Au_3Cu_1 Nanoparticles

Au_3Cu_1-NPs

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Created: June 26, 2008; Updated: August 18, 2008.

Chemical name:	Au_3Cu_1 Nanoparticles	
Abbreviated name:	Au_3Cu_1-NPs	
Synonym:		
Agent Category:	Metal	
Target:	Non-targeted	
Target Category:	Blood-pool retention	
Method of detection:	MRI	
Source of signal\contrast:	Cu	
Activation:	No	
Studies:	• *In vitro* • Rodents	No structure is available in PubChem.

Background

[PubMed]

Magnetic resonance imaging (MRI) maps information about tissues spatially and functionally. Protons (hydrogen nuclei) are widely used in MRI because of their abundance in water molecules. Water comprises ~80% of most soft tissue. The contrast of proton MRI depends largely on the density of the nucleus (proton spins), the relaxation times of the nuclear magnetization (T_1, longitudinal, and T_2, transverse), the magnetic environment of the tissues, and the blood flow to the tissues. Insufficient contrast between normal and diseased tissues requires the development of contrast agents. Most contrast agents affect the T_1 and T_2 relaxation times of the surrounding nuclei, mainly the protons of water. T_2^* is the spin–spin relaxation time composed of variations from molecular interactions and intrinsic magnetic heterogeneities of tissues in the magnetic field (1).

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NLM Citation: Leung K. Au_3Cu_1 Nanoparticles. 2008 Jun 26 [Updated 2008 Aug 18]. In: Molecular Imaging and Contrast Agent Database (MICAD) [Internet]. Bethesda (MD): National Center for Biotechnology Information (US); 2004-2013.

Cross-linked iron oxide nanoparticles and other iron oxide formulations primarily affect T_2 and lead to decreased signals. On the other hand, paramagnetic T_1 agents such as gadolinium (Gd^{3+}) and manganese (Mn^{2+}) accelerate T_1 relaxation and lead to brighter contrast images (2).

Gold nanoparticles have been used as X-ray and optical contrast agents in small animals with little toxicity (3). Su et al. (4) have developed hollow Au_3Cu_1 nanoparticles (nanoshells and nanocapsules) as bimetallic MRI contrast agents with enhancing effects in T_1- and T_2-weighted imaging. A Cu^{3+} ion has an electron configuration of d^8 with two unpaired electrons and less magnetic moment than Gd^{3+}, with seven unpaired electrons; however, hollow Au_3Cu_1 nanoparticles are made of large numbers of paramagnetic Cu^{3+} ions to provide a superparamagnetic effect. The large surface area of the porous nanoparticles also provides an effective interaction of Cu^{3+} ions with water molecules.

Synthesis

[PubMed]

Su et al. (4) produced Au_3Cu_1 nanoparticles by adding 1×10^{-6} mol $HAuCl_4$ (dehydrated) to a Cu-colloidal solution, which was prepared with laser irradiation of CuO in 2-propanol. The mixture was sonicated for 10 min to form hollow Au_3Cu_1 nanoshells. The Au_3Cu_1 nanoshells were coated with polyelectrolyte polyethylenimine (PEI) and poly(acrylic acid) (PAA) polymers to form Au_3Cu_1 nanocapsules. The nanoshell cores were 48.9 ± 19.1 nm in diameter, and the shells were 5.8 ± 1.8 nm thick as determined with transmission electron microscopy. The pores were 1–2 nm in diameter. The nanocapsule shells were 6.1 ± 1.2 nm thick. The number of copper atoms/nanoparticle was estimated to be 4.98×10^5.

In Vitro Studies: Testing in Cells and Tissues

[PubMed]

For *in vitro* MR images as well as both T_1 and T_2 measurements at 3 T, all nanoshells and nanocapsules were dispersed in 5% agarose gel at various concentrations (0.125, 0.25, 1.25, 2.5, and 5 mg/ml) (4). Adding Au_3Cu_1 nanocapsules to the agarose gel brightened the T_1 image and enhanced the T_1^{-1} (longitudinal relaxation rate) of water protons. The T_1-weighted MR signal intensity increased up to ~89% as the Au_3Cu_1 nanocapsule concentrations increased from 0 to 5.00 mg/mL; however, use of Au_3Cu_1 nanoshells resulted in only ~26% increase in T_1 image intensity. Interestingly, both nanoparticles enhanced T_2-weighted image intensity by 8% to 11% at 0.125 mg/ml and decreased by 6% and 76% at 5 mg/ml for nanoshells and nanocapsules, respectively. The proton r_1 relaxivities were as large as 3.0×10^4 $mM^{-1}s^{-1}$ (Au_3Cu_1 nanocapsules) and 2.3×10^4 $mM^{-1}s^{-1}$ (Au_3Cu_1 nanoshells). The proton r_2 relaxivities were 2.39×10^5 $mM^{-1}s^{-1}$ for Au_3Cu_1 nanocapsules and 1.82×10^6 $mM^{-1}s^{-1}$ for Au_3Cu_1 nanoshells. Both exhibited little cytotoxicity to monkey kidney epithelial Vero cells in culture at concentrations of 0.1–10,000 ng/ml at 37°C up to 24 h.

Animal Studies

Rodents

[PubMed]

Su et al. (4) studied the long-term toxicological effects in normal mice (n = 6 mice/group) at 30 days after intravenous injection of 2, 20, and 40 mg/kg Au_3Cu_1 nanocapsules with viability rates of 100%, 83%, and 67%, respectively. Most of the Au and Cu were found in the urine at 3 h after injection. MRI studies (T_1- and T_2-weighted imaging at 3 T) were performed in normal mice after injection of 20 mg/kg Au_3Cu_1 nanocapsules. Both images were enhanced in the heart and major vessels at 2 h after injection. Images of the blood vessels in the liver were also enhanced. The calculated blood concentration is ~0.25mg/ml after injection of 20 mg/kg. Au_3Cu_1 nanocapsules may be a tool as positive contrast agent for use in MR angiography.

Other Non-Primate Mammals

[PubMed]

No publication is currently available.

Non-Human Primates

[PubMed]

No publication is currently available.

Human Studies

[PubMed]

No publication is currently available.

References

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