 20 min at room temperature.

References

1 He J H, Luo S Z, Jiang S B,*et al*. Nucl Sci Tech, 2007, **6:** 1–5.

2 Battermann JJ. Radiother Oncol, 2000, **57:** 269–272.

3 Dicker A P, Lin C C, Leeper D B, *et al*. Semin Urol Oncol, 2000, **18:** 152–159.

4 Nath S, Chen Z, Yue N, *et al*. Med Phys, 2000, **27:** 1058–1066.

5 Zelefsky M J. Int J RadiatOncol Biol Phys, 2000, **48:** 601–608.

6 Wu A, Lee C C, Johnson M, *et al*. Int J Radiat Oncol Biol Phys, 2000, **47:** 1397–1403.

7 Li Z. Med Phys, 2001, **28:** 1410–1415.

8 Xie D Y, Zhang Z C, Luo X Y. Acad J Sec Mil Med Univ. 2000, **21:** 174–176.

9 Martinez-Monge R, Nag S, Nieroda C A, *et al*. Cancer, 1999, **85:** 1218–1225.

10 Zelefsky M J. Cancer J, 2000, **6:** 249–255.

11 Henkel T O, Kahmann F. Arch Ital Urol Androl, 2000, **72:** 295–301.

12 Nath R, Meigooni A S, Nath R. Med Phys, 1990, **17:** 1032–1040.

13 Manolkar R B, Sane S U, Pillai K T, *et al*. Appl Radiat Isot, 2003, **59:** 145–150.

14 Mathew C, Majali M A, Balakrishnan S A. Appl Radiat Isot, 2002, **57:** 359–367.

15 Ling C C. Int Radiat Oncol Biol Phys, 1992, **23:** 81–86

16 Nath R, Meigooni A S, Muench P, *et al*. Med Phys, 1993, **20:** 1465–1473.

17 Williamson J F, Quitero F. Med Phys, 1988, **15:** 891–897.