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EFFECT OF GAMMA IRRADIATION ON THE MAGNETIC PROPERTIES OF Fe-XYLENOL ORANGE*

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The effect of gamma irradiation on the magnetic properties of powdered Fe-3,3-bis[bis(carboxyethyl)aminoethyl] cresolsulfonephtrane complex has been investigated. It has been shown that the irradiation leads to a decrease of the values of saturation magnetization as well to decrease of the mean value of magnetic moment of superparamagnetic particles.

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1 Introduction

Even though a considerable volume of information has been accumulated concerning the magnetic properties of organometallic molecular ferromagnets [1, 2, 3, 4], there is much that is still not understood. A little is known about mechanisms involved or about the nature of any irradiation induced inhomogeneities and defects generated by the irradiation in these materials . In our paper the investigations of basic magnetic properties of Fe-3,3-bis[bis(carboxyethyl)aminoethyl] cresolsulfonephtrane complex (FeXYO) in unirradiated state and after high energy gamma irradiation are presented.

2 Experimental procedure

The powders of Fe - 3,3-bis[bis(carboxyethyl)aminoethyl] cresolsulfonephtrane were prepared by dissolving of appropriate amounts of the ingredients in a water ethanol solution. The powdered samples were placed in a thin walled copper container and slightly pressed down. The magnetic measurements were carried out with a vibrating sample magnetometer in the temperature range 4.2 - 300 K in magnetic fields up to 6 T. The zero field cooled (ZFC) and field cooled (FC) measuring processes were recorded at low field (10mT) in determined temperature range. The irradiation was performed at normal atmospheric conditions with the samples placed in a reproducible position using a 1,3 μGy /s ^{60} Co γ - source .

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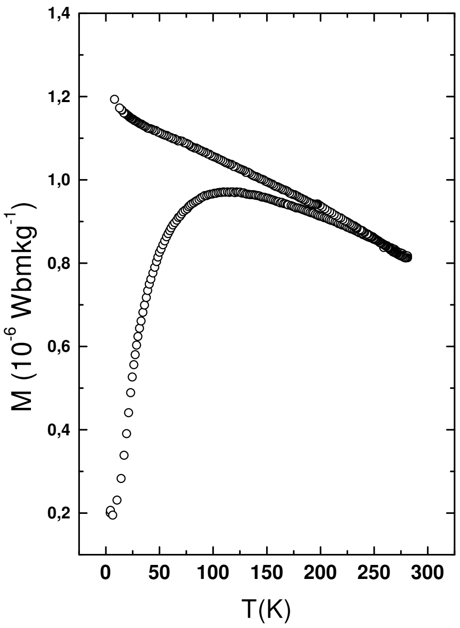

Fig.1.Thermomagnetic curve of unirradiated FeXYO at 10mT

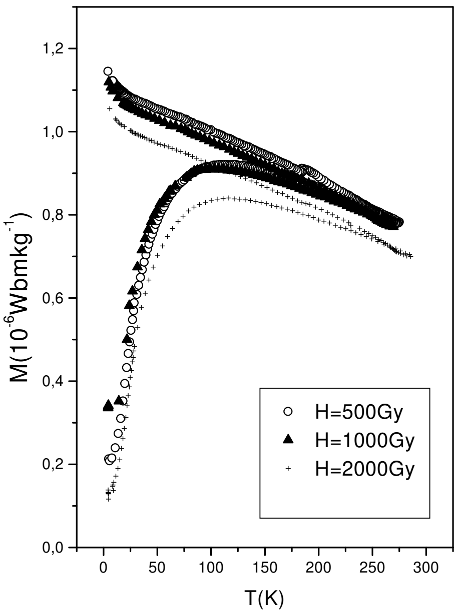

Fig.2.Thermomagnetic curves of FeXYO complex irradiated by 500, 1000, and 2000 Gy, H=10mT

3 Experimental results and discussion

The temperature dependence of magnetization of the FeXYO complex is shown in Fig.1. The observed ZFC and FC thermomagnetic curves display the typical features of a small particle system [5]. The maximum of the ZFC magnetization at $T = T_M$ marks the transition from stable (Stoner - Wohlfarth) single domain particles to superparamagnetic ones. The ZFC curve deviates from the FC magnetization at a temperature T_f = 205 K and shows a very broad maximum at T_M = 102 K. The ZFC magnetization decreases strongly below T_M since the superparamagnetic/ferromagnetic transition activates the anizotropy that forces the particle magnetization along the easy axes , which are randomly oriented. The FC magnetization is a nearly equilibrium state in which below T_M almost all particles have only a positive magnetization projection along the magnetic field direction. The influence of γ-irradiation on the temperature dependence of magnetization of FeXYO samples is demonstrated in Fig.2. It can be seen that the irradiation leads to decrease of magnetization values in whole temperature range except the ZFC curves in low temperature region. In this case at about 8 K minimum in ZFC curves occurs . Although exact interaction mechanisms of γ- radiation with organometallic FeXYO molecule is not well-known, we can suppose that the high energy γ-radiation destroys intramolecular bonds in FeXYO-complex which leads to a decrease of the exchange interaction between magnetic ions. Due to this mechanism a part of smallest particles becomes paramagnetic and consequently total magnetization decreases. The magnetization curves at 4.2 K of FeXYO complex for different irradiation doses is shown in Fig.3. In accordance with $M(T)$ investigations, the decrease of the magnetization after irradiation has been observed too. It is evident that the registered curves display the typi-

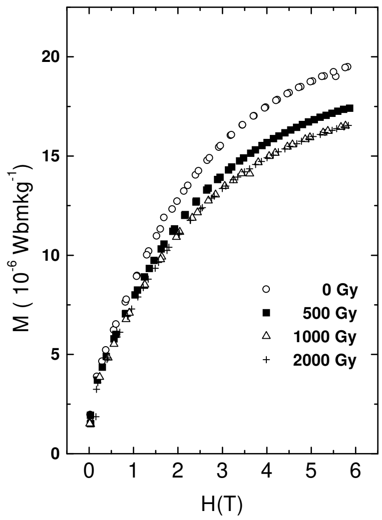

Fig.3. Magnetization curves of FeXYO irradiated by γ radiation

cal features of a superparamagnetic system. We have therefore suggested to describe our curves by the modified Langevin function $M(x) = M_s[coth(x) - 1/x]$ where M_s is the saturation magnetization and $x = mH/k_BT$, where m is magnetic moment associated with the superparamagnetic particle. As a result of fitting our experimental data by Langevin function (M_s data were obtained from the M vs $1/H$ plots) we have got that after irradiation the mean value of the magnetic moment of superparamagnetic particles decreases from $3.25\mu_B$ down to 2.95 μ_B. Similarly decreases the initial susceptibility χ_i. However, moderate discrepancy between the experimental curves and the theoretical ones persists in the low field region. This discrepancy can be ascribed to the presence of large particles, because magnetization of particles with $V \rangle V_s$ (V_s is the critical volume for superparamagnetism) is simply the virgin curve $M = M(H)$ with the strong increase in the low field region . Such discrepancy is more evident in the case of magnetization curves for unirradiated samples registered at higher temperatures.

4 Conclusion

In the view of obtained results one can say that investigated powder FeXYO samples behave superparamagnetically at room temperature. They change into the stable magnetic single domain state at lower temperatures. The γ- irradiation has no influence on the shape of magnetization curve but it influences the magnitude of the saturation magnetization M.

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