radioisotope-containing drug and increasing radioactive impurity overtime. In one example, provided herein are liquid radiopharmaceutical formulations that provide enhanced stability for alpha-emitting radionuclide such as Actinium-225. In one example, provided herein are liquid radiopharmaceutical formulations comprising ^{225}Ac-DOTA-TATE that are stable for at least 120 hours.

[005] In one aspect, provided herein is a liquid radiopharmaceutical composition comprising:

(a) a conjugate, wherein the conjugate is ^{225}Ac-DOTA-TATE and is present in the liquid radiopharmaceutical composition at a concentration equivalent to 5 to 60 mCi/L;

(b) a radiolysis stabilizer, wherein the radiolysis stabilizer is an antioxidant selected from N-acetyl cysteine, Ascorbic acid, N-tert-Butyl-α-phenylnitrone, 3-(3,4-Dihydroxyphenyl)-2-propenoic acid (Caffeic Acid), β-Carotene, Provitamin A, (2S,3R)-2-(3,4-Dihydroxyphenyl)-3,4-dihydro-1(2H)-benzopyran-3,5,7-triol 3-(3,4,5-trihydroxybenzoate ((-) Catechin gallate or CG), 1,4,5-Trihydroxycyclohexanecarboxylic acid, trans-4-Hydroxycinnamic acid (p-Coumaric acid), 3,3',4',5,5',7-Hexahydroxyflavylium chloride, Thiocytic Acid (Dihydrolipoic Acid, DHLA), 4,4',5,5',6,6'-Hexahydroxydiphenic acid 2,6,2',6'-dilactone (Ellagic acid), (-)-cis-3,3',4',5,7-Pentahydroxyflavane (Epi-Catechin or EC), 2-Methoxy-4-(2-propenyl) phenol, trans-4-Hydroxy-3-methoxycinnamic acid (Ferulic acid), 7-Hydroxy-3-(4'-methoxyphenyl)-4H-benzopyran-4-one, all-trans-Fucoxanthin, 3,4,5-Trihydroxybenzoic acid (Gallic acid), (2S,3R)-2-(3,4,5-Trihydroxyphenyl)-3,4-dihydro-1(2H)-benzopyran-3,5,7-triol ((-)-Gallocatechin), Glutathione, 2-(3,4-Dihydroxyphenyl)ethanol, 3,4',5,7-Tetrahydroxyflavone (Kaempferol), (±)-1,2-Dithiolane-3-pentanoic acid, Luteolin, Lycopene, L-Lysine, Neochlorogenic acid, Oleic acid, trans-3,5,4'-Trihydroxystilbene (Resveratrol), 2-(3,4-dihydroxyphenyl)-5,7-dihydroxy-3-[(2S,3R,4S,5S,6R)-3,4,5-trihydroxy-6-[[(2R,3R,4R,5R,6S)-3,4,5-trihydroxy-6-methyloxan-2-yl]oxymethyl]oxan-2-yl]oxychromen-4-one, Rutin hydrate, Selenol-L-methionine, Thiourea, (+)-α-Tocopherol, Xanthophyll, Citric acid (CA), Gentisic acid (GA), Salicylic acid (SA), Erythorbic acid (EA), Phenol, Sodium bisulfite, Butylated hydroxy anisole, Butylated hydroxy toluene, Metabisulfite, Benzyl alcohol, Thymol, Lipoic acid (LA), Thioglycolic acid (TGA), 2,3 Dimercaptopropan-1-ol (BAL), Zinc, Selenium, Albumin, Ethanol, Mannitol, Sucrose, Melatonin, Ebselen, Pyruvic acid, Carboxy-PTIO, 6-hydroxy-2,5,7,8-tetramethylchroman-2-carboxylic acid, Uric acid, Edaravone, Beta carotene, NADPH, Lycopene, Lutein, Catalase, Estrogen, Estradiol, Estriol, Ubiquinol, Copper, Quercetin, Cortisone, Taurine, (2R,3R)-5,7-Dihydroxy-2-(3,4,5-trihydroxyphenyl)-3,4-

dihydro-2H-1-benzopyran-3-yl 3,4,5-trihydroxybenzoate (EpiGallo-Catechin gallate or EGCg), (2R,3R)-2-(3,4-dihydroxyphenyl)-5,7-dihydroxy-3,4-dihydro-2H-chromen-3-yl] 3,4,5-trihydroxybenzoate or Epi-Catechin Gallate (ECG), (2R,3R)-2-(3,4,5-trihydroxyphenyl)-3,4-dihydro-2H-chromene-3,5,7-triol (Epigallo-Catechin or EGC), (2R,3S)-2-(3,4,5-trihydroxyphenyl)-3,4-dihydro-2H-chromene-3,5,7-triol (Gallo-Catechin or GC), (−)-cis-2-(3,4,5-Trihydroxyphenyl)-3,4-dihydro-1(2H)-benzopyran-3,5,7-triol 3-gallate ((-)-Epigalocatechin-3-O-Gallate), 5-Aminolevulinic Acid hydrate, Polysorbate 80, Garlic Acid, Sodium L-Ascorbate, Hyaluronic Acid, Dextran 60-90, Selenol, and L-arginine hydrochloride and L-lysine hydrochloride, or a salt thereof, or a combination thereof;

(c) a free metal chelator selected from Ethylenediaminetetraacetic acid (EDTA), Diethylenetriaminepentaacetic acid (DTPA), 2-S-(4-Isothiocyanatobenzyl)-1,4,7-triazacyclononane-1,4,7-triacetic acid (NOTA), Triethylenetetramine (TETA), 1, 4, 7, 10, 13-pentaazacyclopentadecane-N, N', N'', N''', N''''-pentaacetic acid (PEPA), l,4,8,11-tetraazacyclo tetradecane-l,4,8,11-tetrapropionic acid (TETPA), 2,2′,2”-(10-(2,6-dioxotetrahydro-2H-pyran-3-yl)-1,4,7,10-tetraazacyclododecane-1,4,7-triyl)triacetic acid (DOTA-GA), 1,4,7,10-Tetraazacyclododecane-1,4,7,10-tetra(methylene phosphonic acid) (DOTP), Deferoxamine (DFO), N, N-bis(2-hydroxybenzyl)ethylenediamine-N,N-diacetic acid (HBED), 6,6'-((1,4,10,13-tetraoxa-7,16-diazacyclooctadecane-7,16-diyl)bis(methylene))dipicolinic acid (Macropa), Meso-2,3-dimercaptosuccinic acid (DMSA), Dimercaptopropane sulfonate (DMPS), Dihydrolipoic acid (DHLA), Lipoic acid (LA), Thioglycolic acid (TGA), and 2,3 Dimercaptopropan-1-ol (BAL), or a combination thereof; and

(d) an aqueous vehicle.

[005a] In another aspect, provided herein is a liquid radiopharmaceutical composition comprising:

(a) a conjugate, wherein the conjugate is ^{225}Ac-DOTA-TATE, and is present in the liquid radiopharmaceutical composition at a concentration equivalent to 5 to 100 mCi/L;

(b) a radiolysis stabilizer, wherein the radiolysis stabilizer is ascorbic acid or a salt thereof, ethanol, or gentisic acid or a salt thereof, and is present in the liquid radiopharmaceutical composition at a concentration of 50 mM to 500 mM;

(c) a free metal chelator, wherein the free metal chelator is selected from EDTA, macropa, TETA, PEPA, TETPA, DFO, DOTP, DHLA, TGA, LA, and DTPA, or a combination thereof, and is present in the liquid radiopharmaceutical composition at a concentration of 0.01 mg/mL to 5 mg/mL; and

(d) an aqueous vehicle.

[005b] In one example, provided herein is a liquid radiopharmaceutical composition comprising: (i) a conjugate, wherein the conjugate is ^{225}Ac-DOTA-TATE; (ii) one or more stabilizing agents; and (iii) an aqueous vehicle. In one example, provided herein is a liquid radiopharmaceutical composition comprising: (i) a conjugate, wherein the conjugate is ^{225}Ac-DOTA-TOC; (ii) one or more stabilizing agents; and (iii) an aqueous vehicle. In one example, the present disclosure relates to a liquid radiopharmaceutical composition comprising, a conjugate, optionally one or more stabilizing agents, and an aqueous vehicle. The conjugate further comprises a targeting ligand, a metal chelator covalently attached to the targeting ligand, and a radionuclide that is bound to the metal chelator. In some examples, the targeting ligand binds to a somatostatin receptor (SSR), such as a somatostatin receptor type 1 (SSTR1), somatostatin receptor type 2 (SSTR2), somatostatin receptor type 3 (SSTR3), somatostatin receptor type 4 (SSTR4), and/or somatostatin receptor type 5 (SSTR5). In some examples, the targeting ligand binds to a somatostatin receptor type 2 (SSTR2). In some examples, the targeting ligand is a binding peptide, which comprises 6 to 14 amino acid residues. In some examples, the binding peptide comprises an amino acid sequence with at least 90% identity to a sequence selected from SEQ IDs 1 to 96. In some examples, the binding peptide comprises an amino acid sequence selected from SEQ IDs 1 to 96. In some examples, the targeting ligand is octreotate, octreotide, D-Phe^1-cyclo(Cys^2-Tyr^3-D-Trp^4-Lys^5-Thr^6-Cys^7)Thr^8 (SEQ ID NO: 97) (tyr^3-octreotate or TATE), D-Phe^1-cyclo(Cys^2-Tyr^3-D-Trp^4-Lys^5-Thr^6-Cys^7)Thr(ol)^8 (SEQ ID NO: 98) (Phe^1-Tyr^{3}octreotide, edotreotide, or TOC), D-Phe^1-cyclo(Cys^2-Phe^3-D-Trp^4-Lys^5-Thr^6-Cys^7)Thr(ol)^8 (SEQ ID NO: 99) (OC), D-Phe^1-cyclo(Cys^2-1-Nal-D-Trp^4-Lys^5-Thr^6-Cys^7)Thr(ol)^8 (SEQ ID NO: 100) (NOC), p-Cl-Phe-cyclo(D-Cys-Aph(Hor)-D-Aph(Cbm)-Lys-Thr-Cys)D-Tyr-NH_2) (SEQ ID NO: 101) (JR11), or p-Cl-Phe-cyclo(D-Cys-Tyr-D-Aph(Cbm)-Lys-Thr-Cys)-D-Tyr-NH_2 (SEQ ID NO: 102) (LM3). In some examples, the targeting ligand is tyr^3-octreotate, edotreotide, octreotate, or octreotide. In some examples, the targeting ligand is tyr^3-octreotate. In some examples, the targeting ligand is an agonist of the SSR. In some examples, the targeting ligand is an antagonist of the SSR. In another example, the targeting ligand is a small molecule compound, such as L-797,591, L-779,976, L-796,778, L-803,087, or L-817,818. In some examples, a binding affinity of the targeting ligand to a human SSR is not more than 250 nM, not more than 100 nM, not more than 50 nM, or not more

