MOSSBAUER SPECTROSCOPY OF IRON DEPOSITS IN THALASSEMIC HEART TISSUE

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ABSTRACT

Thalassemia [1] is a genetic hemoglobin disorder resulting in a hemolytic anemia. An excess of iron found in the bloodstream is eventually deposited in the tissue of different organs, especially the heart. The iron deposits in the cardiac walls result in the enlargement of the heart and eventual congestive heart failure. An identification of the iron deposits is of significance because of the possibility of introducing iron chelating agents to bind iron and remove it from the tissue. We have used Mössbauer spectroscopy of 57Fe to compare thalassemic heart tissue, (I), with normal heart tissue, (II), as well as with horse spleen ferritin. A large absorption observed in (I) but not in (II) shows that we are observing iron deposited by the disease. At 77 K, the isomer shift $\delta = 0.45$ mm/sec and quadrupole splitting $\Delta E_Q = 0.70$ mm/sec, almost identical with ferritin. At 4.2 K, magnetic hyperfine splitting is observed with the outer lines separated by $\sim 15.60$ mm/sec corresponding to an effective magnetic field at the nucleus $H_{eff} \sim 485$ kOe. As T increases from 4.2 K to 77 K the magnetic hyperfine lines decrease in intensity and the central quadrupole doublet grows in intensity. This identifies the iron deposits to be small, superparamagnetic particles of ferritin [2] or hemosiderin, two closely related iron storage proteins containing an iron core of (FeOOH)$_3$(FeO·OPO$_3$H$_2$). The superparamagnetic [3] relaxation time of magnetically ordered fine particles is given by $\tau = \tau_0 \exp(2K/Vk_BT)$ where $\tau_0$ is a constant characteristic of the material, $K$ is the magnetic anisotropy constant and $V$ is the volume of the particle. The condition for observation of hyperfine structure in the Mössbauer spectra is that $\tau > \tau_L$, where $\tau_L$ is the Larmor precision time of the nuclear magnetic moment of 57Fe about the effective magnetic field at the nucleus due to the aligned electronic spin. Analysis of the temperature dependence of the Mössbauer spectra yields the particle volume distribution. We find the particle diameters to range from $\sim 60 \AA$ to $\sim 90 \AA$.

REFERENCES

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