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Radiation Stability of the BSA Modified Biocompatible Magnetic Fluid

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The aim of the presented work was to investigate the stability of biocompatible magnetic fluid, i.e. water-based magnetic fluid containing magnetite nanoparticles stabilized by surfactant sodium oleate and modified by bovine serum albumin (BSA) after electron irradiation. Samples with the same concentration of Fe_3O_4 but different mass ratio BSA/Fe_3O_4 (w/w= 0.25, 1.0 and 2.5) were studied. The electron irradiation caused about 10% reduction of the saturation magnetization in the samples with w/w BSA/Fe_3O_4 ratio of 0.25 and less than 5% in the samples with w/w BSA/Fe_3O_4 ratio of 1 and 2.5.

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1. Introduction

Magnetic fluids are widely used for medical applications. In order to choose magnetic fluids for a specific application, a comprehensive characterization is needed. Coating can improve oxidation resistance, mechanical stability, and biocompatibility. The preferential killing of cancer cells without damaging normal cells has been a desired goal in cancer therapy for many years. Magnetic fluids hyperthermia is one of the promising approaches in cancer therapy. In work [1] it was shown that the combined thermotherapy and radiation with 20 Gy was as effective as the radiation at three times higher dose. From this point of view it is important to study the influence of the irradiation on physical properties and colloidal stability of magnetic fluids for bioapplications. In our previous works [2, 3] we have investigated the radiation stability of water-based magnetic fluids with magnetic particles coated with natrium oleate and the same magnetic fluid modified with polyethylene glycol (PEG) of various molar weight and molar ratio of Fe_3O_4 and PEG. In this work we investigate the stability of water-based magnetic fluid containing magnetite nanoparticles stabilized by sodium oleate and modified by bovine serum albumin (BSA) after electron irradiation.

2. Experiment

The details of the preparation of magnetic fluid with defined w/w BSA/Fe_3O_4 ratios, as well as characterization of prepared samples were described by Siposova et al. [4].

The irradiation of samples was conducted by electrons of Strontium-Yttrium beta source setup. The beta setup consists of 16 Strontium sources packed in a disk cassette of 35 cm diameter. The source radiates continuous electron spectrum 0–2.27 MeV with average energy 0.6 MeV and density of the electrons $\Phi = 0.98 \times 10^7$ electrons/(cm^2·s). The samples in a polyethylene container were exposed at the distance of 20 cm in front of the source. The magnetization curves, infrared spectra, X-ray measurements and zeta potential were measured by SQUID magnetometer (Quantum Design MPMS 5XL), FTIR spectrometer FTLA2000 instrument (ABB, resolution 4 cm^{-1}) by Attenuated Total Reflectance measurements with diamond window, X-ray Bruker D8 Advance diffractometer, working with the Cu K_α radiation and by the dynamic light scattering measurements using a Zetasizer Nano ZS by Malvern Instruments, respectively.

3. Results and discussion

BSA has a good biocompatibility and no cytotoxicity, and is similar to human serum albumin (HSA) [5]. The properties of BSA-modified magnetic fluids (MF BSA) were determined by different methods [4] and it was shown, that they are colloidal stable for the w/w BSA/Fe_3O_4ratios up to 1.1. Therefore for the study of the radiation stability of MF BSA, two colloidal stable samples with the w/w BSA/Fe_3O_4 ratio of 0.25 and 1 and one sample with moderate stability with the w/w BSA/Fe_3O_4 ratio of 2.5 were chosen. The prepared samples were irradiated with different doses 1 Gy, 2 Gy, 4 Gy, 8 Gy, 16 Gy, 32 Gy, 100 Gy, 256 Gy, 512 Gy and 1024 Gy, respectively.

Figure 1 shows the dependences of relative saturated magnetization of the samples on the applied dose. The results show about 10% reduction of the saturated magnetization due to irradiation for the sample with the w/w BSA/Fe_3O_4 ratio of 0.25, while in the case the sample with the w/w BSA/Fe_3O_4 ratio of 1 and 2.5 only a slight

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reduction of saturated magnetization (less than 5%) is observed. The results suggest that with increasing w/w BSA/Fe_3O_4 ratio the samples are more stable against the irradiation. However, the results obtained from measurements of hydrodynamic diameter are in the contradiction.