than 5 nM, as determined by half maximal inhibitory concentration (IC_{50}). In some examples, the binding affinity of the targeting ligand to a human SSR is not more than 250 nM, as determined by half maximal inhibitory concentration (IC_{50}). In some examples, the binding affinity of the targeting ligand to a human SSR is not more than 100 nM, as determined by half maximal inhibitory concentration (IC_{50}). In some examples, the binding affinity of the targeting ligand to a human SSR is not more than 50 nM, as determined by half maximal inhibitory concentration (IC_{50}). In some examples, the binding affinity of the targeting ligand to a human SSR is not more than 5 nM, as determined by half maximal inhibitory concentration (IC_{50}). In some examples, the binding affinity of the targeting ligand to a human SSR is not more than 2 nM, as determined by half maximal inhibitory concentration (IC_{50}). In some examples, the human SSR is SSTR2. In some examples, the targeting ligand is covalently linked to the metal chelator through a linker. In some examples, the radiopharmaceutical composition retains at least 90 % of the ^{225}Ac content bound as part of the conjugate after 72 hours at about 20ºC to about 25°C as determined by radio thin-layer chromatography (radio-TLC). In some examples, the radiopharmaceutical composition retains at least 90 % of the ^{225}Ac content bound as part of the conjugate after 120 hours at about 20ºC to about 25°C as determined by radio thin-layer chromatography (radio-TLC). In some examples, the radiopharmaceutical composition retains at least 95 % of the ^{225}Ac content bound as part of the conjugate after 120 hours at about 20ºC to about 25°C as determined by radio thin-layer chromatography (radio-TLC). In some examples, the radiopharmaceutical composition retains at least 90 % of the ^{225}Ac content bound as part of the conjugate after 120 hours at about 20ºC to about 25°C as determined by high performance liquid chromatography/fraction collection (HPLC-FC). In some examples, the radiopharmaceutical composition retains at least 90 % of the ^{225}Ac content bound as part of the conjugate after 72 hours at about 20ºC to about 25°C as determined by high performance liquid chromatography/fraction collection (HPLC-FC).

[006] In one example, described herein is a radiopharmaceutical composition comprising a conjugate that further comprises a targeting ligand that covalently links to a metal chelator through a linker. In some examples, the metal chelator is selected from AAZTA, BAT, BAT-TM, Crown, Cyclen, DO2A, CB-DO2A, DO3A, H3HP-DO3A, Oxo-DO3A, p-NH_2-Bn-Oxo-DO3A, DOTA, DOTA-3py, DOTA-PA, DOTA-GA, DOTA-4AMP, DOTA-2py, DOTA-1py, p-SCN-Bn-DOTA, CHX-A″-EDTA, MeO-DOTA-NCS EDTA, DOTAMAP, DOTAGA, DOTAGA-anhydride, DOTMA, DOTASA, DOTAM, DOTP, CB-Cyclam, TE2A, CB-TE2A, CB-TE2P, DM-TE2A, MM-TE2A, NOTA, NOTP, HEHA, HEHA-NCS, p-SCN-Bn-HEHA, DTPA, CHX-A″-DTPA, p-NH_2-Bn-CHX-A″-DTPA, p-SCN-DTPA, p-SCN-Bz-Mx-DTPA, 1B4M-DTPA-

DTPA, p-SCN-Bn1B-DTPA, p-SCN-Bn-1B4M-DTPA, p-SCN-Bn-CHX-A″-DTPA, PEPA, p-SCN-Bn-PEPA, l,4,8,11-tetraazacyclo tetradecane-l,4,8,11-tetrapropionic acid (TETPA), DOTPA, DOTMP, DOTPM, t-Bu-calix[4]arene-tetracarboxylic acid, macropa, macropa-NCS, macropid, H_3L^1, H_3L^4, H_2azapa, H_5decapa, bispa^2, H_4pypa, H_4octapa, H_4CHXoctapa, p-SCN-Bn-H_4octapa, p-SCN-Bn-H_4octapa, TTHA, p-NO_2-Bn-neunpa, H_4octox, H_2macropa, H_2bispa^2, H_4phospa, H_6phospa, p-SCN-Bn-H_6phospa, TETA, p-NO_2-Bn-TETA, TRAP, TRAP-Pr, TPA, HBED, SHBED, HBED-CC, (HBED-CC)TFP, DMSA, DMPS, DHLA, lipoic acid, TGA, BAL, Bis-thioseminarabazones, p-SCN-NOTA, nNOTA, NODAGA, CB-TE1A1P, 3P-C-NETA-NCS, 3p-C-DEPA, 3P-C-DEPA-NCS, TCMC, PCTA, NODIA-Me, TACN, pycup1A1B, pycup2A, THP, DEDPA, H_2DEDPA, p-SCN-Bn-H_2DEDPA, p-SCN-Bn-TCMC, motexafin, NTA, NOC, 3p-C-NETA, p-NH_2-Bn-TE3A, SarAr, DiAmSar, SarAr-NCS, AmBaSar, BaBaSar, TACN-TM, CP256, C-NE3TA, C-NE3TA-NCS, NODASA, NETA-monoamide, C-NETA, TACN-HSB, NOPO, BPCA, p-SCN-Bn-DRO, DRO-ChX-Mal, DFO, DFO-IAC, DFO-BAC, DiP-LICAM, EC, SBAD, BAPEN, TACHPYR, NEC-SP, L^{py}, L1, L2, L3, and EuK-106. In another example, the metal chelator is a metal chelator illustrated in FIG. 3 to FIG. 17. In some examples, the metal chelator is DOTA, HEHA, or macropa. The metal chelator can be DOTA.

[007] In one example, the disclosure described herein is a radiopharmaceutical composition comprising one or more stabilizing agents. The stabilizing agent can comprise a radiolysis stabilizer, which can be an amino acid or a peptide or a derivative thereof, a vitamin or a derivative thereof, a lipid or a derivative thereof, a carbohydrate or a derivative thereof, a volume expander or an antioxidant. In some examples, the amino acid or peptide is selected from N-Acetyl-L-cysteine, Glutathione, L-Lysine, Selenol-L-methionine, Glutathione, Albumin, Melatonin, Taurine, Alanine, Arginine, Asparagine, Aspartic acid, Cysteine, Glutamine, Glutamic acid, Glycine, Histidine, Isoleucine, Lysine, Methionine, Phenylalanine, Proline, Serine, Threonine, Tryptophan, Tyrosine, Valine, and derivatives thereof. In some examples, the amino acid is Methionine. In some examples, the radiolysis stabilizer is an antioxidant, such as a flavonoid or a derivative thereof. In some examples, the flavonoid is (2S,3R)-2-(3,4-Dihydroxyphenyl)-3,4-dihydro-1(2H)-benzopyran-3,5,7-triol 3-(3,4,5-trihydroxybenzoate ((-) Catechin gallate or CG), 3,3',4',5,5',7-Hexahydroxyflavylium chloride, (-)-cis-3,3',4',5,7-Pentahydroxyflavane (Epi-Catechin or EC), 7-Hydroxy-3-(4'-methoxyphenyl)-4H-benzopyran-4-one, 3,4,5-Trihydroxybenzoic acid (Gallic acid), 3,4',5,7-Tetrahydroxyflavone (Kaempferol), Luteolin, 2-(3,4-dihydroxyphenyl)-5,7-dihydroxy-3-[(2S,3R,4S,5S,6R)-3,4,5-trihydroxy-6-[[(2R,3R,4R,5R,6S)-3,4,5-trihydroxy-6-methyloxan-2-yl]oxymethyl]oxan-2-yl]oxychromen-4-one (Rutin hydrate), Quercetin, (2R,3R)-5,7-Dihydroxy-2-(3,4,5-trihydroxyphenyl)-3,4-dihydro-2H-1-benzopyran-3-yl 3,4,5-trihydroxybenzoate (EpiGallo-Catechin gallate or EGCg), (2R,3R)-

2-(3,4-dihydroxyphenyl)-5,7-dihydroxy-3,4-dihydro-2H-chromen-3-yl] 3,4,5-trihydroxybenzoate or Epi-Catechin Gallate (ECG), (2R,3R)-2-(3,4,5-trihydroxyphenyl)-3,4-dihydro-2H-chromene-3,5,7-triol (Epigallo-Catechin or EGC), or (2R,3S)-2-(3,4,5-trihydroxyphenyl)-3,4-dihydro-2H-chromene-3,5,7-triol (Gallo-Catechin or GC). In some examples, the flavonoid is a catechin or a derivative thereof, for example, (2S,3R)-2-(3,4-Dihydroxyphenyl)-3,4-dihydro-1(2H)-benzopyran-3,5,7-triol 3-(3,4,5-trihydroxybenzoate ((-) Catechin gallate or CG), (-)-cis-3,3',4',5,7-Pentahydroxyflavane (Epi-Catechin or EC), 3,4,5-Trihydroxybenzoic acid (Gallic acid), (2R,3R)-5,7-Dihydroxy-2-(3,4,5-trihydroxyphenyl)-3,4-dihydro-2H-1-benzopyran-3-yl 3,4,5-trihydroxybenzoate (EpiGallo-Catechin gallate or EGCg), (2R,3R)-2-(3,4-dihydroxyphenyl)-5,7-dihydroxy-3,4-dihydro-2H-chromen-3-yl] 3,4,5-trihydroxybenzoate or Epi-Catechin Gallate (ECG), (2R,3R)-2-(3,4,5-trihydroxyphenyl)-3,4-dihydro-2H-chromene-3,5,7-triol (Epigallo-Catechin or EGC), or (2R,3S)-2-(3,4,5-trihydroxyphenyl)-3,4-dihydro-2H-chromene-3,5,7-triol (Gallo-Catechin or GC). The antioxidant can also be a carotenoid or a derivative thereof, such as all-trans-Fucoxanthin, Lycopene, Xanthophyll, Beta carotene, Lycopene, or Lutein. In some examples, the antioxidant is N-acetyl cysteine, L-Ascorbic acid, N-tert-Butyl-α-phenylnitrone, 3-(3,4-Dihydroxyphenyl)-2-propenoic acid (Caffeic Acid), β-Carotene, Provitamin A, (2S,3R)-2-(3,4-Dihydroxyphenyl)-3,4-dihydro-1(2H)-benzopyran-3,5,7-triol 3-(3,4,5-trihydroxybenzoate ((-) Catechin gallate or CG), 1,4,5-Trihydroxycyclohexanecarboxylic acid, trans-4-Hydroxycinnamic acid (p-Coumaric acid), 3,3',4',5,5',7-Hexahydroxyflavylium chloride, Thiocytic Acid (Dihydrolipoic Acid, DHLA), 4,4',5,5',6,6'-Hexahydroxydiphenic acid 2,6,2',6'-dilactone (Ellagic acid), (-)-cis-3,3',4',5,7-Pentahydroxyflavane (Epi-Catechin or EC), 2-Methoxy-4-(2-propenyl) phenol, trans-4-Hydroxy-3-methoxycinnamic acid (Ferulic acid), 7-Hydroxy-3-(4'-methoxyphenyl)-4H-benzopyran-4-one, all-trans-Fucoxanthin, 3,4,5-Trihydroxybenzoic acid (Gallic acid), (2S,3R)-2-(3,4,5-Trihydroxyphenyl)-3,4-dihydro-1(2H)-benzopyran-3,5,7-triol ((-)-Gallocatechin), Glutathione, 2-(3,4-Dihydroxyphenyl)ethanol, 3,4',5,7-Tetrahydroxyflavone (Kaempferol), (±)-1,2-Dithiolane-3-pentanoic acid, Luteolin, Lycopene, L-Lysine, Neochlorogenic acid, Oleic acid, trans-3,5,4'-Trihydroxystilbene (Resveratrol), 2-(3,4-dihydroxyphenyl)-5,7-dihydroxy-3-[(2S,3R,4S,5S,6R)-3,4,5-trihydroxy-6-[[(2R,3R,4R,5R,6S)-3,4,5-trihydroxy-6-methyloxan-2-yl]oxymethyl]oxan-2-yl]oxychromen-4-one, Rutin hydrate, Selenol-L-methionine, Thiourea, (+)-α-Tocopherol, Xanthophyll, Citric acid (CA), Gentisic acid (GA), Salicylic acid (SA), Erythorbic acid (EA), Phenol, Sodium bisulfite, Butylated hydroxy anisole, Butylated hydroxy toluene, Metabisulfite, Benzyl alcohol, Thymol, Lipoic acid (LA), Thioglycolic acid (TGA), 2,3 Dimercaptopropan-1-ol (BAL), Zinc, Selenium, Albumin, Ethanol, Mannitol, Sucrose, Melatonin, Ebselen, Pyruvic acid, Carboxy-PTIO, Trolox, Uric acid,

