Determination of radio-chemical purity and specific activity of radionuclide lutetium-177 chloride without carrier

L.O. Khajiev[*2], I.I. Sadikov[1], A.M. Abdukayumov[2], Z.O. Usarov[2]

[1]Institute of Nuclear Physics AS RUz, Mirzo Ulugbek district, Ulugbek township, Khorasan 1, 100214, Tashkent, Uzbekistan
[2]State Enterprise «Radiopreparat» of Institute of Nuclear Physics AS RUz, Tashkent, Uzbekistan

Received 27.12.2021, revised 28.03.2022.

*Corresponding author: e-mail hajiyev.lazizbek@mail.ru

В настоящей работе рассмотрены методы определения радиохимической чистоты и удельной активности радионуклида лютеция-177 в форме хлорида. Указанные показатели определяли методом тонкослойной хроматографии (ТСХ) и бумажной хроматографии. В качестве подвижной фазы в ТСХ использовали раствор цитрата натрия концентрацией 0.1 моль/л, а в бумажной хроматографии 10% раствор ацетата аммония и метанола в соотношении фаз 1:1 и NH_4OH:CH_3OH:H_2O в соотношении фаз 0.4:2:4.

Ключевые слова: радионуклид лютеций-177, радиохимическая чистота, удельная активность, тонкослойная хроматография, бумажная хроматография, цитрат натрия, гидроксид аммония, метанол, аммония ацетат, DTPA, Whatman 3MM, Ludlum-2200, силикагель.

In this work, methods for determining the radiochemical purity and specific activity of the radionuclide lutetium-177 in the form of chloride are considered. These indicators were determined by thin layer and paper chromatography. As a mobile phase in TLC, a solution of sodium citrate with a concentration of 0.1 mol/l was used, and in paper chromatography a 10% solution of ammonium acetate and methanol in a phase ratio of 1:1; and NH_4OH:CH_3OH:H_2O in a phase ratio of 0.4:2:4.

Keywords: radionuclide lutetium-177, radiochemical purity, specific activity, thin layer chromatography, paper chromatography, sodium citrate, ammonium hydroxide, methanol, ammonium acetate, DTPA, Whatman 3MM, Ludlum-2200, silica gel.

DOI: https//doi.org/10.52304/.v24i1.309

I. Introduction

At present, radionuclides with optimal nuclear-physical properties are widely used in nuclear medicine for the treatment of oncologic diseases, especially cancer.

Among the most promising β-emitting radionuclides for cancer therapy, ^{177}Lu can be distinguished, which has a convenient half-life ($T_{1/2}$ = 6.71 days), an acceptable β-particle energy (E_{max} = 0.497 MeV), and soft concomitant γ-radiation (E_γ = 113 keV, 6.4%; 208 keV, 11%). The decay product of ^{177}Lu is the stable isotope ^{177}Hf.

Radiopharmaceuticals (RP) based on ^{177}Lu are highly effective therapeutic agents in the treatment of liver, prostate and skin cancer, as well as other diseases, including rheumatic arthritis and hemophilia.

Relatively short path length of ^{177}Lu β-particles in biological tissues (<2 mm) with localization of a significant number of radionuclide atoms in the immediate vicinity of the tumor cell provides selective destruction of the tumor with minimal damage to the surrounding tissues. Since ^{177}Lu simultaneously emits β-particles and γ-quanta, it is ideal for the therapy of malignant neoplasm and at the same time makes it

possible to visualize the course of the therapeutic effect [1].

Recently, the radionuclide ^{177}Lu is considered one of the most promising for radionuclide therapy using labeled antibodies and peptides (targeted delivery of drugs to affected organs and tissues) [2].

^{177}Lu has optimal characteristics for use in nuclear medicine: a convenient half-life, acceptable energy of β-particles, which makes it possible to destroy small tumors and metastases 1–3 mm in size without affecting healthy tissues; soft accompanying γ-radiation with sufficient energy for imaging. The relatively long half-life of ^{177}Lu is convenient for targeted drug delivery for slow targeting antibodies. In addition, ^{177}Lu has chemical characteristics suitable for protein labeling with functional chelating agents such as diethylenetriaminepentaacetic acid (DTPA) or 2,2′,2″,2‴-(1,4,7,10-Tetraazacyclododecane-1,4,7,10-tetrayl) tetraacetic acid (DOTA) [3].