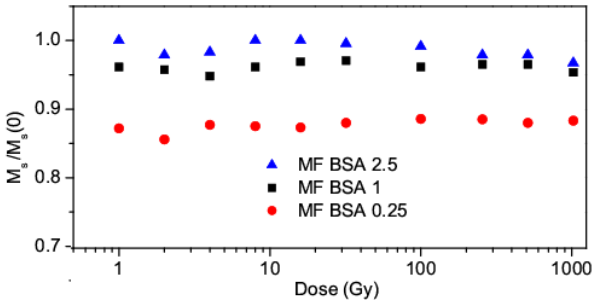

Fig. 1. Dependence of $M_s/M_s(0)$ on irradiation doses of MF BSA.

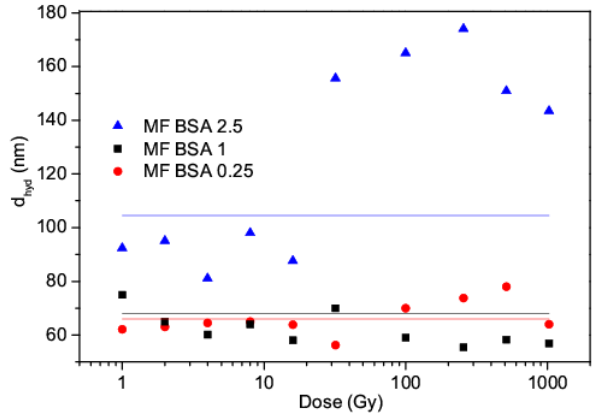

Fig. 2. Hydrodynamic diameter of the modified magnetic particles as a function of dose. The lines represent hydrodynamic diameter before irradiation.

Figure 2 shows that the highest changes in hydrodynamic diameter after irradiation are observed in the sample with the w/w BSA/Fe_3O_4 ratio 2.5. These results suggest that the increase of hydrodynamic diameter is caused mainly by degradation of BSA. With the aim to confirm this suggestion, the infrared spectra of all samples after irradiation were measured. For the samples with w/w BSA/Fe_3O_4 ratio of 0.25 and 1 no changes in infrared spectra are observed, but in the case of the sample with w/w BSA/Fe_3O_4 ratio of 2.5, the significant change is observed in the region 2840 cm^{-1} – 3000 cm^{-1}, which corresponds to C–H vibrations in sodium oleate and BSA, as well as at 1244 cm^{-1}, which corresponds to (C–N)+(N–H) vibration in BSA (Fig. 3). The X-ray diffraction data confirmed that magnetic particles were not affected by irradiation.

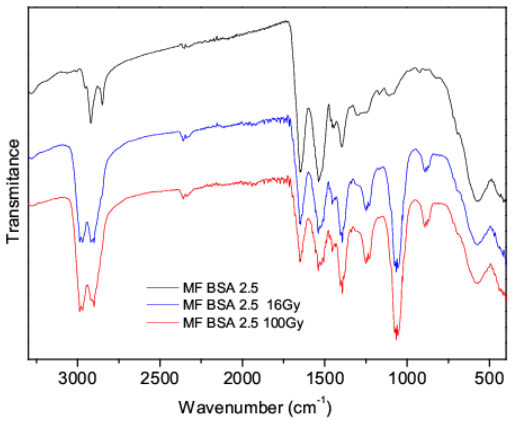

Fig. 3. Infrared spectra of MF BSA with w/w BSA/Fe_3O_4 ratio 2.5 before and after irradiation (spectra are shifted vertically for clarity).

4. Conclusions

The obtained results suggest that irradiation with small doses causes release of BSA and this process leads to the reduction of hydrodynamic diameter. The irradiation with doses higher than 16 Gy causes conformational and structural changes in released BSA and consequently to the creation of BSA aggregates in sample with high concentration of BSA.

Acknowledgments

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