^{17}O-Oxygen

$^{17}O_2$

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Chemical name:	^{17}O-Oxygen	
Abbreviated name:	$^{17}O_2$	
Synonym:		
Agent category:	Compound	
Target:	Oxygen metabolism	
Target category:	Non-targeted	
Method of detection:	Magnetic resonance imaging (MRI)	
Source of signal:	^{17}O	
Activation:	No	
Studies:	• *In vitro* • Rodents • Non-primate non-rodent mammals • Humans	Structure not available in PubChem.

Background

[PubMed]

Magnetic resonance imaging (MRI) maps information about tissues spatially and functionally. Protons (hydrogen nuclei) are widely used to create images because of their abundance in water molecules, which comprise >80% of most soft tissues. The contrast of proton MRI images depends mainly on the density of nuclear proton spins, the relaxation times of the nuclear magnetization (T1, longitudinal; T2, transverse), the magnetic environment of the tissues, and the blood flow to the tissues. However, insufficient contrast between normal and diseased tissues requires the use of contrast agents. Most

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contrast agents affect the T1 and T2 relaxation of the surrounding nuclei, mainly the protons of water. T2* is the spin–spin relaxation time composed of variations from molecular interactions and intrinsic magnetic heterogeneities of tissues in the magnetic field (1). Cross-linked iron oxide (CLIO) and other iron oxide formulations affect T2 primarily and lead to a decreased signal. On the other hand, paramagnetic T1 agents, such as gadolinium (Gd^{3+}) and manganese (Mn^{2+}), accelerate T1 relaxation and lead to brighter contrast images.

The human brain (5% of total body weight) accounts for ~20% of total body oxygen consumption (2). Oxygen is consumed to produce water *via* oxidative phosphorylation and reoxidation of reduced molecules in the mitochondria. The cerebral rate of oxygen consumption ($CMRO_2$) and the cerebral blood flow (CBF) are sensitive and quantitative indicators of the health of the brain. Reduced cerebral perfusion and oxygen consumption have been observed in neurodegenerative and cerebrovascular diseases. $CMRO_2$ has been imaged using ^{15}O positron emission tomography (PET) to monitor the $H_2{}^{15}O$ concentration in the brain during inhalation of $^{15}O_2$ (3, 4). However, ^{15}O PET is not popular because of the short half-life (~2 min) of ^{15}O, on-site generation of $^{15}O_2$, and high background noise ($^{15}O_2$ bound to hemoglobin *versus* $H_2{}^{15}O$). $CMRO_2$ has also been measured with ^{17}O nuclear magnetic resonance (NMR) spectroscopy and MRI after inhalation of $^{17}O_2$, which is converted to $H_2{}^{17}O$ (5, 6). ^{17}O cannot be detected because molecular $^{17}O_2$ is dissolved in the blood or is bound to hemoglobin as $^{17}O_2$. ^{17}O is detectable as in $H_2{}^{17}O$. ^{17}O decreases the proton T2 relaxation time of water as the direct method of NMR/MRI measurement. The other method is indirect MRI measurement based on the enhancement of T1p relaxation of protons in water by ^{17}O. $CMRO_2$ and CBF can be measured with ^{17}O NMR spectroscopy and MRI after inhalation of $^{17}O_2$. CBF can be measured with ^{17}O NMR spectroscopy and MRI after injection of $H_2{}^{17}O$.

Related Resource Links:

- Clinical trials (^{15}O-water)
- ^{15}O-water information in FDA

Synthesis

[PubMed]

$^{17}O_2$ and $H_2{}^{17}O$ are available commercially. No details of their synthesis were reported.

In Vitro Studies: Testing in Cells and Tissues

[PubMed]

Zhu et al. (6) performed NMR measurement of T1 and T2 relaxation times of $H_2{}^{17}O$ in saline solution at 4.7 T. The T1 and T2 values were 6.59 and 4.28 ms, respectively. The T1 and T2 values at 9.4 T were similar to those at 4.7 T.

Animal Studies

Rodents

[PubMed]

Zhu et al. (7) performed NMR spectroscopy for fast imaging of $CMRO_2$ in rat brain at 9.4 T during a short inhalation of $^{17}O_2$. The $CMRO_2$ and CBF values (n = 7) were found to be 2.19 ± 0.14 μmol/g/min and 0.53 ± 0.07 ml/g/min, respectively.

Tailor et al. (5) introduced $^{17}O_2$ to rats using a closed respiration circuit delivery system. ^1H T1p-weighted MRI was performed as indirect ^{17}O imaging at 4 T. The $CMRO_2$ value (n = 4) was estimated to be 2.10 ± 0.44 μmol/g/min.

Fiat et al. (8) estimated the $CMRO_2$ value (n = 5) to be 2.09 ± 0.35 μmol/g/min with ^{17}O NMR spectroscopy and imaging (7 T) during $^{17}O_2$ inhalation in rats.

Other Non-Primate Mammals

[PubMed]

Fiat et al. (8) estimated the $CMRO_2$ value (n = 5) to be 1.18 ± 0.58 μmol/g/min with ^{17}O NMR spectroscopy and imaging (4.7 T) during $^{17}O_2$ inhalation in cats. The CBF value was estimated to be 0.38 ± 0.12 ml/g/min.

Pekar et al. (9) estimated the $CMRO_2$ value (n = 7) to be 1.5 ± 0.05 μmol/g/min using ^1H MRI measurement (4.7 T) during $^{17}O_2$ inhalation in cats. The CBF value was estimated to be 0.38 ± 0.15 ml/g/min.

Non-Human Primates

[PubMed]

No publication is currently available.

Human Studies

[PubMed]

Fiat et al. (10) performed ^{17}O MRI mapping of one human brain at 1.5 T during $^{17}O_2$ inhalation. The $CMRO_2$ and CBF values were estimated to be ~1.4 μmol/g/min and ~0.6 ml/g/min, respectively.

Atkinson et al. (11) performed ^{17}O MRI mapping of one human brain at 9.4 T during $^{17}O_2$ inhalation. The $CMRO_2$ values for the gray and white matter were estimated to be 1.42 ± 0.05 μmol/g/min and 0.75 ± 0.11 μmol/g/min, respectively. The $CMRO_2$ value for the whole brain was found to be 1.18 μmol/g/min. These $CMRO_2$ values are in agreement with 15O-PET published values (3, 4).

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