Characterization of magnetic-modified diamond nanoparticles for targeted drug delivery

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Nanodiamond (ND) bio-applications are developed due to its physical-chemical properties (surface, structure, spectroscopic) and bio-compatibility.
On the other hand, promising bio-applications of magnetic nanoparticles (NP) are also developed.
In this work we characterize magnetic ND which can combine advantages of ND and magnetic NP.

• ND powder was synthesized by laser treatment of specially prepared hydrocarbon targets in liquid media without the use of metals and metal oxides [E. Perevedentseva, D. Peer, V. Uvarov, B. Zousman, O. Levinson, Nanodiamonds of Laser Synthesis for Biomedical Applications, J. Nanoscience & Nanotechnology, 15(2), 1045-1052 (2015)] • ND powder was treated chemically and thermally in medium free of metals by the method proposed by Ray Techniques Ltd • It was found that this specific treatment of ND surface resulted in strong magnetism of diamond nanoparticles (RayND-M).

I. Structure, size, surface properties characterization:

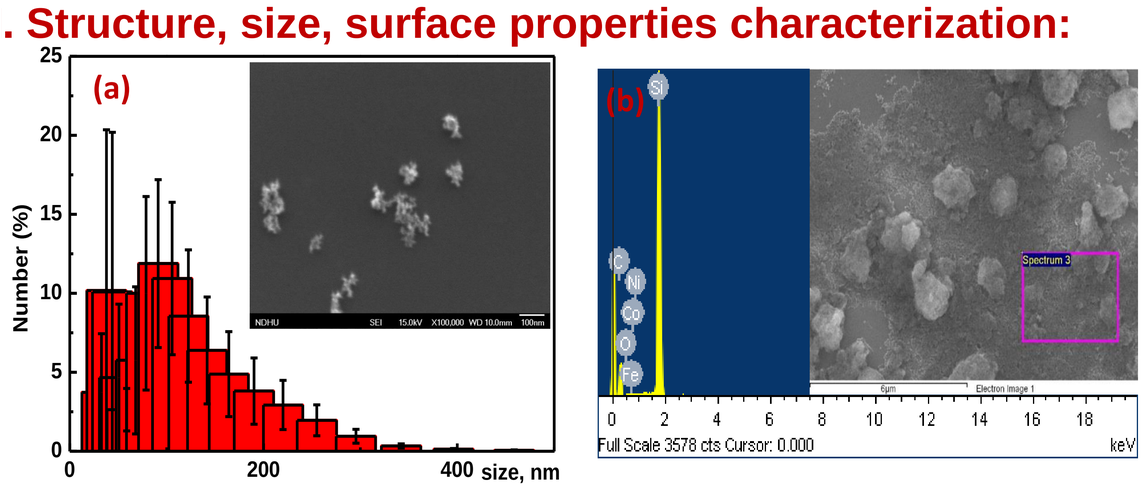

Figure 1. (a) The size distribution of RayND-M particles. Average size is 96 nm. Inset is SEM image. High aggregation of crystallites of size 4-5 nm is observed.The ζ-potential is -28.5 at pH 6.09.
(b) The energy dispersive spectrum (EDS) of RayND-M shows that the magnetic atoms admixtures are negligible: Fe: 0-0.17 weight %, Ni: 0 weight %; Co: 0-0.2 weight %

