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Application Note

ISO-007

The Essential Role of Enriched Stable Nuclides in Positron Emission Tomography (PET)

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Positron Emission Tomography (PET) is one of the most rapidly expanding areas of medical diagnosis. PET is routinely used in determining the extent of tumor metastases, utilizing an analog of glucose in which the hydroxy group at the two position is replaced by a radioactive fluorine atom. This compound, 2-fluoro-2-deoxy-D-glucose (FDG), is taken up in tissues in an amount very similar to glucose, but is retained in the tissue unlike normal glucose, which is rapidly metabolized largely to water and carbon dioxide. This retention of the radioactivity allows the visualization of tumors, which metabolize glucose to a greater extent than normal tissue. In research studies, the glucose utilization of the tumors can be quantified. Due to the two-hour half-life of fluorine-18, this compound must be distributed from regional centers. All of these centers utilize enriched oxygen-18 to produce the fluoride used to make FDG. Fluorine-18 is reacted with agents also supplied by Sigma-Aldrich to produce the radioactive drug used in the medical diagnostic studies.

Other enriched compounds include enriched molecular oxygen and nitrogen enriched in nitrogen-13 and are also used as target materials to produce PET radiopharmaceuticals. Oxygen gas is used in several centers to produce another radioactive drug, fluorine-18-labeled dopamine, used to study brain function, particularly in patients with schizophrenia and other psychiatric diseases. In the most common cyclotron used to produce PET radiopharmaceuticals, the enriched nitrogen is used to produce a series of very simple compounds containing radioactive oxygen-15. Oxygen-15, which has a two-minute half-life, can be used to study brain blood flow and brain oxygen metabolism. In a multicenter study funded by the National Institutes of Neurological Diseases and Stroke, labeled oxygen is being used to predict which patients will benefit from a brain surgery intracranial/ extracranial bypass surgery, which restores blood flow to areas of the brain where delivery of oxygen is significantly reduced.

Imaging relies upon the supply of enriched stable isotopes. In the future, it is anticipated that a whole battery of new compounds will be used to study many other parameters in tumors, brain and heart diseases, and they will rely upon the continued supply of stable isotopes.

ISOTEC® materials for the production of ^{18}FDG

- **Water-^{18}O**, 97 atom % ^{18}O (**329878**)
- **$^{15}N_2/O_2$** gas mix ratio 39:1 (**600911**)
- Mannose Triflate (**M1568**)
- Kryptofix® (**291110**)

PET Kits – Ready to Use

Designed for the MX_{FDG} and FX_{FDG} Synthesizer Module	
676055	Full Reagent Kit for FX_{FDG} Module
676047	Full Reagent Kit for MX_{FDG} Module

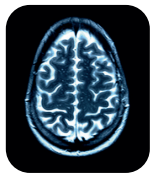
MERCK

PET Applications

We offer target materials for the production of radionuclides ^{18}F, ^{11}C, and ^{15}O. In addition to the target materials, we also offer all reagents used in the production of ^{18}FDG. PET research studies have various applications that include Cardiology, Oncology, Neurology, Pharmacology, and Neuropsychology and Cognitive Neuroscience.

Cardiology

PET is the most common form of diagnostic testing for use in cardiology, for example myocardial viability and coronary heart disease. The radionuclide ^{13}N, produced from Water-^{16}O (**329886**) is used in myocardial perfusion. PET scans help to differentiate viable myocardium from infracted tissue in patients that are suspected to have hibernating or stunned myocardium.



Neurology

PET is also used to distinguish recurrent brain tumors from radiation fibrosis or necrosis, which is essential to neurological studies. Oxygen-$^{15}O_2$, produced from $^{15}N_2$(99%)/Oxygen (RG) Gas Mix 39:1 (**600911**), measures the flow of blood to the upper or main portion of the brain. The isotope ^{11}C, produced from $^{14}N_2$ (**608661**), is used as a radiotracer in PET scans to study normal/abnormal brain functions. It is one of the methods in localizing areas of the brain affected by epileptic seizures.

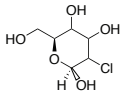
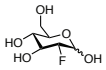
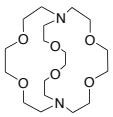
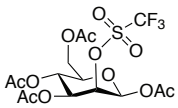
Oncology

The onset of PET imaging has generated various interests with investigative studies in oncology using ^{18}F-FDG. ISOTEC® supplies the Water-^{18}O (**329878**), Kryptofix® (**291110**), and the Mannose triflate (**M1568**) necessary to produce the ^{18}F-FDG. Today, PET has distinctive uses in clinical areas such as cancers, lymphoma, melanoma, strokes, and tumors.

Pharmacology and Neuropsychology

PET is widely used in pre-clinical and clinical trials to study psychiatric and cognitive disorders along with developing new radiolabel drugs.

Compounds of Interest

Structure	Cat. No.	Compound		MW
	C203	2-Chloro-2-deoxy-D-glucose		198.6
	F5006	2-Deoxy-2-fluoro-D-glucose		182.2
	291110	Kryptofix® 4,7,13,16,21,24-Hexaoxa-1,10-diazabicyclo[8.8.8]hexacosane, 98%		376.5
	M1568	Mannose Triflate β-D-Mannopyranose 1,3,4,6-tetra-*O*-acetate 2-*O*-trifluoromethanesulfonate 1,3,4,6-Tetra-*O*-acetyl-2-*O*-trifluoromethanesulfonyl-β-D-mannopyranose TATM		480.4
$^{15}N_2/O_2$	600911	$^{15}N_2$(98%)/O_2(RG) gas mix ratio 39:1	Minimum 98 atom % ^{15}N	
$^{18}O_2$	602892	Oxygen-$^{18}O_2$ (Gas)	Minimum 99 atom % ^{18}O	36
$H_2{}^{18}O$	329878	Water-^{18}O	Minimum 97 atom % ^{18}O	20.02

Literature of Interest

1. Welch, M. J. et al. Assessment of myocardial metabolism in diabetic rats using small-animal PET: a feasibility study. *J. Nucl. Med.* **2006**, *47(4),* 689.
2. Welch, M. J., et al. Production of nonstandard PET radionuclides and the application of radiopharmaceuticals labeled with these nuclides. *Ernst Schering Res Found Workshop,* **2007**, *62,* 159. Review.
3. Karantanis, D. et al. Contribution of F-18 FDG PET-CT in the detection of systemic spread of primary central nervous system lymphoma. *Clin. Nucl. Med.,* **2007**, *32(4),* 271.
4. Vansteenkiste, J. F.; Stroobants, S. S. PET scan in lung cancer: current recommendations and innovation. *J. Thorac. Oncol.,* **2006**, *1(1),* 71. Review.
5. Kubota, K.; Yukihiro, M.; Ito, K. Perspective for imaging of tumor metabolism. *Nippon Rinsho.,* **2007**, *65(2),* 352. Review. Japanese.
6. Landau, B. R., et al. 6-Fluoro-6-deoxy-D-glucose as a Tracer of Glucose Transport. *Am. J. Physiol. Endocrinol. Metab.,* **2007**, 3.
7. Cherry, S. R. Fundamentals of positron emission tomography and applications in preclinical drug development. *J. Clin. Pharmacol.,* **2001**, *41(5),* 482. Review.
8. Johannsen, B. The usefulness of radiotracers to make the body biochemically transparent. *Amino Acids.,* **2005**, *29(4),* 307. Review.

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