ABSTRACT

This dissertation investigates the positron-emitting radioisotopes of scandium: ^{43}Sc ($t_{1/2}$ = 3.891 h, β^+_{mean} = 476 keV) and ^{44g}Sc ($t_{1/2}$ = 3.97 h, β^+_{mean} = 632 keV), and establishes their potential as alternatives to the well-established PET radionuclide ^{68}Ga ($t_{1/2}$ = 67.71 m, β^+_{mean} = 829.5 keV). ^{44g}Sc emits a high energy gamma of 1157 keV (I_γ = 99.9%) which delivers excess dose to patients and may reduce image quality. Thus, ^{43}Sc, which has lower energy gamma emissions (E_γ = 372.9 keV; I_γ = 22.5%), may be preferred in clinical settings. We, and others, have investigated methods to produce ^{44g}Sc, but production of ^{43}Sc has largely been neglected due to the need for deuterons and/or enriched material. ^{43}Sc and ^{44g}Sc's roughly four-hour half-lives allow for biodistribution images > 4 hours post-injection and may be transported to nearby clinics without a cyclotron on-site. Both $^{43/44g}$Sc exist primarily in the +3-oxidation state similar to therapeutic isotopes such as ^{177}Lu and ^{161}Tb. The chemical similarity of scandium to light lanthanides suggests that scandium-labeled agents may have comparable biodistributions to the same agents labelled with ^{177}Lu or ^{161}Tb. This dissertation explores cyclotron production methods for $^{43/44g}$Sc on enriched ^{4x}CaO targets, comparing production yields and radionuclidic purity between several production routes accessible on a small cyclotron. This work also investigates ^{43}Sc's and ^{44g}Sc's potential *in vitro* and *in vivo* for cancer imaging applications. Phantom studies were performed on clinical PET/CT scanners to compare contrast and recovery between ^{43}Sc/^{44g}Sc and other conventionally used positron-emitting radionuclides. Additionally, [$^{43/44g}$Sc]Sc-FAPI-46 and [^{68}Ga]Ga-FAPI-46 PET/CT imaging were compared in a murine model of pancreatic ductal adenocarcinoma. Finally, the uptake and biodistribution of [^{44g}Sc]Sc-DOTA-TATE, [^{68}Ga]Ga-DOTA-TATE, and [^{161}Tb]Tb-DOTA-TATE was compared through *in vitro* and *in vivo* PET/CT and SPECT/CT studies to assess theranostic potential in neuroendocrine tumors.