Edaravone, Beta carotene, NADPH, Lycopene, Lutein, Catalase, Estrogen, Estradiol, Estriol, Ubiquinol, Copper, Quercetin, Cortisone, Taurine, (2R,3R)-5,7-Dihydroxy-2-(3,4,5-trihydroxyphenyl)-3,4-dihydro-2H-1-benzopyran-3-yl 3,4,5-trihydroxybenzoate (EpiGallo-Catechin gallate or EGCg), (2R,3R)-2-(3,4-dihydroxyphenyl)-5,7-dihydroxy-3,4-dihydro-2H-chromen-3-yl] 3,4,5-trihydroxybenzoate or Epi-Catechin Gallate (ECG), (2R,3R)-2-(3,4,5-trihydroxyphenyl)-3,4-dihydro-2H-chromene-3,5,7-triol (Epigallo-Catechin or EGC), (2R,3S)-2-(3,4,5-trihydroxyphenyl)-3,4-dihydro-2H-chromene-3,5,7-triol (Gallo-Catechin or GC), (-)-Epigalocatechin-3-O-Gallate, 5-Aminolevulibic Acid hydrate, Ploysorbate 80, Garlic Acid, Sodium L-Ascorbate, Hyaluronic Acid, Dextran 60-90, Selenol, and LysaKare. The radiolysis stabilizer can also be a vitamin or a derivative thereof, for example, L-Ascorbic acid, β-Carotene, Provitamin A, (+)-α-Tocopherol, Erythorbic acid (EA), Trolox, and Lutein. In some examples, the radiolysis stabilizer is a lipid. The lipid can be a fatty acid, such as a saturated or unsaturated C_6 to C_{30} fatty acid. In some examples, the fatty acid is oleic acid, Myristoleic acid, Palmitoleic acid, Sapienic acid, Elaidic acid, Vaccenic acid, or Linoleic acid, α-Linolenic acid. In another example, the lipid is a steroid or derivatives thereof, for example, Estrogen, Estradiol, Estriol, or Cortisone. The radiolysis stabilizer can also be a carbohydrate or a derivative thereof, such as Mannitol, Sucrose, Dextran (e.g., Dextran 40, Dextran 70), and Cyclodextrins, (e.g., α (alpha)-cyclodextrin, β (beta)-cyclodextrin, and γ (gamma)-cyclodextrin). In some examples, the radiolysis stabilizer is a volume expander. The volume expander can be a polymer or a polymer mixture, such as PEG 3350, PEG 4000, Polygeline, Haemaccel, Gelofusine, and PLENVU (polyethylene glycol 3350, sodium sulfate, ascorbic acid, sodium chloride and potassium chloride US FDA 2018 Label). In some examples, the volume expander is selected from Dextran, Dextran 40, Dextran 70, Cyclodextrins, α (alpha)-cyclodextrin, β (beta)-cyclodextrin, and γ (gamma)-cyclodextrin, PEG 3350, PEG 4000, Polygeline, Gelofusine, and PLENVU (polyethylene glycol 3350, sodium sulfate, ascorbic acid, sodium chloride and potassium chloride US FDA 2018 Label). In some examples, radiolysis stabilizer is selected from N-Acetyl-L-cysteine, L-Ascorbic acid, N-tert-Butyl-α-phenylnitrone, 3-(3,4-Dihydroxyphenyl)-2-propenoic acid (Caffeic Acid), β-Carotene, Provitamin A, (2S,3R)-2-(3,4-Dihydroxyphenyl)-3,4-dihydro-1(2H)-benzopyran-3,5,7-triol 3-(3,4,5-trihydroxybenzoate ((-) Catechin gallate, or CG), 1,4,5-Trihydroxycyclohexanecarboxylic acid, trans-4-Hydroxycinnamic acid (p-Coumaric acid), 3,3',4',5,5',7-Hexahydroxyflavylium chloride, Thiocytic Acid (Dihydrolipoic Acid, DHLA), 4,4',5,5',6,6'-Hexahydroxydiphenic acid 2,6,2',6'-dilactone (Ellagic acid), (-)-cis-3,3',4',5,7-Pentahydroxyflavane (Epi-Catechin or EC), 2-Methoxy-4-(2-propenyl) phenol, trans-4-Hydroxy-3-methoxycinnamic acid (Ferulic acid), 7-Hydroxy-3-(4'-methoxyphenyl)-4H-benzopyran-4-one, all-trans-Fucoxanthin, 3,4,5-Trihydroxybenzoic acid

(Gallic acid), (2S,3R)-2-(3,4,5-Trihydroxyphenyl)-3,4-dihydro-1(2H)-benzopyran-3,5,7-triol ((-)-Gallocatechin), Glutathione, 2-(3,4-Dihydroxyphenyl)ethanol, 3,4',5,7-Tetrahydroxyflavone (Kaempferol), (±)-1,2-Dithiolane-3-pentanoic acid, Luteolin, Lycopene, L-Lysine, Neochlorogenic acid, Oleic acid, trans-3,5,4'-Trihydroxystilbene (Resveratrol), 2-(3,4-dihydroxyphenyl)-5,7-dihydroxy-3-[(2S,3R,4S,5S,6R)-3,4,5-trihydroxy-6-[[(2R,3R,4R,5R,6S)-3,4,5-trihydroxy-6-methyloxan-2-yl]oxymethyl]oxan-2-yl]oxychromen-4-one, Rutin hydrate, Selenol-L-methionine, Thiourea, (+)-α-Tocopherol, Xanthophyll, Alanine and its derivatives, Arginine and its derivatives, Asparagine and its derivatives, Aspartic acid and its derivatives, Cysteine and its derivatives, Glutamine and its derivatives, Glutamic acid and its derivatives, Glycine and its derivatives, Histidine and its derivatives, Isoleucine and its derivatives, Lysine and its derivatives, Methionine and its derivatives, Phenylalanine and its derivatives, Proline and its derivatives, Serine and its derivatives, Threonine and its derivatives, Tryptophan and its derivatives, Tyrosine and its derivatives, Valine and its derivatives, Citric acid (CA), Gentisic acid (GA), Salicylic acid (SA), Erythorbic acid (EA), Phenol, Sodium bisulfite, Butylated hydroxy anisole, Butylated hydroxy toluene, Glutathione, Metabisulfite, Benzyl alcohol, Thymol, Lipoic acid (LA), Thioglycolic acid (TGA), 2,3 Dimercaptopropan-1-ol (BAL), Zinc, Selenium, Albumin, Ethanol, Mannitol, Sucrose, Melatonin, Ebselen, Pyruvic acid, Carboxy-PTIO, Trolox, Uric acid, Edaravone, Beta carotene, NADPH, Lycopene, Lutein, Catalase, Estrogen, Estradiol, Estriol, Ubiquinol, Copper, Quercetin, Cortisone, 2,3-dimercaptosuccinic acid (DMSA), monisoamyl derivative (MiADMSA), Taurine, Dextran, Dextran 40, Dextran 70, PEG 3350, PEG 4000, Polygeline, Gelofusine, PLENVU (polyethylene glycol 3350, sodium sulfate, ascorbic acid, sodium chloride and potassium chloride US FDA 2018 Label), Cyclodextrins, α (alpha)-cyclodextrin, β (beta)-cyclodextrin, and γ (gamma)-cyclodextrin, (2R,3R)-5,7-Dihydroxy-2-(3,4,5-trihydroxyphenyl)-3,4-dihydro-2H-1-benzopyran-3-yl 3,4,5-trihydroxybenzoate (EpiGallo-Catechin gallate or EGCg), (2R,3R)-2-(3,4-dihydroxyphenyl)-5,7-dihydroxy-3,4-dihydro-2H-chromen-3-yl] 3,4,5-trihydroxybenzoate or Epi-Catechin Gallate (ECG), (2R,3R)-2-(3,4,5-trihydroxyphenyl)-3,4-dihydro-2H-chromene-3,5,7-triol (Epigallo-Catechin or EGC), and (2R,3S)-2-(3,4,5-trihydroxyphenyl)-3,4-dihydro-2H-chromene-3,5,7-triol (Gallo-Catechin or GC).

[008] In one example, disclosed herein is a radiopharmaceutical composition comprising one or more stabilizing agents that further comprise a first and a second radiolysis stabilizer. In some examples, the first and the second radiolysis stabilizer has a molar ratio that is from 1:5 to 5:1. In one example, disclosed herein is a radiopharmaceutical composition comprising a radiolysis stabilizer. In some examples, the radiolysis stabilizer is present in the radiopharmaceutical composition at about 0.01 mM to about 5 M. In some examples, the stabilizing agent is

present in the radiopharmaceutical composition from about 5 mM, 10 mM, 25 mM, 50 mM, or 75mM to about 80 mM, 100 mM, 125 mM, 150 mM, 175 mM, 200 mM, 250 mM, or 500 mM. In some examples, the stabilizing agent is present in the radiopharmaceutical composition at about 0.1 mM to about 500 mM. In some examples, the stabilizing agent is present in the radiopharmaceutical composition at about 10 mM to about 500 mM. In some examples, the stabilizing agent is present in the radiopharmaceutical composition at about 20 mM to about 100 mM. In some examples, the radiolysis stabilizer is present in the radiopharmaceutical composition at about 0.0001 wt% to about 10 wt%. In some examples, the radiolysis stabilizer is present in the radiopharmaceutical composition at about 0.01 wt% to about 5 wt%, about 0.05 wt% to about 2 wt%, or about 0.1 wt% to about 1 wt%. In some examples, the radiolysis stabilizer is present in the radiopharmaceutical composition at a concentration of from about 0.1 to 50 mg/mL.

