EPR imaging study of Nanodiamonds

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Recent advances in nanotechnology have attracted considerable interest for nanodiamonds (NDs) in industrial and research areas thanks to their remarkable intrinsic properties including large specific area, poor cytotoxicity, chemical stability, ease of large-scale production and magnetic and optical properties as a result of relative stability of radical-like centers inside the particle. This feature constitutes a main interest for versatile applications, which makes NDs, a relevant platform against non-stable organic radicals (*e.g.*, sensitive to reduction). Two particle origins were of interest: NDs produced by detonation or by grinding of micro-sized crystals obtained by high pressure-high temperature (HPHT) static synthesis. Overall, NDs show a high concentration of radical-like paramagnetic centers (up to 10^{19} spin/g), which are due to structural defects and carbon dangling bonds) inside the diamond core and on the cluster surface. The observed EPR line shapes were characterized with peak-to-peak resonance width (ΔH_{pp}) from 2.3 to 10 Gauss according to some parameters (*e.g.*, NDs origin, treatment). Their experimental EPR spectrum can be assumed as a sum of two components of single lines with the same g-factor (g = 2.0028) but having different linewidths contributions. Since the resolution in EPR imaging is closely proportional to the EPR resonant linewidth, we studied surface modification (*e.g.*, oxidation) and size exclusion to modify the structure and thus reducing the broad component of the signal. Nanodiamond physicochemical properties were evaluated by different characterization techniques including dynamic light scattering (DLS), transmission electron microscopy (TEM), thermalgravimetric analysis (TGA), Fourier transform-infrared (FT-IR) and X-ray photoelectron spectroscopy (XPS) to determine the nature of the particle surface and to monitor the size exclusion and stability of the suspensions.

Here, we describe the development and design of a nanodiamond strategy (*e.g.*, particle origin, surface oxidation, size exclusion) to demonstrate high spectroscopic and imaging feasibilities using these particles for EPR. To achieve this, mathematical and IT procedures were developed and allowed experimental evidence of the conditions required for optimal phantom images resolution (*R*=0.5 mm, HPHT-sub18).

The ability to perform low frequency EPR (L-band, 1 GHz) resolution imaging in combination with the stable intrinsic properties of nanodiamonds, raises the possibility of performing non-invasive tracking of nanodiamonds.

This project has received funding from European Union’s Horizon 2020 research and innovation program under grant agreement No 863099.

References

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