Over the past few years, the ^{177}Lu radionuclide has attracted considerable attention and has shown great promise in scientific, commercial and clinical circles for use in various therapeutic procedures [4, 5].

In a relatively short period of time, ^{177}Lu not only strengthened its potential, but also firmly established itself in the field of targeted radionuclide therapy (TRT), and ^{177}Lu has practically penetrated into all areas of radionuclide therapy in vivo and, possibly, is ready to become a key therapeutic radionuclide for TRT [6].

Bone metastases often occur with the progression of various tumors, such as prostate, breast, and lung cancers. They often cause progressive pain [7] and occur in many patients with solid malignancies [8]. Approximately 50% of patients with breast carcinoma and 80% of patients with prostate cancer develop metastatic bone disease, and nearly half of them experience bone pain [9]. Despite ongoing treatment in these patients, a systemic bone-dependent radiopharmaceutical for the treatment of advanced bone metastases has potential advantages [10]. Among the radioactive lanthanides used in nuclear medicine, ^{177}Lu is an interesting candidate for therapeutic protocols. ^{177}Lu radiopharmaceuticals have been developed and used in various procedures such as somatostatin receptor radiation therapy [11], radio-immunotherapy [12], bone palliative therapy [13], and radio synovectomy [14, 15].

In the last decade, the ^{177}Lu radionuclide is considered one of the most promising for radionuclide therapy (RNT) using labeled antibodies and peptides [16]. Antibodies radio-labeled with ^{177}Lu are attractive therapeutic agents due to their beta energy and half-life of the radionuclide, this complex is well suited to in vivo pharmacokinetics.

To date, there have been several clinical trials and preclinical studies of ^{177}Lu-detectable monoclonal antibodies, including ^{177}Lu-J591 [17, 18] for the treatment of prostate cancer and ^{177}Lu 81C6 and L8A4 [19, 20] for brain cancer.

Radiofrequency ^{177}Lu labeling on an antibody molecule is an alternative method of direct radiofrequency ablation that has been successfully used in the production of radiofrequency antibodies for imaging and therapy. DOTA anikores are most often used for radioactive labeling and form stable complexes of ^{177}Lu-DOTA with ^{177}Lu [20]. Many DOTA antibodies labeled with alpha and beta releasing radionuclides are used as agents for cancer treatment [21, 22].

^{177}Lu labeled with J591, a humanized monoclonal antibody targeting the extracellular portion of prostate-specific membrane antigen (PSMA), has been used for targeted therapy in hormone resistant and chemoresistant prostate cancer [17].

This article presents preliminary experimental results for the determination of radiochemical purity (RCP) and radiochemical inclusion, i.e. formation of a complex of the radionuclide $^{177}LuCI_3$, without a carrier, with a complexone diethylenetriaminepentaacetic acid (DTPA) in various stoichiometric ratios, by thin layer chromatography (TLC).

II. Experimental part

II.1. Determination of radiochemical purity and radiochemical impurities

RCP is one of the main indicators of the quality of RP, which determines the pharmaco-dynamics of the drug in the clinic, the reliability of the information received and, as a rule, the diagnostic or therapeutic efficacy.

Ideally, any RP should not contain other labeled compounds in addition to the main one, but in most practical cases, the drug will contain radiochemical impurities, the amount of which is detected when determining the radiochemical purity of the target drug.

In practice, a drug is considered radiochemical pure if it has activity of 97–98% due to the basic substance. In principle, any analytical separation methods can be used to determine the radiochemical purity, for example, paper chromatography, thin layer chromatography, electrophoresis and others [23].

©Academy of Sciences of Republic of Uzbekistan, 2022

The reagents: sodium citrate, hydrochloric acid, NH_4OH, methanol, ammonium acetate used in the experiments were of chemically pure grade. Methanol solvent and DTPA bifunctional chelating agent were purchased from Sigma Aldrich (USA) with the highest available purity and were used without further purification unless otherwise indicated.

