Feasibility study for the production of an ^{82}Br radioactive source for measuring surface velocity in single-phase systems

L. A. A. G. Silva[1,4], C. Raitz[2], C. M. Barbosa[3,5], C. M. Salgado[3]
E-mail: lucasalecsander10@poli.ufrj.br, craitzj@hotmail.com, caroline.mattos@coppe.ufrj.br, otero@ien.gov.br

[1] *CENS, IEN*
[2] *SEINS, IEN*
[3] *DIRA, IEN*
[4] *DNC, POLI, UFRJ*
[5] *PEN, COPPE, UFRJ*

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This report presents a study of the NaBr salt for Radio-Particle Tracking (RPT), particle activity and density of radioactive sources. Ionizing radiation can interact with matter, plucking electrons of their atoms and modifying their molecules [1]. These materials are generated through neutron activation, activated by bombardment with neutrons or high-energy photons in nuclei of isotopes [2].
The RPT technique is useful for assessing industrial pipelines and agitator's conditions, preventing interruption of the production chain. Typically, activated ^{198}Au powder is used in RPT experiments. The powder scatters quickly inside the probed medium, leaving a very short time window to measure its flow properties. This study presents the possibility of using macro-particles that can be used and retrieved many times.
For the experiments, a sample of NaBr salt will be placed inside a capsule for neutron activation in the Argonauta reactor at the *Instituto de Engenharia Nuclear* – IEN. An X-Ray Fluorescence Analysis (XRFA) was performed to assess the purity of a NaBr P.A. sample from VETEC. The analysis indicated the presence of 99.32% of NaBr, which is close to the value specified on the packaging of 99.50%.
Two geometries were chosen for the capsule: a sphere with a diameter of 2 cm and a cube with a 2 cm side. The encapsulation materials are PLA and Epoxy Resin. The NaBr salt will be centered in the capsule within a sphere of radius 1 mm or 5 mm. The particle density must be the same as the investigated fluid with RPT technique, so as not to cause any perturbation in the probed medium. Then, we calculate the density of radioactive particles with different geometries, using the following densities: 3.30 g/cm^3 for NaBr, 1.43 g/cm^3 for PLA, and 1.25 g/cm^3 for Epoxy Resin. The result is presented in Table 1.

Table 1 – Density of each radioactive particle used in the simulations.

Material	Geometry	NaBr (R=1mm) [g/cm³]	NaBr (R=5mm) [g/cm³]
PLA	**Cube**	1.438	2.409
PLA	**Sphere**	1.432	1.664
Epoxy	**Cube**	1.259	2.323
Epoxy	**Sphere**	1.252	1.506

The next stage was to estimate the activity of each particle considering that all Br atoms were activated during the neutron activation process. The ^{82}Br specific activity is 4.07×10^{16} Bq/g. The estimated activity for particles with inner radius R=1 mm is 4.366×10^{14} Bq, and for particles with R=5 mm is 540.2×10^{14} Bq.
A detection system containing the radioactive particle (salt + capsule) and a NaI detector located 8 cm away from the particle was simulated with the MCNPX program. From the results, we calculated the number of photons from the ^{82}Br decay entering the detector per second, as can be seen in Table 2.

Table 2 – Activities for the simulated setup.

Material	Geometry	NaBr (R=1mm) [10^{12} cts/s]	NaBr (R=5mm) [10^{12} cts/s]
PLA	**Cube**	1.10	136
PLA	**Sphere**	1.09	135
Epoxy	**Cube**	1.10	136
Epoxy	**Sphere**	1.11	137
NaBr (no capsule)		1.22	151

The proposed particles can be used in RPT experiments with fluid densities from about 1.2 to 2.4 g/cm³. Therefore, it is not recommended for light fluids, like water or salt-water. Future works will investigate the possibility of making lighter particles and simulate the particles on a RPT experiment, including the effects of the ^{24}Na in the Monte Carlo simulations.

References

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