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Abstract

3D printed radioactive phantoms for Positron Emission Tomography

S. Seeger[1*°], E. Elmoujarkach[1°], N. Möller[1], C. Schmidt[2], and M. Rafecas[1]

[1] *Institute of Medical Engineering, Universität zu Lübeck, Lübeck, Germany*
[2] *Isotope Laboratory of the Natural Sciences Section, Universität zu Lübeck, Lübeck, Germany*
° *These authors contributed equally to this work*
[*] *Corresponding author, email: seeger@imt.uni-luebeck.de*

In Positron Emission Tomography (PET), radioactive phantoms are needed for calibration, characterization and quality assurance (QA) of the scanners. They can be simple structures such as flat radioactive sources, or hollow cylinders filled with liquid radioactive solutions. Image quality studies require more complex phantoms, which often consist of several fillable parts. To characterize the performance of high-resolution imaging devices, it is desirable to integrate tiny radioactive structures into the phantoms. Thanks to the latest and significant advances in 3D printing technology, it is now possible to print phantoms that include submillimeter structures. Since filling small structures with radioactive liquid is problematic (e.g., bubbles), direct printing with radioactive material would be preferable. Recently, phantoms printed with liquid resin mixed with ^{18}F- Fludeoxyglucose (^{18}F-FDG), a radiotracer for PET, with a half life of 110 min, were developed for clinical devices [1,2]. Due to their large size, these phantoms cannot be used for small animal PET. In this work, we have adapted this technique to allow for printing small structures. To achieve the necessary submillimeter resolution for the phantoms, we have adapted a reasonably priced desktop Digital Light Processing (DLP) 3D printer (*Anycubic Photon Mono*). The modifications included a by 83% reduced size resin tank (31mm^3) and a smaller build plate (60x30mm^2). The aim was to reduce the amount of required radioactive substances while preserving the activity concentration in the phantoms. Preliminary tests using ^{18}F-FDG mixed to the resin were carried out with printed flat and point-like sources. The high resolution capability of the printer was not affected by the new resin mixture. The results show a homogeneous activity distribution within the phantoms. Additionally, more complex phantoms with regions containing different activity concentrations were printed and assembled. By combining active and non-active prints, we plan to create realistic phantoms, e.g. based on segmented anatomical data. While the short-life of ^{18}F-FDG is sufficient to create single-use phantoms, this is not practical for regular calibration and QA procedures. Therefore, our future work includes the extension to longer-lived radionuclides. We have started implementing the printing procedure for ^{89}Zirconium (^{89}Zr), with a half-life of 78h. This isotope is problematic when used in liquid form in phantoms because it bonds to the walls. If this step is successful, the extension to ^{22}Sodium (^{22}Na), with a half-live of 2.6 years, will allow us to produce long lasting quality phantoms.

AUTHOR'S STATEMENT

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