To carry out thin layer chromatography of the studied samples, a TLC plate with a thin layer of silica gel (Art. 5553, Merck) was used, and Whatman 3MM chromatographic paper (Sigma Aldrich) was used for paper chromatography, and a chamber with a flat plate was used as a chamber for thin layer chromatography and paper chromatography, bottom and ground cover allowing the use of plates of standard sizes 100×100, 150×150 and 200×200 mm.

The complexation of the radionuclide $^{177}LuCI_3$ with DTPA in various stoichiometric ratios was carried out in a polyethylene test tube from Eppendorf.

To determine the distribution of $^{177}Lu^{3+}$, ^{177}Lu ions or ^{177}Lu colloid and ^{177}Lu:DTPA complex on a thin-layer plate and chromatographic strip, a single-channel γ-radiometric device Ludlum-2200 with a 243 (NaI) well scintillation detector was used. The scintillator used in the complex, which makes it possible to increase the measurement geometry up to 4p.

Chromatography process. The TLC method is the most effective than others due to its low cost, availability, acceptable experimental speed, and wider separation capabilities. In this regard, the radiochemical purity and radiochemical impurities of lutetium-177 chloride ($^{177}LuCI_3$) were determined by TLC.

The study of the paper chromatography method is carried out on Whatman 3MM chromatographic paper 1.5×10 cm long. For these studies, 5 µl of the test solution is applied at a distance of 1.5 cm from the lower end of the paper strips, which are developed in 10% ammonium acetate in methanol (30:70 vol./vol.). The strips are then dried and cut into 1 cm segments. The radioactivity associated with each segment is measured in a NaI(Tl) well type detector. While the colloidal forms or other ionic forms of ^{177}Lu (such as $^{177}LuCl_4$) remains at the start, Rf = 0.05, and the free $^{177}Lu^{3+}$ ions migrate to the finish, the Rf value is Rf = 0.9–1 [24]. The Rf value (deceleration factor) was calculated using the following formula Rf = A/B, where A – distance (cm) from the start line to the position of the peak of radioactivity, B – distance (cm) from start line to solvent front

As a mobile phase in TLC, a solution of sodium citrate with a concentration of 0.1 mol/l and pH = 5.1–5.2 was used, and in paper chromatography a 10% solution of ammonium acetate and 100% methanol in a phase ratio of 1:1; and 25%NH_4OH:100% CH_3OH:H_2O in a phase ratio of 0.4: 2: 4.

The tested initial preparation of lutetium chloride-177, without carrier in 0.04 M HCI solution, was diluted to a volumetric activity of 20–50 mCi/ml with 0.04 M hydrochloric acid solution.

A plate with a thin layer of silica gel and strips for BC were prepared as follows: 3 strips of 15×140 mm were cut, a sample of the drug solution with a volume of 1.0–1.5 µl was applied to the start line (15 mm from the edge of the strip), this was 1.48–2.22 MBq. The spots of the preparation on the plate and the strips of BC were dried in air. Then the plates were transferred to the TLC chamber and one end of it with the starting line was immersed in the solvent (mobile phase) in a vertical position. Under the influence of capillary forces the solvent moves up the plate dragging various components of the substance along with it. The various components of the substance lend themselves to ascent in different ways, so they are separated, that is, chromatography by the bottom-up method. When the front of the mobile phase reached a level of 120–130 mm from the starting line (60 minutes), the plates were removed and dried under a fume hood. In planar thin layer chromatography, the components of a substance differ in their relative position on the strip after chromatography (Fig. 1).

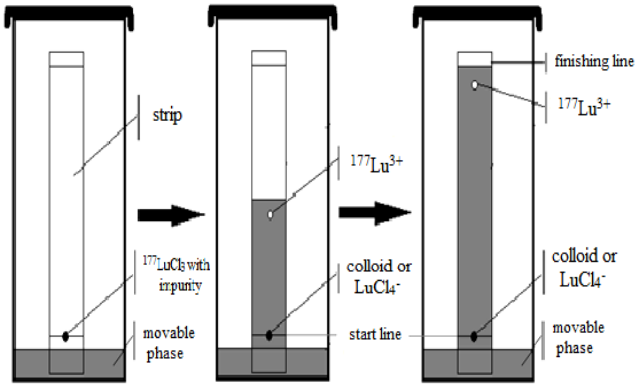


Figure 1. Diagram of the radiochemical purity (RCP) analysis process by thin layer chromatography.

