Multitasking Iron Oxide Magnetic Nanoclusters for Diagnosis and Medical Treatment

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Today's patient treatment may necessitate designing advanced material platforms that could be utilized simultaneously for diagnosis and therapy Such a kind of "theranostic" agent should be simple and cost-efficient to synthesize On the other hand detailed characterisation of its physical and chemical properties, as well as its biocompatibility is essential

Working along this challenge, we have succeeded in developing a size-controllable and water-dispersible assembly of maghemite nanocrystals (NCs) that exhibits good colloidal stability without further surface functionalization These variable size Colloidal Nanoclusters (CNCs) (Fig 1a) have been characterized by SQUID magnetometry, Mössbauer spectroscopy and Transmission Electron Microscopy (Fig 1b) The experiments and Monte Carlo simulations point to the CNCs' weak ferrimagnetic response Our analysis reveals a behaviour that is the outcome of intra-cluster features that include dipolar interactions among the composing particles, as well as intra-particle exchange interactions [1] The comprehensive knowledge of the microscopic mechanisms involved warrants further exploitation of this system

In this respect, the potentiality of the CNCs is demonstrated by our relaxometric studies which show that these nano-platforms have a clear advantage against superparamagnetic (SPM) contrast agents, like Endorem®, as there is a significant enhancement of 4-times of their transverse ^{1}H-NMR relaxivity (r_2; Fig 1c) [2] Additionally, the CNCs' thermal response (Specific Loss Power; Fig 1b inset) in hyperthermia is compared against that of individual SPM NCs Our findings point how the CNCs ferrimagnetic nature and the corresponding intra-cluster interactions provide good ingredients for a high heating response Importantly, preliminary incubation experiments of the nanoclusters with mice spleen cells point to their low cytotoxicity and biocompatibility (Fig 1d) The tailored physical properties and the one-step synthesis render the CNCs a multifunctional material, which is likely to serve as a theranostic agent in biomedicine

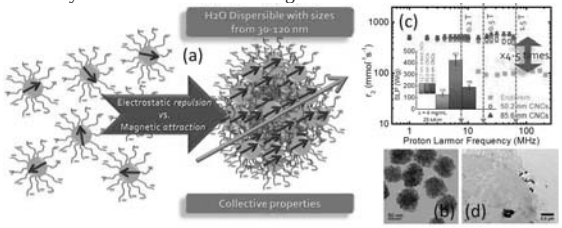

FIG 1 (a) Schematic of the CNCs formation (b)TEM image (c) r_2 and SLP (inset) values for CNCs (d) TEM from incubation of CNCs with mice spleen cells

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Dextran-ferrite Magnetic Nanoparticles Contrast-enhanced MRI and Combined Magneto-thermochemotherapy Cancer Treatment

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The early detection of proliferation, infiltration and metastases by MRI monitoring (MRM) is an important problem of oncology. We synthesized and tested dextran-ferrite sol (DFS) for contrast-enhanced MRI for the early detection of proliferation, infiltration and metastases. Dacarbazine (DC), Melphalan (MP) and and Docetaxsel (DT) containing Dextran-ferrite DFS was tested - for combined magneto-thermochemotherapy (CMTC) with slime aspiration to improve cancer treatment. Investigation of melanoma B 16 proliferation by BIOSPEC BC 70/30 (Bruker) was showed: weak signals of protons from small sites of pathogenic cells are neutralized by intensive signals from normal tissues. Ferrite nanoparticles can be used as MR-negative contrast agents[1]. Contrast enhanced MRI proliferation is represented in Fig. 1. Hypodermic and skin tumors were treated with the magnetically convenient drugs. Increase of drug concentration in tumor tissues due to the magnetic field was achieved by use of NdFeB bandages (induction 0.2-0.3 Tl)[2]. Quantification of magnetic nanoparticles in mice bodies was carried out by electron-sensor monitoring device based on non-linear magnetization of nanoparticles[3]. At first 60 female mice with melanoma B16 underwent non-enhanced MR imaging with T_2-weighted sequences. Then 0.2 ml 2.5% DFS (hydrodynamic of particles diameter from 30 to 130 nm, dose to 5.0 mg Fe/kg) was injected in mice caudal vein, and after 2-24 hours second MRM and DFS-enhanced T_2-weighted GRE sequences were performed. The DFS (70 mg/kg), DC 0.05 mg; MP 0.02 mg, DT 0.05 mg were injected into multiple tumor sites and concentrated in the tumor tissue with magnetic bandages. Treatment of tumor (~25 mm^3) by AC magnetic field at +48 C for 30 min led to its regression up to 45% and increase of survival up to 275%. The treatment of infiltration and metastases by caudal vein injection Cyclophosphamide and MP led to increase of survival up to160%.

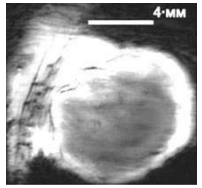

Fig 1 The primary tumor, black stain was formed by the B 16 cells containing DF particles.

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