Production of Radiobromide: New Nickel Selenide Target and Optimized Separation by Dry Distillation

K. Breunig, I. Spahn, S. Spellerberg, B. Scholten[1], H.H. Coenen

Institute of Neuroscience and Medicine, INM-5: Nuclear Chemistry,
Forschungszentrum Jülich, D-52425 Jülich, Germany

Introduction

Radioisotopes of bromine are of special interest for nuclear medical applications. The positron emitting isotopes ^{75}Br ($T_{½}$ = 1.6 h; β^+ = 75.5 %) and ^{76}Br ($T_{½}$ = 16.2 h; β^+ = 57 %) have suitable decay properties for molecular imaging with PET, while the Auger electron emitters ^{77}Br ($T_{½}$ = 57.0 h) and ^{80m}Br ($T_{½}$ = 4.4 h) as well as the β^--emitter ^{82}Br ($T_{½}$ = 35.3 h) are useful for internal radiotherapy. ^{77}Br is additionally suited for SPECT. The isotopes ^{75}Br, ^{76}Br and ^{77}Br are usually produced at a cyclotron either by ^{3}He and α-particle induced reactions on natural arsenic or by proton and deuteron induced reactions on enriched selenium isotopes [1]. As target materials for the latter two reactions, earlier elemental selenium [2] and selenides of Cu, Ag, Mn, Mo, Cr, Ti, Pb and Sn were investigated [cf. 3–7].

Besides several wet chemical separation techniques the dry distillation of bromine from the irradiated targets was investigated, too [cf. 2, 4, 5]. However, the method needs further development.

Nickel selenide was investigated as a promising target to withstand high beam currents, and the dry distillation technique for the isolation of n.c.a. radiobromine from the target was optimized.

Material and Methods

Crystalline Nickel-(II) selenide (0.3–0.5 g) was melted into a 0.5 mm deep cavity of a 1 mm thick Ni plate covered with a Ni grid. NiSe has a melting point of 959 °C. For development of targeting and the chemical separation, natural target material was used. Irradiations of NiSe were usually performed with protons of 17 MeV using a slanting water cooled target holder at the cyclotron BC1710 [8]. For radiochemical studies a beam current of 3 µA and a beam time of about 1 h were appropriate.

To separate the produced no-carrier-added (n.c.a.) radiobromine from the target material a dry distillation method was chosen. The apparatus was developed on the basis of a dry distillation method for iodine [cf. 9,10] and optimized to obtain the bromine as n.c.a. [*Br]bromide in a small volume of sodium hydroxide solution.

Changing different components of the apparatus, the dead volume could be minimized and an almost constant argon flow as carrier medium was realized. Various capillaries of platinum, stainless steel and quartz glass with different diameters and lengths were tested to trap the radiobromine.

Results and Conclusion

Nickel selenide proved successful as target material for the production of radiobromine by proton irradiation with 17 MeV protons. The target was tested so far only at beam currents up to 10 µA, but further investigations are ongoing.

The optimized dry distillation procedure allows trapping of 80–90 % of the produced radiobromine in a capillary. For this purpose quartz glass capillaries proved to be most suitable. After rinsing the capillary with 0.1 M NaOH solution the activity can be nearly completely obtained in less than 100 µL solution as [*Br]bromide immediately useable for radiosynthesis. So, the overall separation yield was estimated to 81 ± 5 %.

The radionuclidic composition and activity of the separated radiobromide was measured by γ-ray spectrometry. Due to the use of natural selenium the determination of the isotopic purity was not meaningful, but it could be shown that the radiobromine was free from other radioisotopes co-produced in the target material and the backing. The radiochemical purity as well as the specific activity were determined by radio ionchromatography.

Further experiments using NiSe produced from nickel and enriched selenium are to be performed. The isotopic purity of the produced respective radiobromide, the production yield at high beam currents and the reusability of the target material have to be studied.

[1]Corresponding author, E-mail: b.scholten@fz-juelich.de

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References

1. S.M. Qaim, G. Stöcklin: *Radiochim. Acta* **34**, pp. 25–40, 1983.
2. Z. Kovács, G. Blessing, S. M. Qaim, G. Stöcklin: *Int. J. Appl. Radiat. Isot.* **36**, pp. 635–642, 1985.
3. A. G. M. Janssen, R. L. P. Van Den Bosch, J. J. M. De Goeij, H. M. J. Theelen: *Int. J. Appl. Radiat. Isot.* **31**, pp. 405–409, 1980.
4. W. Vaalburg, A. M. J. Paans, J. W. Terpstra, T. Wiegman, K. Dekens, A. Rijskamp, M. G. Woldring: *Int. J. Appl. Radiat. Isot.* **36**, pp. 961–964, 1985.
5. V. Tolmachev, A. Lövqvist, L. Einarsson, J. Schultz, H. Lundqvist: *Appl. Radiat. Isot.* **49**, pp. 1537–1540, 1998.
6. K. Suzuki, G. Blessing, S.M. Qaim, G. Stöcklin: *Int. J. Appl. Radiat. Isot.* **33,** pp. 1445–1448, 1982.
7. C. P. Madhusudhan, S. Treves, A. P. Wolf, R. M. Lambrecht: *J. Radioanal. Chem.* **53**, pp. 299–305, 1979.
8. B. Scholten et al.: 13th International Workshop on Targetry and Target Chemistry, Risø, Denmark, 26-28 July 2010, Proceedings, Risø; *No. 1787(EN)*, pp. 14–18, 2011.
9. S.M. Qaim, A. Hohn, Th. Bastian, K. M. El-Azoney, G. Blessing, S Spellerberg, B Scholten, H. H. Coenen: *Appl. Radiat. Isot.* **58**, pp. 69–78, 2003.
10. J. Schmitz: *Eur. J. Nucl. Med. Mol. Imaging* **38**, pp. 4–9, 2011.

[1]Corresponding author, E-mail: b.scholten@fz-juelich.de