The plates were dried at room temperature, pasted over from both sides with a polyethylene film with a sticky layer.

©Academy of Sciences of Republic of Uzbekistan, 2022

The first and last centimeter of the plates and strips were discarded and, starting from the side of the starting line, they were marked into 10 mm segments, numbered and cut off. It turns out 12 segments for measurements (for each plate).

Before measurements, the background was measured 3 times, the result was averaged. Then, the number of pulses in each successive segment of the chromatogram was measured in a γ-radiometric device. The measurement time for each segment is 10 sec.

The results of chromatogram calculations based on the ratio of the peak areas corresponding to the main and impurity chemical forms of lutetium were calculated radiochemical purity by the formula:

$$\mathrm{RCP} = \frac{\Sigma_{\mathrm{peak}}}{\Sigma_{\mathrm{total}}} \times 100\%,$$

where Σ_{peak} – the sum of pulses in the $^{177}Lu^{3+}$ peak; Σ_{total} – the total amount of impulses minus the background; RCP – radiochemical purity.

II.2. Determination of the inclusion of the substance lutetium chloride ^{177}Lu with the complexing agent diethylenetriaminepentaacetate by thin layer chromatography

In a polyethylene test tube from Eppendorf containing 100 μl of a $CaNa_3DTPA$ solution with a content of 5×10^{-10} mol, respectively, 370 MBq of the preparation of lutetium chloride ^{177}Lu is added. The ratio between ^{177}Lu:$CaNa_3DTPA$ was 1:1. The mixture is thoroughly mixed and placed in a thermostat. Maintain in a thermostat for 30 minutes at a temperature of 37°C.

Afterwards, on a plate with a thin layer of silica gel (Art. 5553, Merck), 15×140 mm, departing from one of the edges by 15 mm (starting line), the prepared mixtures were applied in such an amount that it was possible to statistically reliably register on a radiometric installation, at least 0.5% of the applied activity. It was experimentally revealed that the application of 1 μl (3.5 MBq) of the solution is optimal. The spots of the preparation were dried in air and chromatographed by the ascending method for 60 minutes, using as a mobile phase a 0.1 M sodium citrate solution prepared by dissolving 2.58 g of sodium citrate in 100 ml of bidistilled water, pH is 5.1–5.2.

After the front of the mobile phase reached the finish line, they were taken out of the chamber, dried at room temperature, and pasted on both sides with plastic wrap with a sticky layer.

The first and last centimeter of the plate was discarded. Then they marked, starting from the side of the starting line, into segments of 1 cm, numbered and cut into pieces. 12 sections are received for measurements.

For the developed chromatogram, the distribution of ^{177}Lu:DTPA activity along its length was determined on a Ludlum-2200 γ-radiometric device. Before measurements, the background was measured 3 times and averaged. Then, each successive chromatogram segment was cut off and placed for activity measurement in a γ-radiometric device. The measurement time for each segment is 10 sec.

The ratio of the areas of the peaks corresponding to the main complex ^{177}Lu:DTPA and impurity $^{177}Lu^{3+}$ ionic forms was used to calculate the percentage of inclusion of ^{177}Lu with DTPA. The percentage of inclusion of ^{177}Lu with DTPA was calculated and the specific activity is calculated by the formula:

$$\mathrm{SA}_{^{177}\mathrm{Lu}} = \frac{110 \times C_{^{177}\mathrm{Lu:DTPA}}}{C_0},$$

where SA – specific activity of the drug; 110 – theoretical maximum specific activity of the preparation, Ci/ mg; $C_{^{177}\mathrm{Lu:DTPA}}$ – the number of counting pulses of the chromatogram section containing ^{177}Lu:DTPA; C_0 – the number of counting pulses of the entire chromatogram.

