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Adsorption of iodide on silver rods for ^{125}I seed preparation

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1. Introduction

Recently, the rate of prostate cancer is increasing rapidly in Korea. Brachytherapy using ^{125}I seeds has drawn attention as one of the treatment options of this type of cancer. ^{125}I is a radionuclide, which emits 27 keV and 31 keV X-rays and 35 keV γ-ray with a half-life of 59.4 days. This radioisotope is produced by the bombardment of neutrons on the ^{124}Xe target and decays via electron capture to ^{125}Te. The brachytherapy sources are fabricated as seeds and implanted permanently to the prostate. The seed consists of a titanium capsule as a shell with a dimension of 0.8 mm in external diameter, 0.05 mm in wall thickness and 4.5 mm in length. A silver (Ag) rod with a dimension of 3 mm in length and 0.5 mm in diameter is used as the radioactive core after adsorption of ^{125}I and is placed in the shell. The silver rod also acts as an X-ray marker to visualize by X-ray imaging [1] and determine the location of seeds in the prostate. Currently, the supply of ^{125}I seeds depends only on imports. Hence, national research and development are needed for local production. This research work is carried out to find the optimum conditions in the preparation of the radioactive core, more specifically in the adsorption of iodide on the silver rods.

2. Experiments

2.1 Materials

A silver rod (Ag, purity 99.9%) was obtained from HeeSung steel Co., Ltd., Korea. Sodium iodide (NaI) was obtained from Sigma Aldrich Co., LLC., USA as a cold iodide. ^{131}I with a half-life of 8.02 days is produced at HANARO and used as a tracer instead of ^{125}I. All other chemicals used in this work are at least ACS reagent grade.

2.2 Condition of experiments

The characteristics of iodide adsorption are studied for cases of the method of surface treatment of a silver rod, contact concentration of iodide, and the aging after pretreatment of the rod.

The effect of the surface treatment of the silver rod on the adsorption was studied for the cases of untreated, oxidized rod, sulfidized rod, and sulfidized rod after oxidation.

Such rods either pretreated or not were soaked in an iodide solution traced with ^{131}I and stirred using a roll mixer for 24 hours. Ten Ag rods were used for each contact solution. The equivalent concentration of the iodide solution is 10 mCi/5 ml as ^{125}I for each contact sample.

The effect of the iodide concentration on the adsorption was studied using ten sulfidized Ag rods in the concentration range of 5-100 mCi as ^{125}I at a fixed solution volume (5 ml). Other adsorption conditions were the same.

The effect of aging after sulfidation was studied by varying the aging time from 1 day to 3 weeks. Five sulfidized Ag rods were contacted with 5 mCi as ^{125}I in a 2.5 ml solution. The other adsorption conditions were the same.

2.3 Measurement of the activity

For the analysis of adsorbed quantities of iodide, the radioactivities of ^{131}I both on the rods and in the solutions were measured after the reaction using the gamma spectroscopy technique.

3. Results

3.1 Surface treatment of Ag rod

As shown in Table 1, 37.02% of iodide is adsorbed on the untreated silver rod. On the other hand, the adsorbed amount of iodide increases to 56.45% after oxidation, 79.46% after sulfidation, and 78.39% after oxidation followed by sulfidation. From this study, it is realized that sulfidation is the most effective treatment. There is no significant effect of oxidation before sulfidation. Hence, the sulfidation method is adopted in this research.

surface treatment	adsorbed radioactivity (μCi/10 rods)	adsorption (%)
untreated	0.2823	37.02
oxidized	0.4305	56.45
sulfidized	0.6060	79.46
sulfidized after oxidation	0.5978	78.39

Table 1. Measured radioactivity of ^{131}I on Ag rods at different surface treatments

3.2 Concentration of iodide

Figure 1 shows the relationship between the iodide concentration in a 5 ml solution, which is contacted with 10 sulfidized rods and the adsorbed amount of ^{125}I (equivalent quantity) on a rod. Normally, ^{125}I brachytherapy seeds are manufactured with 1-2 mCi radioactivity. Hence, it is required to use 10-30 mCi/5 ml of the contact solution to produce 1-2 mCi sources for each 10 pieces of rod.

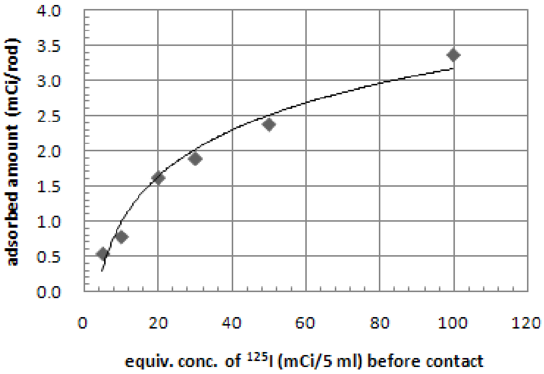

Figure 1. Effect of concentration of iodide on adsorption

3.3 Aging effect after sulfidation

Figure 2 shows the aging effect on the adsorption capacity after the surface treatment. There is only a 4% loss of the adsorption capacity after 21 days for the case of sulfidation. On the other hand, 12% loss is observed in the case of oxidation followed by the sulfidation. Hence, the sulfidation process can provide more stable surface modification than the sulfidation after oxidation.

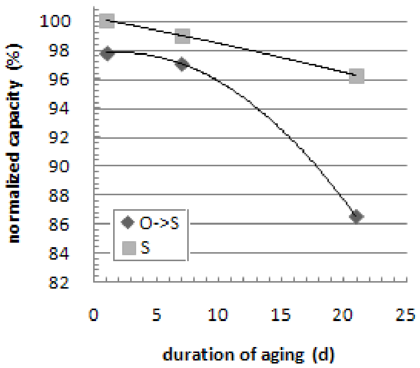

Figure 2. Efficiency on duration of aging

4. Conclusions

Silver is a good source core because it strongly adsorbs iodide and acts as an X-ray marker. By the study of surface pretreatment, it is noticed that the sulfidation can provide the best adsorption characteristic of the iodide. Also, the sulfidized rods are stable for the extended shelf time which is one of the important issues for the mass production of seeds.

Sulfidation after the oxidation method also provides high adsorption efficiency, but the rods treated by this method are not stable after the extended shelf time.

REFERENCES

[1] Izabela Cieszykowska, Andrzej Piasecki, Mieczyslaw Mielcarski, An approach to the preparation of iodine-125 seed-type sources, NUKLEONIKA, Vol.50(1), p. 17, 2005.