[009] In one example, disclosed herein is a radiopharmaceutical composition comprising one or more stabilizing agents that comprise a free metal chelator, which is not attached to the targeting ligand. In some examples, the free metal chelator is selected from Ethylenediaminetetraacetic acid (EDTA), Diethylenetriaminepentaacetic acid (DTPA), 2-S-(4-Isothiocyanatobenzyl)-1,4,7-triazacyclononane-1,4,7-triacetic acid (NOTA), Triethylenetetramine (TETA), 1, 4, 7, 10, 13-pentaazacyclopentadecane-N, N', N'', N''', N''''-pentaacetic acid (PEPA), l,4,8,11-tetraazacyclo tetradecane-l,4,8,11-tetrapropionic acid (TETPA), triethylenetetraminepentaacetic acid, 2,2′,2”-(10-(2,6-dioxotetrahydro-2H-pyran-3-yl)-1,4,7,10-tetraazacyclododecane-1,4,7-triyl)triacetic acid (DOTA-GA), 1,4,7,10-Tetraazacyclododecane-1,4,7,10-tetra(methylene phosphonic acid (DOTP), Deferoxamine (DFO), N, N-bis(2-hydroxybenzyl)ethylenediamine-N,N-diacetic acid (HBED), 1,4,7,10-Tetraazacyclododecane-1,4,7,10-tetra(methylene phosphonic acid) (DOTP), 6,6'-((1,4,10,13-tetraoxa-7,16-diazacyclooctadecane-7,16-diyl)bis(methylene))dipicolinic acid (Macropa), Meso-2,3-dimercaptosuccinic acid (DMSA), Dimercaptopropane sulfonate (DMPS), Dihydrolipoic acid (DHLA), Lipoic acid (LA), Thioglycolic acid (TGA), and 2,3 Dimercaptopropan-1-ol (BAL). In some examples, the free metal chelator is EDTA, DTPA, or Macropa. In some examples, the free metal chelator is present in the radiopharmaceutical composition at about 0.001 wt% to about 10 wt%. In some examples, the free metal chelator is present in the radiopharmaceutical composition at about 0.01 wt% to about 5 wt%, about 0.05 wt% to about 2 wt%, or about 0.1 wt% to about 1 wt%. In some examples, the free metal chelator is present in the radiopharmaceutical composition at a concentration of from 0.01 to 50 mg/mL. In some examples, the free metal chelator is present in the radiopharmaceutical composition at about 10 mM to about 500 mM.

[010] In one example, disclosed herein is a radiopharmaceutical composition comprising one or

more stabilizing agents that comprise one or more pH stabilizers. In one example, disclosed herein is a radiopharmaceutical composition comprising a pH stabilizer. In some examples, the pH stabilizer is the same as the radiolysis stabilizer. The pH stabilizers can function as a pH buffer. In some examples, the one or more pH stabilizers comprise an organic acid, such as an acetic acid, fumaric acid, ascorbic acid, propionic acid, benzene sulfonic acid, carbonic acid, citrate acid, aspartic acid, maleic acid, methane sulfonic acid, or tartaric acid. In some examples, the one or more pH stabilizers comprise an inorganic acid, for example, hydrobromic acid, hydrochloric acid, phosphoric acid, boric acid, or sulfuric acid. In some examples, the one or more pH stabilizers can comprise a base, such as tromethamine (Tris), ammonium hydroxide, diethanolamine, or sodium hydroxide. In some examples, the one or more pH stabilizers can also comprise an amino acid or a salt thereof. In some examples, the amino acid is glycine, lysine, arginine, histidine, or a salt thereof. In another example, the one or more pH stabilizers comprise an alkaline salt, for example, sodium acetate, sodium ascorbate, sodium benzoate, sodium bicarbonate, sodium carbonate, tribasic sodium phosphate acid, dibasic sodium phosphate acid, monobasic sodium phosphate acid, sodium tartrate, sodium lactate, sodium succinate, or disodium succinate. In some examples, the one or more pH stabilizers can comprise an acid salt, such as ammonium sulfate. In some examples, the one or more pH stabilizers comprise Sodium acetate, Sodium ascorbate, Ascorbic acid, Acetic acid, Fumaric acid propionic acid, ascorbic acid, ammonium sulfate, ammonium hydroxide, arginine, aspartic acid, benzene sulfonic acid, sodium benzoate, sodium bicarbonate, boric acid, sodium carbonate, carbonic acid, diethanolamine, citrate acid, hydrobromic acid, glycine, histidine, sodium lactate, (l)-lysine, maleic acid, methane sulfonic acid, phosphate acid, monobasic sodium phosphate acid, tribasic sodium phosphate acid, dibasic sodium phosphate acid, sodium hydroxide, sodium/disodium succinate, sulfuric acid, sodium tartrate, tartaric acid, tromethamine (tris), or a combination thereof. In some examples, the one or more pH stabilizers are present in the radiopharmaceutical composition at about 0.001 wt% to about 10 wt%. In some examples, one or more pH stabilizers are present in the radiopharmaceutical composition at about 0.01 wt% to about 5 wt%, about 0.05 wt% to about 2 wt%, or about 0.1 wt% to about 1 wt%. In some examples, the one or more pH stabilizers are present in the radiopharmaceutical composition at a concentration of from 0.1 to 5 mg/mL. In some examples, the one or more pH stabilizers are present in the radiopharmaceutical composition at about 10 mM to about 500 mM. The one or more pH stabilizers can be configured to maintain a pH of the radiopharmaceutical composition at about 4 to about 8. The one or more pH stabilizers can be configured to maintain a pH of the radiopharmaceutical composition at about 5 to about 7. In some examples, the pH of the radiopharmaceutical composition is within a range of about 4 to about 8. In some examples,

the pH of the radiopharmaceutical composition is about 5.5 to about 6.0. The radiopharmaceutical composition can comprise one or more radiolysis stabilizers, one or more free metal chelators, and/or one or more pH stabilizers.

[011] In one example, disclosed herein is a radiopharmaceutical composition comprising an aqueous vehicle. The aqueous vehicle can comprise water (e.g., water for injection), saline solution, dextrose in water, dextrose in saline solution, Ringer's solution, or lactated Ringer's solution. The radiopharmaceutical composition can be isotonic. The radiopharmaceutical composition can be a solution or suspension. In some examples, the radiopharmaceutical composition is formulated for IV infusion or bolus injection. In some examples, the radiopharmaceutical composition further comprises one or more excipients selected from: a tonicity adjusting agent, a preservative, an antimicrobial agent, a solubilizing agent, a suspending agent, and a surfactant.

[012] In one example, disclosed herein is a radiopharmaceutical composition comprising a conjugate that further comprises a targeting ligand that covalently links to a metal chelator through a linker. In some examples, the targeting ligand is a binding peptide, and the linker is attached to the binding peptide via the N terminus of the peptide. In some examples, the targeting ligand is a binding peptide, and the linker is attached to the binding peptide via the C terminus of the peptide. In some examples, the targeting ligand is a binding peptide, and the linker is attached to the binding peptide via a non-terminal amino acid of the peptide. The linker can comprise one or more groups selected from: substituted or unsubstituted alkyl, substituted or unsubstituted heteroalkyl, substituted or unsubstituted cycloalkyl, substituted or unsubstituted heterocycloalkyl, substituted or unsubstituted aryl, and substituted or unsubstituted heteroaryl.

[013] In one example, disclosed herein is a radiopharmaceutical composition comprising a conjugate that further comprises a radionuclide. The radionuclide can be an alpha particle-emitting radionuclide, such as actinium-225, astatine-211, thorium-227, or radium-223. In some examples, the alpha particle-emitting radionuclide is actinium-225. In some examples, the actinium-225 is present in the radiopharmaceutical composition that it provides a volumetric radioactivity of about 0.5 to 20 MBq/mL. In some examples, the conjugate is ^{225}Ac-DOTATATE. In another example, the conjugate is ^{225}Ac-DOTATOC. In some examples, the radiopharmaceutical composition retains at least 90 mol% of the initial conjugate after 168 hours at room temperature. In some examples, the composition retains at least 95 mol% of the initial conjugate after 168 hours at room temperature. In some examples, the composition retains at least 98 mol% of the initial conjugate after 168 hours at room temperature. In some examples, the composition retains at least 85 mol%, at least 90 mol%, at least 92 mol%, at least 95 mol%, at least 98 mol% or at least 99 mol% of the initial conjugate after 120 hours at

room temperature. In some examples, the composition retains 95 mol% or more of the initial conjugate after 48 hours, 72 hours, 96 hours, 120 hours, 148 hours, 168 hours, 192 hours, or 216 hours at room temperature. In some examples, the radionuclide is actinium-225, and wherein the composition contains no more than about 5% free actinium after 168 hours at room temperature, compared to the total amount of the initial chelated actinium content in the composition. In some examples, the radionuclide is actinium-225, and wherein the composition contains no more than about 2% or about 1% free actinium after 168 hours at room temperature, compared to the total amount of the initial chelated actinium content in the composition. In some examples, the radionuclide is actinium-225, and wherein the composition contains no more than a total of 5 mol% of free daughter isotopes of actinium-225 after 168 hours at room temperature, compared to the total amount of the initial chelated actinium content in the composition. In some examples, the radionuclide is actinium-225, and wherein the composition contains no more than a total of 1 mol% of un-chelated (free) daughter isotopes of actinium-225 after 168 hours at room temperature, compared to the total amount of the initial chelated actinium content in the composition. In some examples, the purity or the molar percentage of the initial conjugate is determined by radio thin layer chromatography (radio-TLC). In some examples, the purity or the molar percentage of the initial conjugate is determined by instant thin layer chromatography (iTLC).