Determination of the specific activity of the $^{177}LuCl_3$ preparation with ^{177}Lu without a carrier in 0.04 M HCl solution is based on the ability to form a complex of the $^{177}Lu^{3+}$ ion with the diethylenetriaminepentaacetate complexing agent in a stoichiometric ratio, considering the radiometric measurement results of ^{177}Lu.

The influence of various factors on the yield of ^{177}Lu-DTPA inclusion, including ligand concentration and temperature, was also studied, and the corresponding results are shown in Table 3.

III. Results and its discussion

III.1. According to the radiopharmaceutical preparation (RFP) requirements, the radiochemical purity of the lutetium-177 radionuclide (in the basic form $^{177}Lu^{3+}$ ions) must be at least 98%.

Averaged for three plates, the results of measurements of the preparation of lutetium-177 chloride without a carrier are shown in Table 1.

©Academy of Sciences of Republic of Uzbekistan, 2022

Table 1. Results of measurements of the radiochromatogram.

Segment №	Number of impulses in 10 sec	Segment №	Number of impulses in 10 sec
1	2578	7	248
2	433	8	295
3	301	9	524
4	286	10	12320
5	317	11	659911
6	299	12	369854

Measurement conditions: The length of each segment of the electrophotogram is 1 cm; background is 200 pulses.

The histogram of the distribution of the activity of lutetium-177 obtained from the data in Tabl. 1 is shown in Fig. 2.

The histogram shows zones of different chemical forms: $^{177}Lu^{3+}$ ions and colloid or $^{177}LuCl_4^-$. As can be seen from the histogram, in the indicated chromatography mode the Rf of $^{177}Lu^{3+}$ ions is (0.9–1.0). Possible other radiochemical impurities (colloid or $^{177}LuCl_4^-$) remain at the site of drug application with Rf = 0, which indicates the reliability of the results obtained.

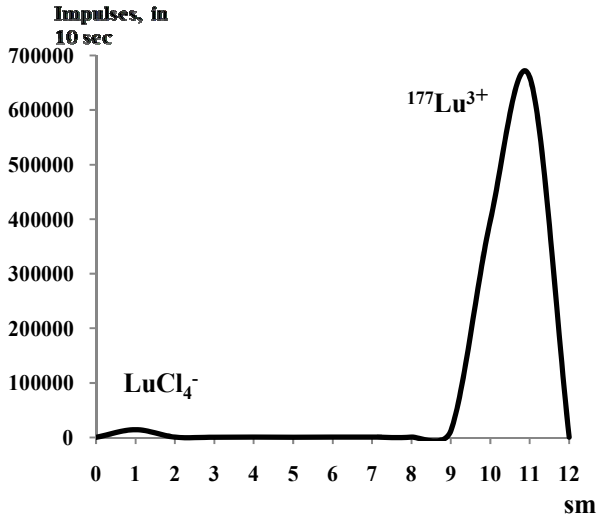
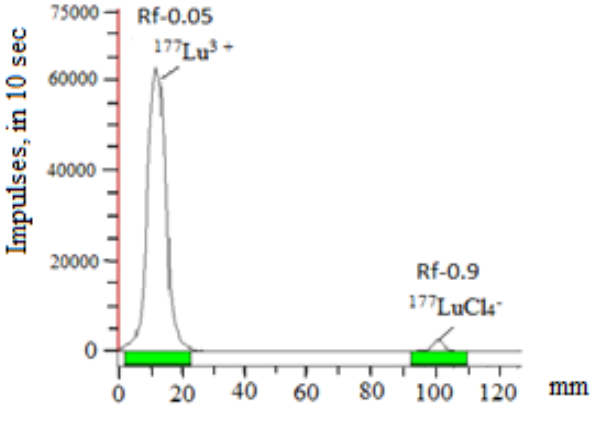


