Fluorescent Nanodiamonds: Fabrication, Properties, and Applications

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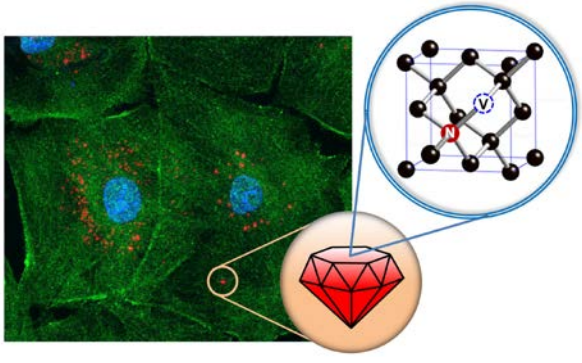
Nanocarbons are a family consisting of fullerenes, carbon nanotubes, graphenes, nanodiamonds, and many other variations. Fluorescent nanodiamonds (FNDs) joined the family in 2005 [1]. The nanomaterial is unique in that it contains a high density ensemble of negatively charged nitrogen-vacancy (NV^-) centers as built-in fluorophores. The centers possess a number of outstanding optical and magnetic properties. Firstly, NV^- has an absorption maximum at ~550 nm and when exposed to green-orange light, it emits bright fluorescence at ~700 nm with a lifetime of longer than 10 ns. These spectroscopic properties are not affected by surface modification and subsequent conjugation with bioactive molecules. The distinct differences in wavelength and lifetime between NV^- emission and cell autofluorescence have enabled background-free imaging of FNDs in cells and tissue sections. Secondly, as an artificial atom in the solid state, the NV^- center is both chemically and photophysically stable. Thus, FNDs are well suited for use as a contrast agent for superresolution imaging by stimulated emission depletion (STED) and correlative light-electron microscopy (CLEM). Thirdly, the NV^- center in diamond is an atom-like quantum system with a total spin of 1. The ground states of the spins show a crystal field splitting of 2.87 GHz, separating the $m_s = 0$ and ±1 sublevels. Interestingly, the transitions between the spin sublevels can be optically detected and manipulated by microwave radiation, a technique known as optically detected magnetic resonance (ODMR), allowing for ultra-sensitive detection of temperature and magnetic field at the nanoscale. This lecture provides a summary of the recent advances in FND-enabled technologies that have fueled discoveries in diverse research areas spanning biology, chemistry, physics, and materials science and engineering [2].



References:

[1] S.-J. Yu, M.-W. Kang, H.-C. Chang, K.-M. Chen, and Y.-C. Yu, J. Am. Chem. Soc. **127**, 17604–17605 (2005).

[2] W. W.-W. Hsiao, Y. Y. Hui, P.-C. Tsai, and H.-C. Chang, Acc. Chem. Res. **49**, 400–407 (2016).

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