[014] In one example, disclosed herein is a radiopharmaceutical composition, comprising: (a) the conjugate, wherein the conjugate is present in the radiopharmaceutical composition at a concentration equivalent to about 0.1 to about 100 mCi/L (e.g., about 10 to about 50 mCi/L, about 0.5 to about 100 mCi/L, 1 to about 50 mCi/L); (b) a radiolysis stabilizer, wherein the radiolysis stabilizer is present in the radiopharmaceutical composition at a concentration of about 50 to about 200 mM (e.g., about 80 to about 120 mM); (c) optionally a pH stabilizer, wherein the pH stabilizer is present in the radiopharmaceutical composition at concentration of about 0.1 wt% to about 10wt%; (d) a free metal chelator, wherein the free metal chelator is present in the radiopharmaceutical composition at concentration of about 0.01 mg/mL to about 5 mg/mL (e.g., about 0.01 mg/mL to about 1 mg/mL); and (e) an aqueous vehicle. In one example, disclosed herein is a radiopharmaceutical composition, comprising: (a) the conjugate, wherein the conjugate is present in the radiopharmaceutical composition at a concentration equivalent to about 1 to 50 mCi/L (e.g., about 10 to 50 mCi/L) ; (b) a radiolysis stabilizer, wherein the radiolysis is ascorbic acid or a salt thereof (e.g., sodium L-ascorbate) and is present in the radiopharmaceutical composition at a concentration of about 50 to about 200 mM (e.g., about 80 to about 120 mM); (c) a free metal chelator, wherein the free metal chelator is selected from EDTA, macropa, TETA, PEPA, TETPA, DFO, DOPT, DHLA, TGA, LA, and DTPA, or a combination thereof, and

wherein the free metal chelator is present in the radiopharmaceutical composition at a concentration of about 0.01 mg/mL to about 1 mg/mL; and (d) an aqueous vehicle, wherein the aqueous vehicle is saline solution. In some examples, the radiopharmaceutical composition further comprises a pH stabilizer. In some examples, the radiopharmaceutical composition further comprises a second radiolysis stabilizer. In some examples, the second radiolysis stabilizer (e.g., Dextran 40) is present in the radiopharmaceutical composition at a concentration of about 1 wt% to about 10wt%. In some examples, the second radiolysis stabilizer is present in the radiopharmaceutical composition at a concentration of about 0.05 wt% to about 5 wt%. In one example, disclosed herein is a radiopharmaceutical composition, comprising: (a) the conjugate, wherein the conjugate is present in the radiopharmaceutical composition at a concentration equivalent to about 1 to 50 mCi/L (e.g., about 10 to 50 mCi/L); (b) a radiolysis stabilizer; (c) optionally, a pH stabilizer, wherein the pH stabilizer is configured to maintain a pH of the radiopharmaceutical composition at about 4 to 8; (d) a free metal chelator, wherein the free metal chelator is configured to maintain a level of free radionuclide in the radiopharmaceutical composition below about 0.05 mCi/L; and (e) an aqueous vehicle. In some examples, the radiolysis stabilizer (such as ascorbic acid or sodium ascorbate) can function as a pH stabilizer. In some examples, the radiolysis stabilizer and the pH stabilizer is the same compound. In one example, disclosed herein is a radiopharmaceutical composition, comprising: (a) the conjugate, wherein the conjugate is present in the radiopharmaceutical composition at a concentration equivalent to about 0.5 to 50 mCi/L; (b) a radiolysis stabilizer; and (c) optionally, a pH stabilizer, wherein the pH stabilizer is configured to maintain a pH of the radiopharmaceutical composition at about 4 to 8; (d) a free metal chelator, wherein the free metal chelator is configured to maintain a level of free radionuclide in the radiopharmaceutical composition below about 0.05 mCi/L; and (e) an aqueous vehicle. In some examples, the radiolysis stabilizer (such as ascorbic acid or sodium ascorbate) can function as a pH stabilizer. In some examples, the radiolysis stabilizer and the pH stabilizer is the same compound. In some examples, the conjugate is present in the radiopharmaceutical composition at a concentration equivalent to about 2 to 50 mCi/L. In some examples, the conjugate is present in the radiopharmaceutical composition at a concentration equivalent to about 5 to 50 mCi/L. In some examples, the conjugate is present in the radiopharmaceutical composition at a concentration equivalent to about 1 to 100 mCi/L. In some examples, the conjugate is present in the radiopharmaceutical composition at a concentration equivalent to about 10 to 50 mCi/L.

[015] In another aspect, provided herein is a method of making a liquid radiopharmaceutical composition described herein, the method comprising:

combining ^{225}Ac, or a pharmaceutically acceptable salt thereof with DOTA-TATE, or a pharmaceutically acceptable salt thereof, thereby producing a mixture comprising ^{225}Ac-DOTA-TATE; and

adding radiolysis stabilizer and free metal chelator to the mixture.

[015a] In one example, the present disclosure relates to a method of making a radiopharmaceutical composition described herein. In some examples, the method of making the radiopharmaceutical composition comprises combining a radionuclide (such as ^{225}Ac) with an -

un-labeled conjugate (e.g., DOTATATE or DOTATOC) in the presence of one or more stabilizer agents, wherein the un-labeled conjugate comprises a targeting ligand and a metal chelator covalently attached to the targeting ligand, thereby producing a mixture comprising a labeled conjugate (e.g., ^{225}Ac-DOTATATE or ^{225}Ac-DOTATOC), and optionally combining one or more stabilizing agents to the mixture. In some examples, the method of making the radiopharmaceutical composition comprises combining a radionuclide (such as ^{225}Ac) with an un-labeled conjugate (e.g., DOTATATE or DOTATOC), wherein the un-labeled conjugate comprises a targeting ligand and a metal chelator covalently attached to the targeting ligand, thereby producing a labeled conjugate, and combining the one or more stabilizing agents with the labeled conjugate.

[016] In one example, the present disclosure relates to a method of treating a disease in a subject in need thereof comprising administering to the subject the radiopharmaceutical composition described herein. The disease can be a cancer. In some examples, the cancer is an SSR-associated cancer, such as an SSTR2-associated cancer. The cancer can be a neuroendocrine cancer, a lymphatic cancer, a pancreatic cancer, a pituitary cancer, a breast cancer, a stomach cancer, a lung cancer, medulloblastoma, or neuroblastoma. In some examples, the cancer is a neuroendocrine cancer, which can optionally be recurrent. In some examples, the neuroendocrine cancer is refractory to a radiotherapy that comprises beta-particle emitting radionuclide. In some examples, the subject has received a radiotherapy that comprises beta-particle emitting radionuclide prior to the administering of the radiopharmaceutical composition described herein. The neuroendocrine cancer can also be a neuroendocrine lung cancer or a neuroendocrine pancreatic cancer. In some examples, the neuroendocrine cancer is a Carcinoid tumor in the lungs, gastrointestinal tract or thymus, Pancreatic neuroendocrine tumor (e.g., Gastrinoma, Insulinoma, Glucagonoma, VIPoma, gastroenteropancreatic neuroendocrine tumor) Medullary thyroid carcinoma, Merkel cell carcinoma, Pheochromocytoma of the adrenal gland, Adrenal cancer, Small cell carcinoma (such as in the lungs), or Large cell carcinoid tumor (such as in the lungs). In some examples, the lung cancer is small-cell lung cancer. In some examples, the lung cancer is extensive stage small cell lung cancer. In some examples, the cancer is untreated. In some examples, the cancer is recurrent or refractory. In some examples, the small-cell lung cancer is untreated. In some examples, the small-cell lung cancer is recurrent or refractory. In some examples, the radiopharmaceutical composition is administered to the subject in an amount equivalent to about 1kBq/kg to about 0.2GBq/kg body weight per dose. In some examples, the radiopharmaceutical composition is administered to the subject in an amount equivalent to about 5kBq/kg to about 50,000kBq/kg body weight per dose. In some examples, the radiopharmaceutical composition is administered to the subject

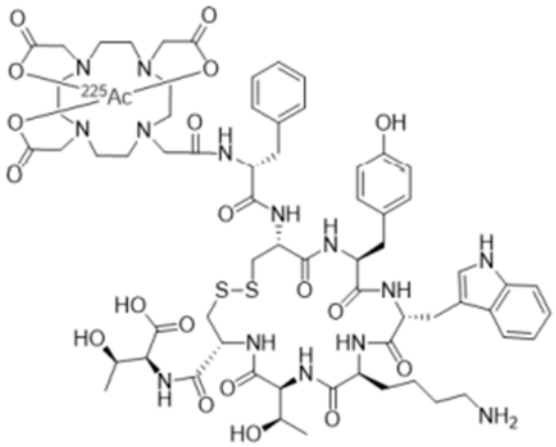
in an amount equivalent to about 20k Bq/kg to about 5,000kBq/kg body weight per dose. In some examples, the radiopharmaceutical composition is administered to the subject in an amount equivalent to about 50k Bq/kg to about 500 kBq/kg body weight per dose. In some examples, the radiopharmaceutical composition is administered to the subject in an amount equivalent to about 50k Bq/kg to about 200 kBq/kg body weight per dose. In some examples, the radiopharmaceutical composition is administered to the subject in an amount equivalent to about 60 kBq/kg to about 150 kBq/kg body weight per dose. In some examples, the radiopharmaceutical composition is administered to deliver a radioactivity dose of about 1 to 1,000 µCi. In some examples, the radiopharmaceutical composition is administered to deliver a radioactivity dose of about 10 to 500 µCi. In some examples, the radiopharmaceutical composition is administered to deliver a radioactivity dose of about 100 to 500 µCi. In some examples, the radiopharmaceutical composition is administered to deliver a radioactivity dose of about 100 to 300 µCi. In some examples, the radiopharmaceutical composition is administered to deliver a radioactivity dose of about 150 to 300µCi. In some examples, the radiopharmaceutical composition is administered to deliver a radioactivity dose of about 175 to 275 µCi. In some examples, the radiopharmaceutical composition is administered at an 8-week interval. In some examples, the radiopharmaceutical composition is administered to achieve a cumulative dose in the subject of about 10,000 kBq to about 100,000 kBq. In some examples, the radiopharmaceutical composition is administered to achieve a cumulative dose in the subject of about 40,000 kBq to about 70,000 kBq.

[017] In one example, provided herein is a dilution solution comprising one or more stabilizing agents and an aqueous vehicle.

[018] In one example, provided herein is a liquid radiopharmaceutical composition comprising: (a) ^{225}Ac-DOTA-TATE, wherein the ^{225}Ac-DOTA-TATE is present in the radiopharmaceutical composition at a concentration equivalent to about 10 mCi/L to about 30 mCi/L; (b) sodium L-ascorbate, wherein the sodium L-ascorbate is present in the radiopharmaceutical composition at a concentration of about 80 mM to about 110 mM; (c) diethylenetriamine pentaacetate (DTPA), wherein the DTPA is present in the radiopharmaceutical composition at a concentration of about 0.04 mg/mL to about 0.06 mg/mL; and (d) an aqueous vehicle, wherein the aqueous vehicle is sodium chloride saline solution at a concentration of about 0.9% w/w; wherein the radiopharmaceutical composition is a solution, and wherein the radiopharmaceutical composition retains at least 90 % of the ^{225}Ac content as ^{225}Ac-DOTA-TATE after 120 hours at about 20ºC to about 25°C as determined by radio thin-layer chromatography (radio-TLC). In one example, provided herein is a liquid radiopharmaceutical composition consisting essentially of: (a) ^{225}Ac-DOTA-TATE, wherein the ^{225}Ac-DOTA-TATE is present in the radiopharmaceutical