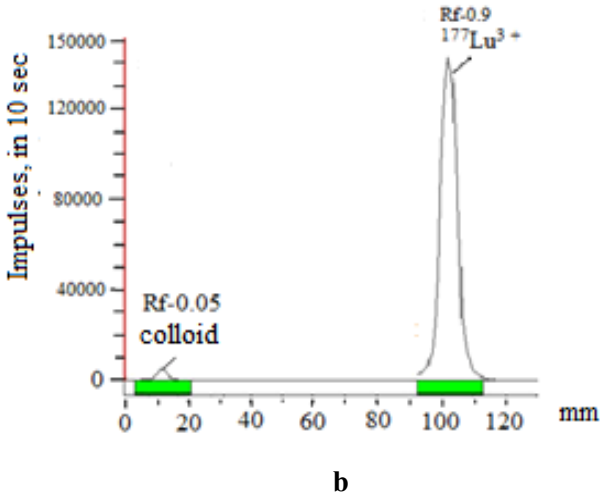
Figure 2. Histogram of the distribution of the activity of lutetium-177 components along the length of the radiochromatogram.

Radiochemical purity was calculated using the formula:

$$RCP = \frac{\Sigma_{peak}\,1041809}{\Sigma_{total}\,1044966} \times 100\% = 99.7\%$$



a



b

Figure 3. (a) PC chromatograms for $^{177}LuCl_3$ eluted with NH_4OH (25%):methanol (100%):water (100%) (0.4:2:4; v/v/v), chromatograms for $^{177}LuCl^3$ eluted using 10% ammonium acetate:methanol solution (1:1; v/v); (b) chromatography on Whatman 3MM.

As can be seen from Fig. 3a, in solvent the free cation $^{177}Lu^{3+}$ remained at the start (Rf = 0.05), while other ionic forms of ^{177}Lu (such as $^{177}LuCl_4^-$) migrate to a higher Rf = 0.9–1. In Fig. 3b it can be seen that the rapidly eluting substance may have been the free cation $^{177}Lu^{3+}$ (Rf = 0.9-1), while other ionic forms of ^{177}Lu (such as $^{177}LuCl_4^-$) remained in their original state (Rf = 0.05), as well as colloids.

The calculated value of the radiochemical purity of the preparation for both methods was 99.5% and

©Academy of Sciences of Republic of Uzbekistan, 2022

99.4%, respectively, which confirms the correctness of the first method.

III. According to the requirements for the drug used in medical practice, the specific activity for lutetium-177 should be at least 50 Ci / mg.

The results of measurements by the layer chromatography method are shown in Table 2. Measurement conditions: length of electrophotogram segment 1 cm; background 200 pulses, measurement time 10 seconds.

Table 2. Results of measurements of the radiochromatogram.

Segment №	Number of impulses in 10 sec, ^{177}Lu:DTPA	Segment №	Number of impulses in 10 sec, ^{177}Lu:DTPA
1	327	7	4379
2	436	8	546
3	471	9	35035
4	84227	10	104044
5	316102	11	75295
6	116342	12	1252

The histogram of the ^{177}Lu:DTPA activity distribution obtained from the data in Table 2 is shown in Fig. 4.

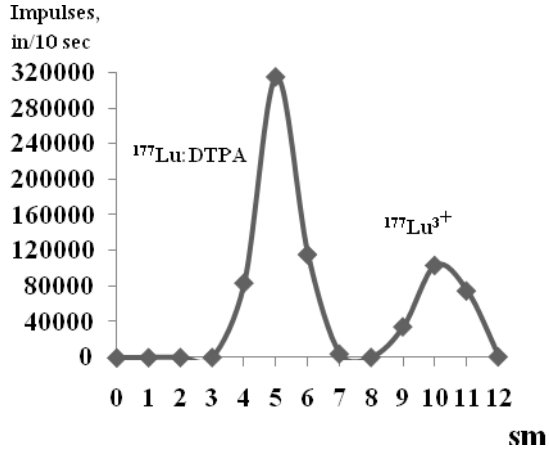


Figure 4. Histogram of the ^{177}Lu:DTPA activity distribution over the radiochromatogram.

As can be seen from Fig. 4, in the indicated chromatography mode the Rf of the ^{177}Lu:DTPA complex is (0.5). The Rf value of unbound $^{177}Lu^{3+}$ ions is (1.0).