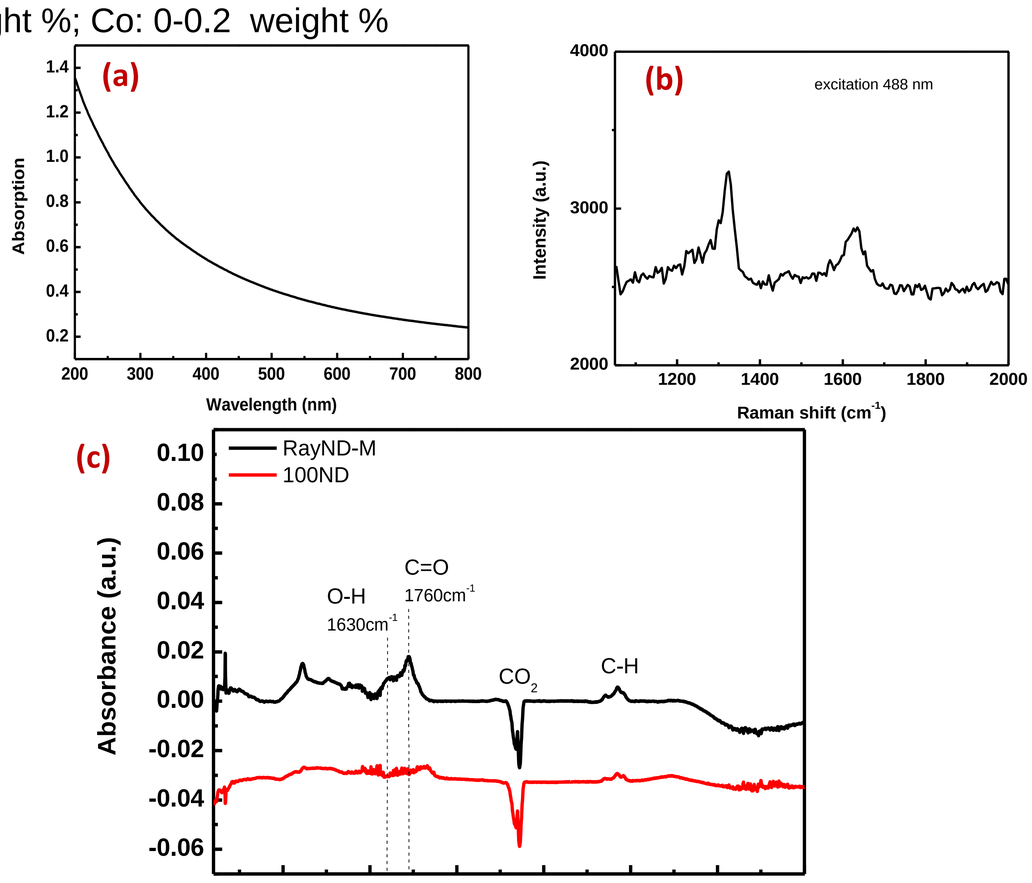

Figure 2. (a) UV-visible spectra; (b) Raman spectra (α-SNOM, WITEC); (c) FTIR spectra of RayND-M.

III. Interaction with living cells

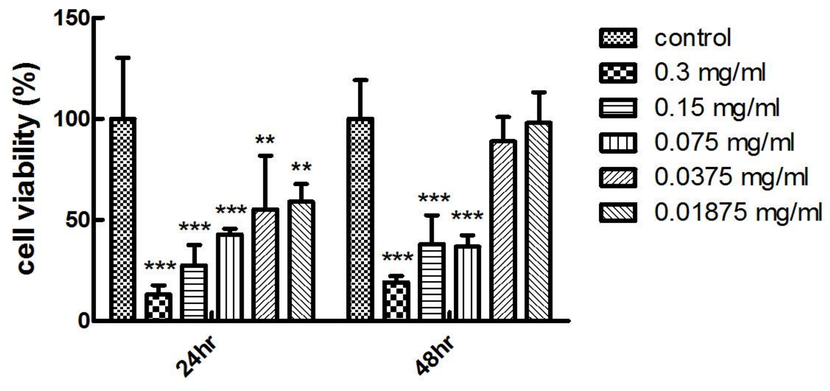

Figure 5. Cytotoxicity of RayND-M at interaction with Baby Hamster Kidney (BHK) living cell (preliminary result) has concentration-dependent character and safe concentration can be selected for application.

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II. Luminescence:

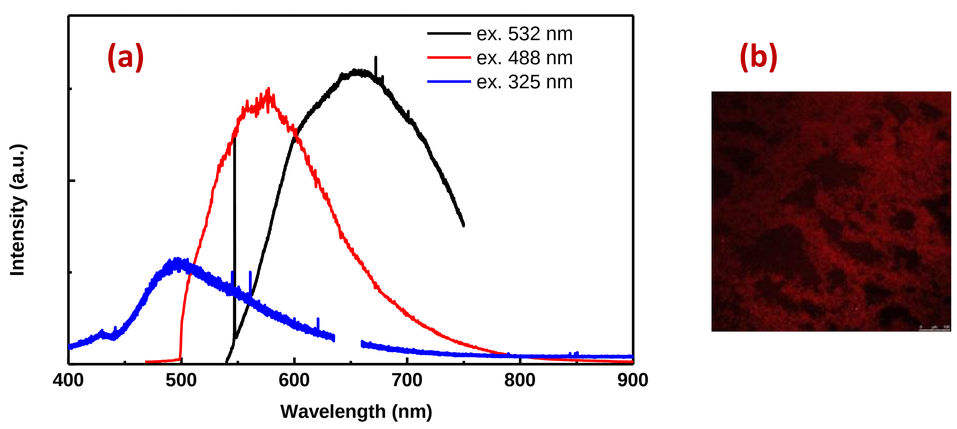

Figure 3. (a) Photoluminescence spectra of RayND-M measured with excitation 532 nm (spectrometer Renishaw), ex. 488 nm (α-SNOM, Witec), and ex. 325 nm (Jobin Yvon - T64000). (b) The confocal microscopic image of RayND-M on glass substrate (water suspension of concentration 2 mg/ml was dropped and dried), ex. 488 nm, detection in range 560-620 nm (TCS-SP5)

