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Development and Characterizations of 3D Printed Plastic Scintillators for High Dose Rate Proton Beam

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3D printing technology can fabricate three-dimensional objects based on layers and is applied across various fields such as biotechnology, medicine, industry, education, and space, etc. This study aimed to produce a scintillator resin capable of detecting radiation using commercial resins for DLP 3D printers. The commercial resin used was a transparent acrylic resin (Acryl Resin Pro, Anycubic Co.) with a density of 1.1 g/cm³, viscosity of 70 mPa·s, and hardness of 79 (Shore D). A scintillator resin was manufactured by mixing 1.0 wt% PPO organic scintillator, 5.0 wt% MMA, and the commercial acrylic resin. This resin was used to print cylindrical 3D plastic scintillator radiation sensors using a commercial 3D DLP printer (Anycubic Photon M3 Max, Anycubic Co.). The emission wavelength spectrum of the printed 3D-printed plastic scintillator ranges from 350 to 700 nm, with peaks at 411 nm and 497 nm, which match well with the quantum efficiency of photomultipliers. The scintillator shows excellent linearity in absorbed dose and measurement data (R-squared 0.998) and shows no dose rate effect in the range of 1 nA to 6 μA for a 45 MeV proton beam from KRISS MC-50 cyclotron. However, due to the low optical output of the sensor, it is limited for measuring low-dose gamma rays or X-rays. Nonetheless, it may be useful for measuring high-dose radiation or high-energy proton radiation. The 3D-printed plastic scintillator has the advantage of being similar to the human body in atomic number and density, making it beneficial for radiation dose measurement. Therefore, when used on the human body, it could assist in evaluating the volumetric dose to organs or targets and may be useful for measuring various types of non-standardized and complex radiation types.

Paper submission Plan

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