Under these conditions, the advance of $^{177}Lu^{3+}$ ions is 80–120 mm, the advance of the ^{177}Lu:DTPA complex is 30–70 mm. The percentage of the activity of the included $^{177}Lu^{3+}$ ions in the ^{177}Lu:DTPA complex to the total activity of the chromatogram at a molar ratio of $^{177}Lu^{3+}$:DTPA of 1:1 should be at least 46%, which corresponds to the specific activity of 50 Ci/mg. The calculated value of the inclusion of the drug "Chloride Lutetium-177" was 70.8%. Specific activity is calculated by the formula:

$$SA_{^{177}Lu} = \frac{110 \times 522830}{738456} = 77.88 \text{ Ci / mg.}$$

Table 3. Influence of different molar ratios of ^{177}Lu and DTPA on inclusion (60 min at pH=5.1–5.2).

^{177}Lu:DTPA molar ratio	Turning on (%)
10:1	28.2
2:1	49.2
1:1	70.8
1:2	98.5
1:3	99.0
1:10	99,4

As can be seen in Table 3, the inclusion yield increased with an increase in the molar ratio of ^{177}Lu:DTPA (from 10:1 to 1:10) and reached more than 99% in 60 minutes.

IV. Conclusion

Unlike other drugs, the main active ingredient of any radiopharmaceutical preparation (RFP) is radionuclides or labeled compounds. Therefore, the main indicators of the quality of RFP are specific activity and radiochemical purity.

It was determined that the radiochemical purity and specific activity of the radionuclide lutetium-177 using thin layer chromatography in 0.1 M sodium citrate solution was 99.7% and 77.88 Ci/mg.

Studies have shown that the thin-layer chromatographic method can reliably determine the radiochemical purity and specific activity of lutetium-177 in a lutetium-177 chloride preparation without a carrier with high accuracy.

Литература (References)

[1] D.Yu. Chuvilin, V.A. Zagryadskiy, L.I. Menshikov, M.A. Proshin, A.N. Semenov. Patent RU, No. 2594020 IPC G21G4 / 08 publ. bul. No. 22 (2016).