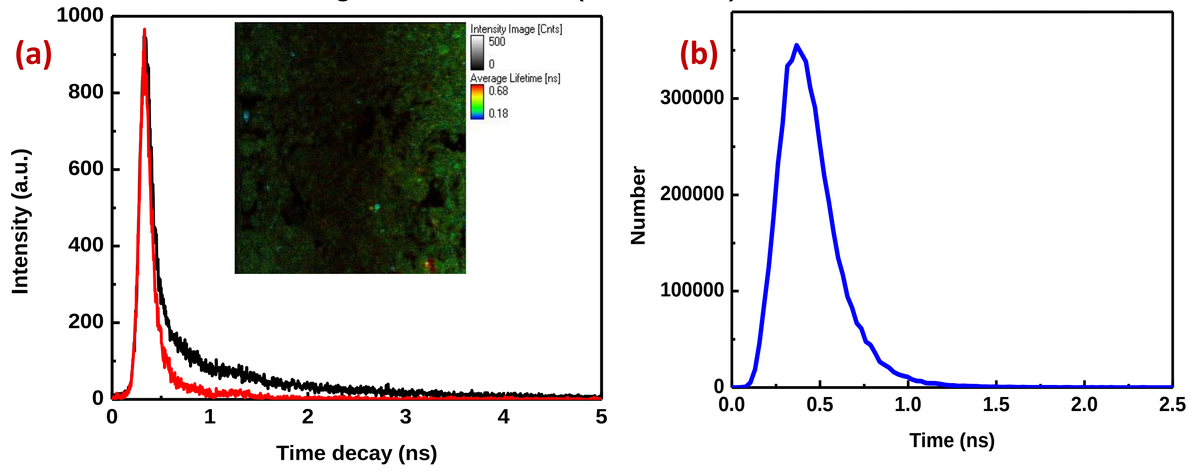

Figure 4. Fluorescence lifetime measurements of RayND-M. 2-photon excitation with femtosecond tunable Ti-Sapphire laser (760 nm, 80 mHz, 150 fs).
(a) Variations of lifetime decay with (inset) fluorescence lifetime imaging of NP deposited on glass substrate; (b) Histogram of lifetimes distribution

IV. Magnetic properties of RayND-M:

Pure diamond structure combines diamagnetic and paramagnetic compounds; in an intermediate graphite–diamond structure spin ordering and magnetic interactions can exist, forming superparamagnetism or/and ferromagnetism Ferromagnetic properties of carbon nanostructures are discussed for five main types of structure: (i) chains of interacting radicals; (ii) carbon structures containing trivalent elements, for example, P, N, and B; (iii) structures composed of sp^2 - and sp^3 -coordinated carbon atoms; (iv) graphite and nanographite; and (v) fullerenes.
[T. L. Makarova Magnetic Properties of Carbon Structures. Semiconductors, 38, 615–638 (2004)]

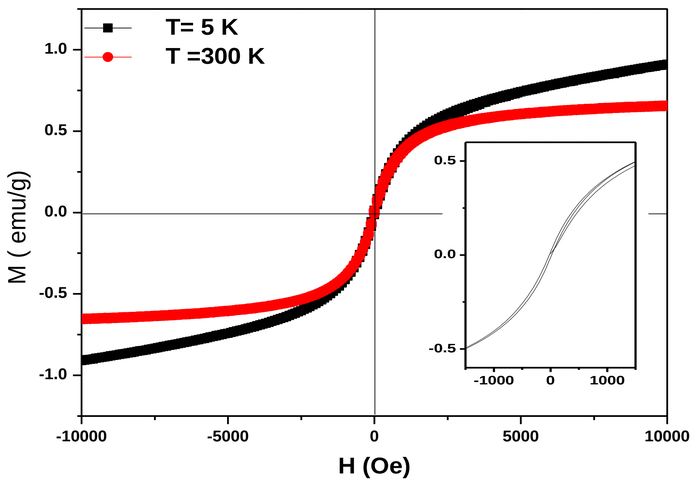

Figure 6. The magnetization curve of RayND-M powder measured with SQUID-VSM vibrating sample magnetometer (Quantum Design, US)

Inset is presented for discussion of presence of hysteresis

Conclusion magnetic nanodiamond RayND-M is promising for number of imaging and targeted delivery bio-applications.

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