composition at a concentration equivalent to about 10 mCi/L to about 30 mCi/L; (b) sodium L-ascorbate, wherein the sodium L-ascorbate is present in the radiopharmaceutical composition at a concentration of about 80 mM to about 110 mM; (c) diethylenetriamine pentaacetate (DTPA), wherein the DTPA is present in the radiopharmaceutical composition at a concentration of about 0.04 mg/mL to about 0.06 mg/mL; and (d) an aqueous vehicle, wherein the aqueous vehicle is sodium chloride saline solution at a concentration of about 0.9% w/w; wherein the radiopharmaceutical composition is a solution, and wherein the radiopharmaceutical composition retains at least 90 % of the ^{225}Ac content as ^{225}Ac-DOTA-TATE after 120 hours at about 20ºC to about 25°C as determined by radio thin-layer chromatography (radio-TLC). In one example, provided herein is a liquid radiopharmaceutical composition consisting of: (a) ^{225}Ac-DOTA-TATE, wherein the ^{225}Ac-DOTA-TATE is present in the radiopharmaceutical composition at a concentration equivalent to about 10 mCi/L to about 30 mCi/L; (b) sodium L-ascorbate, wherein the sodium L-ascorbate is present in the radiopharmaceutical composition at a concentration of about 90 mM to about 110 mM; (c) diethylenetriamine pentaacetate (DTPA), wherein the DTPA is present in the radiopharmaceutical composition at a concentration of about 0.04 mg/mL to about 0.06 mg/mL; and (d) an aqueous vehicle, wherein the aqueous vehicle is sodium chloride saline solution at a concentration of about 0.9% w/w; wherein the radiopharmaceutical composition is a solution, and wherein the radiopharmaceutical composition retains at least 90 % of the ^{225}Ac content as ^{225}Ac-DOTA-TATE after 120 hours at about 20ºC to about 25°C as determined by radio thin-layer chromatography (radio-TLC). In some examples, the ^{225}Ac-DOTA-TATE is present in the radiopharmaceutical composition at a concentration equivalent to about 10 mCi/L to about 25 mCi/L. In some examples, the ^{225}Ac-DOTA-TATE is present in the radiopharmaceutical composition at a concentration equivalent to about 12 mCi/L to 23 mCi/L. In some examples, the ^{225}Ac-DOTA-TATE is present in the radiopharmaceutical composition at a concentration equivalent to about 40 µg to about 120 µg of the DOTA-TATE. In some examples, the sodium ascorbate is present in the radiopharmaceutical composition at a concentration of about 100mM. In some examples, the DTPA is present in the radiopharmaceutical composition at a concentration of about 0.05mg/mL. In some examples, the composition retains at least 90 % of the ^{225}Ac content as ^{225}Ac-DOTA-TATE after 168 hours at about 20ºC to about 25°C. In some examples, the composition retains at least 90 % of the ^{225}Ac content as ^{225}Ac-DOTA-TATE after 192 hours at about 20ºC to about 25°C. In some examples, the radiopharmaceutical composition is formulated as a unit dose form that contains about 12mL of the solution, and wherein the liquid radiopharmaceutical composition consists of: (a) ^{225}Ac-DOTA-TATE present in the radiopharmaceutical composition in an amount of 146-275 µCi in the about 12 mL solution; (b) sodium L-ascorbate present in the radiopharmaceutical

composition at a concentration of about 18.5 mg/mL; (c) DTPA, present in the radiopharmaceutical composition at a concentration of about 0.05 mg/mL; and (d) sodium chloride saline solution at a concentration of about 0.9% w/w. In some examples, the liquid radiopharmaceutical composition has a pH of about 5.5 to about 7.0. In some examples, the radiopharmaceutical composition is formulated for IV infusion.

[019] In one example, provided herein is a liquid radiopharmaceutical composition wherein the  ^{225}Ac-DOTA-TATE has a structure illustrated as: .

[020] In another aspect, provided herein is the use of the liquid radiopharmaceutical composition described herein in the manufacture of a medicament for treating a somatostatin receptor-positive (SSTR+) neuroendocrine tumor in a subject in need thereof, wherein the liquid radiopharmaceutical composition is to be administered to the subject in an effective amount.

[020a] In another aspect, provided herein is the use of the liquid radiopharmaceutical composition described herein in the manufacture of a medicament for treating a somatostatin receptor-positive (SSTR2+) cancer in a subject in need thereof, wherein the liquid radiopharmaceutical composition is to be administered to the subject.

[020b] In yet another aspect, provided herein is the use of the liquid radiopharmaceutical composition described herein in the manufacture of a medicament for treating an SSTR2+ cancer in a subject in need thereof, wherein an H-score of a cancer sample of the subject is at least 11.

[020c] In another aspect, provided herein is the liquid radiopharmaceutical composition described herein for use in therapy.

[020d] In one example, provided herein is a method of treating a somatostatin receptor-positive (SSTR+) neuroendocrine tumor in a subject in need thereof, comprising administering to the subject a therapeutically effective amount of a liquid radiopharmaceutical composition, wherein the liquid radiopharmaceutical composition comprises: (a) ^{225}Ac-DOTA-TATE, wherein

the ^{225}Ac-DOTA-TATE is present in the radiopharmaceutical composition at a concentration equivalent to about 10 mCi/L to about 30 mCi/L; (b) sodium L-ascorbate, wherein the sodium L-ascorbate is present in the radiopharmaceutical composition at a concentration of about 90 mM to about 110 mM; (c) diethylenetriamine pentaacetate (DTPA), wherein the DTPA is present in the radiopharmaceutical composition at a concentration of about 0.04 mg/mL to about 0.06 mg/mL; and (d) an aqueous vehicle, wherein the aqueous vehicle is sodium chloride saline solution at a concentration of about 0.9% w/w; wherein the radiopharmaceutical composition is a solution, and wherein the radiopharmaceutical composition retains at least 90 % of the ^{225}Ac content as ^{225}Ac-DOTA-TATE after 120 hours at about 20º to about 25°C as determined by radio thin-layer chromatography (radio-TLC).

[021] In one example, provided herein is a method of treating a somatostatin receptor-positive (SSTR+) neuroendocrine tumor in a subject in need thereof, comprising administering to the subject a therapeutically effective amount of a liquid radiopharmaceutical composition, wherein the liquid radiopharmaceutical composition consists essentially of: (a) ^{225}Ac-DOTA-TATE, wherein the ^{225}Ac-DOTA-TATE is present in the radiopharmaceutical composition at a concentration equivalent to about 10 mCi/L to about 30 mCi/L; (b) sodium L-ascorbate, wherein

the sodium L-ascorbate is present in the radiopharmaceutical composition at a concentration of about 90 mM to about 110 mM; (c) diethylenetriamine pentaacetate (DTPA), wherein the DTPA is present in the radiopharmaceutical composition at a concentration of about 0.04 mg/mL to about 0.06 mg/mL; and (d) an aqueous vehicle, wherein the aqueous vehicle is sodium chloride saline solution at a concentration of about 0.9% w/w; wherein the radiopharmaceutical composition is a solution, and wherein the radiopharmaceutical composition retains at least 90 % of the ^{225}Ac content as ^{225}Ac-DOTA-TATE after 120 hours at about 20º to about 25°C as determined by radio thin-layer chromatography (radio-TLC).

[022] In one example, provided herein is a method of treating a somatostatin receptor-positive (SSTR+) neuroendocrine tumor in a subject in need thereof, comprising administering to the subject a therapeutically effective amount of a liquid radiopharmaceutical composition, wherein the liquid radiopharmaceutical composition consists of: (a) ^{225}Ac-DOTA-TATE, wherein the ^{225}Ac-DOTA-TATE is present in the radiopharmaceutical composition at a concentration equivalent to about 10 mCi/L to about 30 mCi/L; (b) sodium L-ascorbate, wherein the sodium L-ascorbate is present in the radiopharmaceutical composition at a concentration of about 90 mM to about 110 mM; (c) diethylenetriamine pentaacetate (DTPA), wherein the DTPA is present in the radiopharmaceutical composition at a concentration of about 0.04 mg/mL to about 0.06 mg/mL; and (d) an aqueous vehicle, wherein the aqueous vehicle is sodium chloride saline solution at a concentration of about 0.9% w/w; wherein the radiopharmaceutical composition is a solution, and wherein the radiopharmaceutical composition retains at least 90 % of the ^{225}Ac content as ^{225}Ac-DOTA-TATE after 120 hours at about 20º to about 25°C as determined by radio thin-layer chromatography (radio-TLC). In some examples, the neuroendocrine tumor is gastroenteropancreatic neuroendocrine tumor (GEP-NET). In some examples, the subject received ^{177}Lu-DOTA-TATE or ^{177}Lu-DOTA-TOC treatment prior to the administrating of the liquid radiopharmaceutical composition. In some examples, prior to the administrating of the liquid radiopharmaceutical composition, the subject received ^{177}Lu-DOTA-TATE or ^{177}Lu-DOTA-TOC treatment and the tumor has progressed. In some examples, the radiopharmaceutical composition is administered to the subject in an amount equivalent to about 60 kBq/kg body weight to 120 kBq/kg body weight per dose. In some examples, the radiopharmaceutical composition is administered at an 8-week interval. In some examples, the ^{225}Ac-DOTA-TATE is present in the radiopharmaceutical composition at a concentration equivalent to about 10 mCi/L to about 25 mCi/L.

[023] In one example, provided herein is a method of treating a somatostatin receptor-positive (SSTR+) neuroendocrine tumor in a subject in need thereof, comprising administering to the subject a therapeutically effective amount of a liquid radiopharmaceutical composition, wherein

the liquid radiopharmaceutical composition consists of: (a) ^{25}Ac- DOTA-TATE present in the radiopharmaceutical composition at a concentration equivalent to 10 mCi/L to 25 mCi/L; (b) sodium L-ascorbate present in the radiopharmaceutical composition at a concentration of about 100mM; (c) DTPA, present in the radiopharmaceutical composition at a concentration of about 0.05 mg/mL; and (d) sodium chloride saline solution at a concentration of about 0.9% w/w.

[024] In one example, provided herein is a method of treating a somatostatin receptor-positive (SSTR+) neuroendocrine tumor in a subject in need thereof, comprising administering to the subject a therapeutically effective amount of a liquid radiopharmaceutical composition, wherein the liquid radiopharmaceutical composition is formulated as a unit dose form that has about 12mL of the solution, and wherein the liquid radiopharmaceutical composition consists of: (a) ^{225}Ac-DOTA-TATE present in the radiopharmaceutical composition in an amount of 146 – 275 µCi in about 12 mL solution; (b) sodium L-ascorbate present in the radiopharmaceutical composition at a concentration of about 18.5 mg/mL; (c) DTPA present in the radiopharmaceutical composition at a concentration of about 0.05 mg/mL; and (d) sodium chloride saline solution at a concentration of about 0.9% w/w.

INCORPORATION BY REFERENCE

[025] All publications, patents, and patent applications mentioned in this specification are herein incorporated by reference for the specific purposes identified herein.

BRIEF DESCRIPTION OF THE DRAWINGS

[026] The novel features of the disclosure are set forth with particularity in the appended claims. A better understanding of the features and advantages of the present disclosure will be obtained by reference to the following detailed description that sets forth illustrative embodiments, in which the principles of the disclosure are utilized, and the accompanying drawing (also “figure” and “FIG.” herein), of which:

[027] FIG. 1A depicts the structures of exemplary radiolysis stabilizers catechins and their derivatives; FIG. 1B illustrates the structures of exemplary stabilizing agents cyclodextrin; FIG. 1C illustrates the structures of exemplary stabilizing agents (antioxidants); FIG. 1D illustrates the structures of exemplary stabilizing agents (amino acids); and FIG. 1E illustrates the structures of exemplary stabilizing agents.

[028] FIG. 2A illustrates the structures of exemplary small molecule targeting ligands; FIG. 2B illustrates the structures of exemplary binding peptide.

[029] FIG. 3- FIG. 17 depict the structures of representative metal chelators.

[030] FIG. 18A and FIG. 18B illustrate the abbreviations and modification of amino acids.