©Academy of Sciences of Republic of Uzbekistan, 2022

[2] G.E. Kodina, R.N. Krasikova. Methods for Obtaining Radiopharmaceuticals and Radionuclide Generators for Nuclear Medicine (Moscow, 2014).
[3] P.P. Boldyrev, A.V. Kurochkin, R.F. Nurtdinov, M.A. Proshin, D.Yu. Chuvilin, Yu.A. Yashin. Vestnik Moskovskogo Universiteta, ser. 2 Chemistry **57**, No.3, 184-190 (2016).
[4] C.S. Cutler, H.M. Hennkens, N. Sisay, S. Huclier-Markai, S.S. Jurisson. Chem. Rev. No.113, 858-883 (2013).
[5] A. Dash, F.F. Knapp, Jr, M.R.A. Pillai. Curr. Radiopharm. No.6, 152-180 (2013).
[6] A. Dash, Maro or Raghavan Ambikalmajan Pillai, F. Furn. Knapp. Jr. Therapy **49**(2), 85-107 (2015).
[7] A.N. Serafini. J. Nucl. Med. **42**, 895-906 (2001).
[8] J.E. Bayouth, D.J. Macey, L.P. Kasi, and F.V. Fossella. J. Nucl. Med. **35**, 63-69 (1994).
[9] J.A. Campa and R. Rayne. Semin. Nucl. Med. **22**, 3-10 (1992).
[10] J.F. Eary, C. Collin, M. Stabin, C. Vernon, S. Petersdorf, M. Baker, S. Hartnett, S. Ferency, S.J. Addison, and F.J. Appelbaum. Nucl. Med. **34**, 1031-1036 (1993).
[11] L. Bodei, D. Ferone, C.M. Grana, M. Cremonesi, A. Signore, R.A. Dierckx, and G.J. Paganelli. J. Endocrinol. Invest. **32**, 360-9 (2009).
[12] R.B. Michel, P.M. Andrews, A.V. Rosario, D.M. Goldenberg, and M.J. Mattes. Nucl. Med. Biol. **32**, 269-78 (2005).
[13] S. Chakraborty, T. Das, S. Banerjee, L. Balogh, P.R. Chaudhari, H.D. Sarma, A. Polyák, D. Máthé, M. Venkatesh, G. Janoki, and M.R. Pillai. Cancer Biother. Radiopharm. **23**: 202-13 (2008).
[14] S. Chakraborty, T. Das, S. Banerjee, H.D. Sarma, and M. Venkatesh. Nucl. Med. Commun. **27**, 661-8 (2006).
[15] S. Chakraborty, T. Das, H.D. Sarma, M. Venkatesh, and S. Banerjee. Nucl. Med. Biol. **35**: 589-97 (2008).
[16] S. Vallabhajosula, S.J. Goldsmith, L. Kostakoglu, M.I. Milowsky, D.M. Nanus, N.H. Bander. Clin Cancer Res. **11** (19 Pt 2), 7195-7200 (2005).
[17] S. Vallabhajosula, S.J. Goldsmith, K.A. Hamacher, L. Kostakoglu, S. Konishi, M.I. Milowsky, D.M. Nanus, N.H. Bander. J. Nucl. Med. **46**(5), 850-8 (2005).
[18] A.T. Yordanov, M. Hens, C. Pegram, D.D. Bigner, M.R. Zalutsky. Nucl. Med. Biol. **34**(2), 173-83 (2007).
[19] M. Hens, G. Vaidyanathan, X.G. Zhao, D.D. Bigner, M.R. Zalutsky. Nucl. Med. Biol. **37**(7), 741-50 (2010).
[20] Victoria Calzada, Xiuli Zhang, Marcelo Fernández, Arlhee Díaz-Miqueli, Normando Iznaga-Escobar, L. Susan, Deutscher, Henia Balter, P. Thomas Quinn, and Pablo Cabral. Radiopharmaceuticals **5**, 318-324 (2012).
[21] C.A. Boswell, M.W. Brechbiel. Nucl. Med. Biol. **34**(7), 757-78 (2007).
[22] R.M. Sharkey, E.A. Rossi, W.J. McBride, C.H. Chang,D.M. Goldenberg. Semin. Nucl. Med. **40**(3), 190-203 (2010).
[23] M.A. Bogorodskaya, G.E. Kodina. Chemical Technology of Radiopharmaceuticals (Moscow, 2010).
[24] Comparative Evaluation of Therapeutic Radiopharmaceuticals (International Atomic Energy Agency, VIENNA, 2007).

Ташувчисиз радионуклид лютеций-177 хлориднинг радиокимёвий тозалик ва солиштирма фаоллигини аниқлаш.

Л.О. Ҳажиев[2], И.И. Садиков[1], А.М. Абдукаюмов[2], З.О. Усаров[2]

[1]УзР ФА Ядро физикаси институти, Мирзо-Улугбек р-они, Хуросон кўч., 100214, Тошкент, Узбекистон
[2]«Радиопрепарат» Давлат корхонаси, г. Ташкент, Мирзо-Улугбекский р-они, Хуросон кўч., 100214, Тошкент, Узбекистон

Бу ишда ҳлорид холидаги лютеций-177 радионуклидининг радиокимёвий тозалиги ва солиштирма фаоллигини аниқлаш усуллари кўриб чиқилди. Бу кўрсаткичлар юпқа қатлам ва қоғоз хроматографияси билан аниқланди. Юпқа қатлам хроматографиясида мобил фаза сифатида 0.1 М ли натрий цитрат эритмаси, қоғоз хроматографиясида эса фаза сифатида 10% аммоний ацетат эритмаси: метанол 1:1 нисбатда ва NH_4OH:CH_3OH:H_2O 0.4:2:4 фаза нисбатида ишлатилган.

Калит сўзлар: радионуклид лютеций-177, радиокимёвий тозалик, солиштирма фаоллик, юпқа қатлам хроматография, қоғоз хроматография, натрий цитрат, аммоний гидроксид, метанол, аммоний ацетат, DTPA, Whatman 3MM, Ludlum-2200, силикагель.

©Academy of Sciences of Republic of Uzbekistan, 2022