## CLAIMS

1. A method for producing Pb-212 isotope comprising:

introducing Th-228 into an emanation box,

wherein the emanation box comprises an emanation source comprising a high surface area material;

introducing a carrier gas into the emanation box through a carrier gas feed,

wherein the carrier gas is an inert gas,

wherein the carrier gas flows through the emanation box,

wherein the Th-228 decays to Rn-220 within the emanation box,

wherein the carrier gas carries the Rn-220 resulting from decay of the Th-228 in the emanation box to one or more Rn-220 targets through a multi-way valve coupled to a carrier gas exit port of the emanation box;

separating the Rn-220 from the carrier gas in the one or more Rn-220 targets; directing the carrier gas out of the one or more Rn-220 targets through a carrier gas exhaust port;

directing a liquid through a liquid feed into the one or more Rn-220 targets;

allowing the Rn-220 to undergo radioactive decay into Pb-212 isotope within the one or more Rn-220 targets;

wherein the liquid dissolves the Pb-212 isotope produced by radioactive decay of Rn-220 within the one or more Rn-220 targets;

directing the liquid containing the Pb-212 isotope from the one or more Rn-220 targets to a Pb-212 collection container; and

separating the Pb-212 isotope from the liquid.

2. The method of claim 1, wherein the carrier gas is nitrogen.

3. The method of claim 1, wherein the liquid is an acid solution selected from the group consisting of HCL and $HNO_3$.

4. The method of claim 1, wherein the liquid is cooled to a temperature at or below -72° C by a cooling unit coupled to the one or more Rn-220 targets.

5. The method of claim 1, wherein a flow rate of the carrier gas through the emanation box is controlled based on mass flow rate.

6. The method of claim 1, further comprising:

directing the carrier gas to a first Rn-220 target through the multi-way valve coupled to the carrier gas exit port of the emanation box for a first time period;

opening a first carrier gas exhaust port on the first Rn-220 target after the first time period has elapsed; and

directing the carrier gas to a second Rn-220 target through the multi-way valve coupled to the carrier gas exit port of the emanation box for a second time period after the first time period has elapsed.

7. The method of claim 1, wherein separating the Rn-220 from the carrier gas in the one or more Rn-220 targets comprises:

placing the carrier gas in contact with the liquid within the one or more Rn-220 targets until the Rn-220 has been transferred from the carrier gas to the liquid.

8. The method of claim 1, wherein the high-surface area material comprises a porous metal or porous ceramic material having a surface area between 1 $m^2$ and 100,000 $m^2$.

9. The method of claim 8, wherein the porous metal comprises one or more of titanium, zirconium, gold, platinum, iridium tungsten or combinations thereof.

10. A method for producing Pb-212 isotope comprising:

introducing Ra-224 into an emanation box,

wherein the emanation box comprises an emanation source comprising a high surface area material;

introducing a carrier gas into the emanation box through a carrier gas feed,

wherein the carrier gas is an inert gas,

wherein the carrier gas flows through the emanation box,

wherein the Ra-224 decays to Rn-220 within the emanation box,

wherein the carrier gas carries the Rn-220 resulting from decay of the Ra-224 in the emanation box to one or more Rn-220 targets through a multi-way valve coupled to a carrier gas exit port of the emanation box;

separating the Rn-220 from the carrier gas in the one or more Rn-220 targets;

directing the carrier gas out of the one or more Rn-220 targets through a carrier gas exhaust port;

directing a liquid through a liquid feed into the one or more Rn-220 targets;

allowing the Rn-220 to undergo radioactive decay into Pb-212 isotope within the one or more Rn-220 targets;

wherein the liquid dissolves the Pb-212 isotope produced by radioactive decay of Rn-220 within the one or more Rn-220 targets;

directing the liquid containing the Pb-212 isotope from the one or more Rn-220 targets to a Pb-212 collection container; and

separating the Pb-212 isotope from the liquid.

11. The method of claim 10, wherein the carrier gas is nitrogen.

12. The method of claim 10, wherein the liquid is an acid solution selected from the group consisting of HCL and $HNO_3$.

13. The method of claim 10, wherein the liquid is cooled to a temperature at or below -72° C by a cooling unit coupled to the one or more Rn-220 targets.

14. The method of claim 10, wherein a flow rate of the carrier gas through the emanation box is controlled based on mass flow rate.

15. The method of claim 10, further comprising:

directing the carrier gas to a first Rn-220 target through the multi-way valve coupled to the carrier gas exit port of the emanation box for a first time period;

opening a first carrier gas exhaust port on the first Rn-220 target after the first time period has elapsed; and

directing the carrier gas to a second Rn-220 target through the multi-way valve coupled to the carrier gas exit port of the emanation box for a second time period after the first time period has elapsed.

16. The method of claim 10, wherein separating the Rn-220 from the carrier gas in the one or more Rn-220 targets comprises:

placing the carrier gas in contact with the liquid within the one or more Rn-220 targets until the Rn-220 has been transferred from the carrier gas to the liquid.

17. The method of claim 10, wherein the high-surface area material comprises a porous metal or porous ceramic material having a surface area between 1 $m^2$ and 100,000 $m^2$.

18. The method of claim 17, wherein the porous metal comprises titanium, zirconium, gold, platinum,

iridium tungsten or combinations thereof.

19. The method of claim 1, wherein the one or more Rn-220 targets comprise a zeolite or metal chalcogenide with a zeolite-like structure.

20. The method of claim 10, wherein the one or more Rn-220 targets comprise a zeolite or metal chalcogenide with a zeolite-like structure.