CLAIMS

We Claim:

1. A liquid radiopharmaceutical composition comprising:

(a) a conjugate, wherein the conjugate is ^{225}Ac-DOTA-TATE and is present in the liquid radiopharmaceutical composition at a concentration equivalent to 5 to 60 mCi/L;

(b) a radiolysis stabilizer, wherein the radiolysis stabilizer is an antioxidant selected from N-acetyl cysteine, Ascorbic acid, N-tert-Butyl-α-phenylnitrone, 3-(3,4-Dihydroxyphenyl)-2-propenoic acid (Caffeic Acid), β-Carotene, Provitamin A, (2S,3R)-2-(3,4-Dihydroxyphenyl)-3,4-dihydro-1(2H)-benzopyran-3,5,7-triol 3-(3,4,5-trihydroxybenzoate ((-) Catechin gallate or CG), 1,4,5-Trihydroxycyclohexanecarboxylic acid, trans-4-Hydroxycinnamic acid (p-Coumaric acid), 3,3',4',5,5',7-Hexahydroxyflavylium chloride, Thiocytic Acid (Dihydrolipoic Acid, DHLA), 4,4',5,5',6,6'-Hexahydroxydiphenic acid 2,6,2',6'-dilactone (Ellagic acid), (-)-cis-3,3',4',5,7-Pentahydroxyflavane (Epi-Catechin or EC), 2-Methoxy-4-(2-propenyl) phenol, trans-4-Hydroxy-3-methoxycinnamic acid (Ferulic acid), 7-Hydroxy-3-(4'-methoxyphenyl)-4H-benzopyran-4-one, all-trans-Fucoxanthin, 3,4,5-Trihydroxybenzoic acid (Gallic acid), (2S,3R)-2-(3,4,5-Trihydroxyphenyl)-3,4-dihydro-1(2H)-benzopyran-3,5,7-triol ((-)-Gallocatechin), Glutathione, 2-(3,4-Dihydroxyphenyl)ethanol, 3,4',5,7-Tetrahydroxyflavone (Kaempferol), (±)-1,2-Dithiolane-3-pentanoic acid, Luteolin, Lycopene, L-Lysine, Neochlorogenic acid, Oleic acid, trans-3,5,4'-Trihydroxystilbene (Resveratrol), 2-(3,4-dihydroxyphenyl)-5,7-dihydroxy-3-[(2S,3R,4S,5S,6R)-3,4,5-trihydroxy-6-[[(2R,3R,4R,5R,6S)-3,4,5-trihydroxy-6-methyloxan-2-yl]oxymethyl]oxan-2-yl]oxychromen-4-one, Rutin hydrate, Selenol-L-methionine, Thiourea, (+)-α-Tocopherol, Xanthophyll, Citric acid (CA), Gentisic acid (GA), Salicylic acid (SA), Erythorbic acid (EA), Phenol, Sodium bisulfite, Butylated hydroxy anisole, Butylated hydroxy toluene, Metabisulfite, Benzyl alcohol, Thymol, Lipoic acid (LA), Thioglycolic acid (TGA), 2,3 Dimercaptopropan-1-ol (BAL), Zinc, Selenium, Albumin, Ethanol, Mannitol, Sucrose, Melatonin, Ebselen, Pyruvic acid, Carboxy-PTIO, 6-hydroxy-2,5,7,8-tetramethylchroman-2-carboxylic acid, Uric acid, Edaravone, Beta carotene, NADPH, Lycopene, Lutein, Catalase, Estrogen, Estradiol, Estriol, Ubiquinol, Copper, Quercetin, Cortisone, Taurine, (2R,3R)-5,7-Dihydroxy-2-(3,4,5-trihydroxyphenyl)-3,4-dihydro-2H-1-benzopyran-3-yl 3,4,5-trihydroxybenzoate (EpiGallo-Catechin gallate or EGCg), (2R,3R)-2-(3,4-dihydroxyphenyl)-5,7-dihydroxy-3,4-dihydro-2H-chromen-3-yl] 3,4,5-trihydroxybenzoate or Epi-Catechin Gallate (ECG), (2R,3R)-2-(3,4,5-trihydroxyphenyl)-3,4-dihydro-2H-chromene-3,5,7-triol (Epigallo-Catechin or EGC), (2R,3S)-2-(3,4,5-trihydroxyphenyl)-3,4-dihydro-2H-chromene-3,5,7-triol (Gallo-Catechin or

GC), (−)-cis-2-(3,4,5-Trihydroxyphenyl)-3,4-dihydro-1(2H)-benzopyran-3,5,7-triol 3-gallate ((-)-Epigalocatechin-3-O-Gallate), 5-Aminolevulinic Acid hydrate, Polysorbate 80, Garlic Acid, Sodium L-Ascorbate, Hyaluronic Acid, Dextran 60-90, Selenol, and L-arginine hydrochloride and L-lysine hydrochloride, or a salt thereof, or a combination thereof;

(c) a free metal chelator selected from Ethylenediaminetetraacetic acid (EDTA), Diethylenetriaminepentaacetic acid (DTPA), 2-S-(4-Isothiocyanatobenzyl)-1,4,7-triazacyclononane-1,4,7-triacetic acid (NOTA), Triethylenetetramine (TETA), 1, 4, 7, 10, 13-pentaazacyclopentadecane-N, N', N'', N''', N''''-pentaacetic acid (PEPA), l,4,8,11-tetraazacyclo tetradecane-l,4,8,11-tetrapropionic acid (TETPA), 2,2′,2”-(10-(2,6-dioxotetrahydro-2H-pyran-3-yl)-1,4,7,10-tetraazacyclododecane-1,4,7-triyl)triacetic acid (DOTA-GA), 1,4,7,10-Tetraazacyclododecane-1,4,7,10-tetra(methylene phosphonic acid) (DOTP), Deferoxamine (DFO), N, N-bis(2-hydroxybenzyl)ethylenediamine-N,N-diacetic acid (HBED), 6,6'-((1,4,10,13-tetraoxa-7,16-diazacyclooctadecane-7,16-diyl)bis(methylene))dipicolinic acid (Macropa), Meso-2,3-dimercaptosuccinic acid (DMSA), Dimercaptopropane sulfonate (DMPS), Dihydrolipoic acid (DHLA), Lipoic acid (LA), Thioglycolic acid (TGA), and 2,3 Dimercaptopropan-1-ol (BAL), or a combination thereof; and

(d) an aqueous vehicle.

2. The liquid radiopharmaceutical composition of claim 1, wherein:
   a) the liquid radiopharmaceutical composition retains at least 90% of the ^{225}Ac content bound as part of the conjugate after 72 hours at 20ºC to 25°C as determined by radio thin-layer chromatography (radio-TLC);
   b) wherein the liquid radiopharmaceutical composition retains at least 90% of the ^{225}Ac content bound as part of the conjugate after 120 hours at 20ºC to 25°C as determined by radio thin-layer chromatography (radio-TLC);
   c) the liquid radiopharmaceutical composition retains at least 95% of the ^{225}Ac content bound as part of the conjugate after 120 hours at 20ºC to 25°C as determined by radio thin-layer chromatography (radio-TLC);
   d) the liquid radiopharmaceutical composition retains at least 90% of the ^{225}Ac content bound as part of the conjugate after 120 hours at 20ºC to 25°C as determined by high performance liquid chromatography/fraction collection (HPLC-FC);
   e) the liquid radiopharmaceutical composition retains at least 90% of the ^{225}Ac content bound as part of the conjugate after 72 hours at 20ºC to 25°C as determined by high performance liquid chromatography/fraction collection (HPLC-FC);

f) the liquid radiopharmaceutical composition retains at least 90% of the ^{225}Ac content as part of the conjugate after 168 hours at 20ºC to 25°C as determined by radio thin-layer chromatography (radio-TLC);

g) the liquid radiopharmaceutical composition retains at least 95% of the ^{225}Ac content as part of the conjugate after 168 hours at 20ºC to 25°C as determined by radio thin-layer chromatography (radio-TLC);

h) the liquid radiopharmaceutical composition retains at least 85%, at least 90%, at least 92%, at least 95%, at least 98% or at least 99% of the ^{225}Ac content as part of the conjugate after 120 hours at 20ºC to 25°C as determined by radio thin-layer chromatography (radio-TLC); and/or

i) the liquid radiopharmaceutical composition retains 95% or more of the ^{225}Ac content as part of the conjugate after 48 hours, 72 hours, 96 hours, 120 hours, 148 hours, 168 hours, 192 hours, or 216 hours at 20ºC to 25°C as determined by radio thin-layer chromatography (radio-TLC).

3. The liquid radiopharmaceutical composition of claim 1 or claim 2, wherein the radiolysis stabilizer is ascorbic acid or a salt thereof, ethanol, or gentisic acid or a salt thereof.

4. The liquid radiopharmaceutical composition of any one of claims 1 to 3, wherein the radiolysis stabilizer is present in the liquid radiopharmaceutical composition at 0.01 mM to 5 M.

5. The liquid radiopharmaceutical composition of any one of claims 1 to 4, wherein:

(i) the radiolysis stabilizer is present in the liquid radiopharmaceutical composition from 5 mM, 10 mM, 25 mM, 50 mM, or 75mM to 80 mM, 100 mM, 125 mM, 150 mM, 175 mM, 200 mM, 250 mM, or 500 mM; or

(ii) the radiolysis stabilizer is present in the liquid radiopharmaceutical composition at 10 mM to 500 mM; or

(iii) the radiolysis stabilizer is present in the liquid radiopharmaceutical composition at 50 mM to 200 mM; or

(iv) the radiolysis stabilizer is present in the liquid radiopharmaceutical composition at 0.0001 wt% to 10 wt%; or

(v) the radiolysis stabilizer is present in the liquid radiopharmaceutical composition at 0.01 wt% to 5 wt%, 0.05 wt% to 2 wt%, or 0.1 wt% to 1 wt%; or

(vi) the radiolysis stabilizer is present in the liquid radiopharmaceutical composition at a concentration of from 0.1 to 50 mg/mL.

6. The liquid radiopharmaceutical composition of any one of claims 1 to 5, wherein the free metal chelator is EDTA, DTPA, or Macropa.

