Purpose:

Our recently proposed thermo-brachytherapy seed offers a convenient approach to radiation sensitization with heat in treatment of solid tumors through concurrent administration of hyperthermia and brachytherapy. The seed consists of a titanium capsule, containing radioactive I-125 and a ferromagnetic core, serving as a source of self-regulating hyperthermia when placed in an alternating electromagnetic field. We present an experimental study of the magnetic properties of ferromagnetic Ni-Cu alloy, and develop a protocol for obtaining the material capable of the maximum heat generation. Based on the practically achievable temperature interval we evaluate the effect of thermal expansion on the seed components during the hyperthermia treatment.

Methods:

Alloy samples of Ni1-xCux (0.28≤x≤0.3) were prepared by arc melting method in argon atmosphere. The ingots were annealed in vacuum at 1000°C for 12 hours. These samples were cut into pieces and used for magnetization measurements with SQUID magnetometer. The thermal expansion along greatest dimension of each component of the purposed seed was estimated for temperature increase from 37 to 60 °C.

Results:

The annealed samples show sharp Curie transition at temperature TC~50°C, varying with the alloy concentration. However, the un-annealed sample does not show the clear transition, thus indicating a strong influence of thermal treatments on the magnetic properties of the Ni-Cu alloy. The annealing favors atomic diffusion, and leads a sample homogenization, minimizing composition fluctuations and maximizing the heat generation. The effect of the temperature rise on the thermal expansion of each component of the seed was found to be negligible.

Conclusions:

We have established the thermal annealing protocol resulting in the maximum heat generation from the Ni-Cu alloy core. The negligible change in dimensions of the seed components due to heating assures the safety of the implementation of thermo-brachytherapy seed for hyperthermia treatments.

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