7. The liquid radiopharmaceutical composition of any one of claims 1 to 6, wherein the free metal chelator is present in the liquid radiopharmaceutical composition at 0.001 wt% to 10 wt%; or at 0.01 wt% to 5 wt%, 0.05 wt% to 2 wt%, or 0.1 wt% to 1 wt%; or wherein the free metal chelator is present in the liquid radiopharmaceutical composition at a concentration of from 0.001 to 50 mg/mL; or wherein the free metal chelator is present in the liquid radiopharmaceutical composition at 10 mM to 500 mM, or at 5 mM to 10 mM, 10mM to 25 mM, 25 mM to 50 mM, 50 mM to 75 mM, 75mM to 100 mM, or 100 mM to 200 mM.
8. The liquid radiopharmaceutical composition of any one of claims 1 to 7, wherein the free metal chelator is present in the liquid radiopharmaceutical composition at a concentration of from 0.01 to 5 mg/mL, 0.01 to 1 mg/mL, 0.01 to 0.5 mg/mL, or 0.01 to 1 mg/mL.
9. The liquid radiopharmaceutical composition of any one of claims 1 to 8, further comprising one or more pH stabilizers, wherein:
    (i) the one or more pH stabilizers comprise an organic acid, or a salt thereof; and/or
    (ii) the one or more pH stabilizers comprise an inorganic acid, or a salt thereof; and/or
    (iii) the one or more pH stabilizers comprise a base, or a salt thereof; and/or
    (iv) the one or more pH stabilizers comprise an amino acid or a salt thereof, and wherein the amino acid is glycine, lysine, arginine, histidine or a combination thereof; and/or
    (v) the one or more pH stabilizers comprise an alkaline salt, an acid salt, or both.
10. The liquid radiopharmaceutical composition of claim 9, wherein the one or more pH stabilizers comprise an organic acid, or a salt thereof, wherein the organic acid is an acetic acid, fumaric acid, ascorbic acid, propionic acid, benzene sulfonic acid, carbonic acid, citrate acid, aspartic acid, maleic acid, methane sulfonic acid, or tartaric acid.
11. The liquid radiopharmaceutical composition of claim 9, wherein the one or more pH stabilizers comprise an alkaline salt, an acid salt, or both, wherein the alkaline salt is sodium acetate, sodium ascorbate, sodium benzoate, sodium bicarbonate, sodium carbonate, tribasic sodium phosphate acid, dibasic sodium phosphate acid, monobasic sodium phosphate acid, sodium tartrate, sodium lactate, sodium succinate, or disodium succinate.
12. The liquid radiopharmaceutical composition of claim 9, wherein the one or more pH stabilizers comprise Sodium acetate, Sodium ascorbate, Acetic acid, Fumaric acid propionic acid, ascorbic acid, ammonium sulfate, ammonium hydroxide, arginine, aspartic acid, benzene sulfonic acid, sodium benzoate, sodium bicarbonate, boric acid, sodium carbonate, carbonic acid, diethanolamine, citrate acid, hydrobromic acid, glycine,

histidine, sodium lactate, (l)-lysine, maleic acid, methane sulfonic acid, phosphate acid, monobasic sodium phosphate acid, tribasic sodium phosphate acid, dibasic sodium phosphate acid, sodium hydroxide, sodium/disodium succinate, sulfuric acid, sodium tartrate, tartaric acid, tromethamine (tris), or a combination thereof.

13. The liquid radiopharmaceutical composition of any one of claims 9 to 12, wherein the one or more pH stabilizers are present in the liquid radiopharmaceutical composition at 0.001 wt% to 10 wt%, or at 0.01 wt% to 5 wt%, 0.05 wt% to 2 wt%, or 0.1 wt% to 1 wt%; or wherein the one or more pH stabilizers are present in the liquid radiopharmaceutical composition at a concentration of from 0.1 to 5 mg/mL; or wherein the one or more pH stabilizers are present in the liquid radiopharmaceutical composition at 10 mM to 500 mM, or at 0.1 mM to 2 mM, 1mM to 2 mM, 1 mM to 10 mM, 5 mM to 10 mM, 5 mM to 15 mM, 1 mM to 15 mM or 1 mM to 25 mM.
14. The liquid radiopharmaceutical composition of any one of claims 9 to 13, wherein the one or more pH stabilizers are configured to maintain a pH of the liquid radiopharmaceutical composition at 4 to 8, or at 5 to 7.
15. The liquid radiopharmaceutical composition of any one of claims 1 to 14, wherein the pH of the liquid radiopharmaceutical composition is within a range of 4 to 8, or wherein the pH of the liquid radiopharmaceutical composition is 5.5 to 6.0.
16. The liquid radiopharmaceutical composition of any one of claims 1 to 15, wherein the aqueous vehicle comprises water, saline solution, dextrose in water, dextrose in saline solution, Ringer's solution, or lactated Ringer's solution.
17. The liquid radiopharmaceutical composition of any one of claims 1 to 16, wherein the aqueous vehicle is a saline solution.
18. The liquid radiopharmaceutical composition of any one of claims 1 to 17, wherein the liquid radiopharmaceutical composition is a solution or suspension, and/or wherein the liquid radiopharmaceutical composition is formulated for IV infusion or bolus injection.
19. The liquid radiopharmaceutical composition of any one of claims 1 to 18, wherein the composition contains 5% or 2% or 1% free actinium-225 after 168 hours at 20ºC to 25°C, compared to the total amount of the actinium-225 in the composition as determined by radio thin-layer chromatography (radio-TLC); or wherein the composition contains a total of 5 % of un-chelated daughter isotopes of actinium-225 after 168 hours at 20ºC to 25°C, compared to the total amount of the actinium-225 in the composition as determined by radio thin-layer chromatography (radio-TLC).
20. A liquid radiopharmaceutical composition comprising:

(a) a conjugate, wherein the conjugate is ^{225}Ac-DOTA-TATE, and is present in the

liquid radiopharmaceutical composition at a concentration equivalent to 5 to 100 mCi/L;

(b) a radiolysis stabilizer, wherein the radiolysis stabilizer is ascorbic acid or a salt thereof, ethanol, or gentisic acid or a salt thereof, and is present in the liquid radiopharmaceutical composition at a concentration of 50 mM to 500 mM;

(c) a free metal chelator, wherein the free metal chelator is selected from EDTA, macropa, TETA, PEPA, TETPA, DFO, DOTP, DHLA, TGA, LA, and DTPA, or a combination thereof, and is present in the liquid radiopharmaceutical composition at a concentration of 0.01 mg/mL to 5 mg/mL; and

(d) an aqueous vehicle.

21. The liquid radiopharmaceutical composition of claim 20, comprising:

(a) ^{225}Ac-DOTA-TATE, wherein the ^{225}Ac-DOTA-TATE is present in the liquid radiopharmaceutical composition at a concentration equivalent to 10 to 50 mCi/L;

(b) a radiolysis stabilizer, wherein the radiolysis stabilizer is sodium L-ascorbate and is present in the liquid radiopharmaceutical composition at a concentration of 80 to 120 mM, or 50 mM to 200 mM;

(c) DTPA, wherein the DTPA is present in the liquid radiopharmaceutical composition at a concentration of 0.01 mg/mL to 1 mg/mL; and

(d) an aqueous vehicle, wherein the aqueous vehicle is saline solution.

22. The liquid radiopharmaceutical composition of claim 20 or claim 21, further comprising one or more pH stabilizers configured to maintain a pH of the liquid radiopharmaceutical composition at 4 to 8.

23. The liquid radiopharmaceutical composition of any one of claims 1 to 22, wherein the free metal chelator is configured to maintain a level of free radionuclide in the liquid radiopharmaceutical composition below 0.05 mCi/L for at least 72 hours at 20ºC to 25°C as determined by radio thin-layer chromatography (radio-TLC).

24. Use of the liquid radiopharmaceutical composition of any one of claims 1 to 23 in the manufacture of a medicament for treating a somatostatin receptor-positive (SSTR+) neuroendocrine tumor in a subject in need thereof, wherein the liquid radiopharmaceutical composition is to be administered to the subject in an effective amount.

25. The use of claim 24, wherein the neuroendocrine tumor is gastroenteropancreatic neuroendocrine tumor (GEP-NET).

26. The use of claim 24 or claim 25, wherein, prior to the administration of the liquid radiopharmaceutical composition, the subject received ^{177}Lu-DOTA-TATE treatment and the tumor has progressed.
27. The use of any one of claims 24 to 26, wherein the liquid radiopharmaceutical composition is to be administered to the subject in an amount equivalent to 60 kBq/kg body weight to 120 kBq/kg body weight per dose.
28. The use of any one of claims 24 to 27, wherein the liquid radiopharmaceutical composition is to be administered at an 8-week interval.
29. A method of making a liquid radiopharmaceutical composition of any one of claims 1 to 23, the method comprising:

    combining ^{225}Ac, or a pharmaceutically acceptable salt thereof with DOTA-TATE, or a pharmaceutically acceptable salt thereof, thereby producing a mixture comprising ^{225}Ac-DOTA-TATE; and

    adding radiolysis stabilizer and free metal chelator to the mixture.
30. Use of the liquid radiopharmaceutical composition of any one of claims 1 to 23 in the manufacture of a medicament for treating a somatostatin receptor-positive (SSTR2+) cancer in a subject in need thereof, wherein the liquid radiopharmaceutical composition is to be administered to the subject.
31. The use of claim 30, wherein the cancer is a neuroendocrine cancer, a lymphatic cancer, a pancreatic cancer, a pituitary cancer, a breast cancer, a lung cancer, a stomach cancer, medulloblastoma, or neuroblastoma.
32. The use of claim 30, wherein the cancer is a neuroendocrine cancer.
33. The use of claim 32, wherein the neuroendocrine cancer is a neuroendocrine lung cancer or a neuroendocrine pancreatic cancer.
34. The use of claim 32, wherein the neuroendocrine cancer is a carcinoid tumor in the lungs, gastrointestinal tract or thymus, pancreatic neuroendocrine tumor , medullary thyroid carcinoma, Merkel cell carcinoma, pheochromocytoma of the adrenal gland, adrenal cancer, small cell carcinoma, or large cell carcinoid tumor.
35. The use of claim 30, wherein the cancer is a SSTR2+ lung neuroendocrine tumor, or wherein the cancer is small cell lung cancer (SCLC), or wherein the cancer is somatostatin receptor expressing (SSTR+) extensive stage small cell lung cancer (ES-SCLC).
36. The use of claim 35, wherein the SCLC is untreated, recurrent or refractory.
37. The use of claim 35, wherein the subject has received at most 1 cycle of platinum-etoposide and PD-L1 inhibitor therapy.

38. The use of any one of claims 30 to 37, wherein the cancer is untreated or wherein the cancer is recurrent or refractory.
39. The use of any one of claims 30 to 38, wherein the liquid radiopharmaceutical composition is to be administered to the subject in an amount equivalent to 1kBq/kg to 0.2GBq/kg body weight per dose, or in an amount equivalent to 5kBq/kg to 50,000kBq/kg body weight per dose, 20k Bq/kg to 5,000kBq/kg body weight per dose, 50k Bq/kg to 500 kBq/kg body weight per dose, or 50k Bq/kg to 200 kBq/kg body weight per dose, or in an amount equivalent to 60 kBq/kg to 150 kBq/kg body weight per dose; or wherein the liquid radiopharmaceutical composition is to be administered to the subject at a radioactivity of 1 µCi to 1,000 µCi, 10 µCi to 500 µCi, 100 µCi to 500 µCi, 100 µCi to 300 µCi, 125 µCi to 275 µCi, 50 µCi to 125 µCi, or 10 µCi to 50 µCi, or at a radioactivity of 125 µCi to 275 µCi, or at a radioactivity of 125 µCi, 175 µCi, 225 µCi, or 275 µCi.
40. The use of any one of claims 30 to 39, wherein the liquid radiopharmaceutical composition is to be administered at an 4 to 6-week interval.
41. Use of the liquid radiopharmaceutical composition of any one of claims 1 to 23 in the manufacture of a medicament for treating an SSTR2+ cancer in a subject in need thereof, wherein an H-score of a cancer sample of the subject is at least 11.
42. The use of claim 41, wherein the H-Score is between 11 and 300.
43. The liquid radiopharmaceutical composition of any one of claims 1 to 23 for use in therapy.