# Hysteresis loops and magnetic susceptibility for different orientation angle of oriented carbon nanotubes using VSM and SQUID

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## Abstract

Single-Walled Carbon Nanotubes (SWNTs) are potentially useful systems for this purpose since they align with the magnetic field and depict different magnetic properties in the longitudinal and axial directions, preserving anisotropic relaxivity in the NMR [1]. We have reported that exogenous SWNTs are able to induce selectively the anisotropic diffusion of water molecules in the surrounding medium in a manner detectable by MRI methods [2]. Here we report the first measurements to our knowledge of directional relaxivity of SWNTs suspensions trapped in agarose gels using VSM and SQUID magnets.

In this study we have used untreated (CVD) SWNTs oxidized with $HNO_3$ for 24 and 48 hours containing residual catalytic paramagnetic metals [2]. We determined the hysteresis loops and the virgin curve of untreated and oxidized SWNTs during 24 and 48 hours by vibrating sample magnetometer (VSM) and Superconducting Quantum Interference Device (SQUID). The studies were done with oriented SWNTs in an agarose matrix. The measured were obtained at T=100 K and T= 5 K using a VSM and SQUID respectively. The main magnetic properties studies were following: saturation magnetization (Ms), remnant magnetization (Mr), coercive field (Hc) and magnetic susceptibility for different orientation angle.

All the hysteresis loops were obtained using VSM and SQUID equipments showing a paramagnetic behaviour. Figure 1A and 1B depict the oriented suspensions of oxidized SWNTs for 24 and 48 hours which show anisotropic orientation (SQUID).The magnetization ratio (Mr/Ms) and coercitivy value change with the orientation angle for different samples studied. The same behaviour was detected as measured by VSM. Figure 1C shows that the values of magnetic susceptibility decrease as increase orientation angle. These features confirm the results described by T.A. Searles et al. [3].

## References

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**Figure**

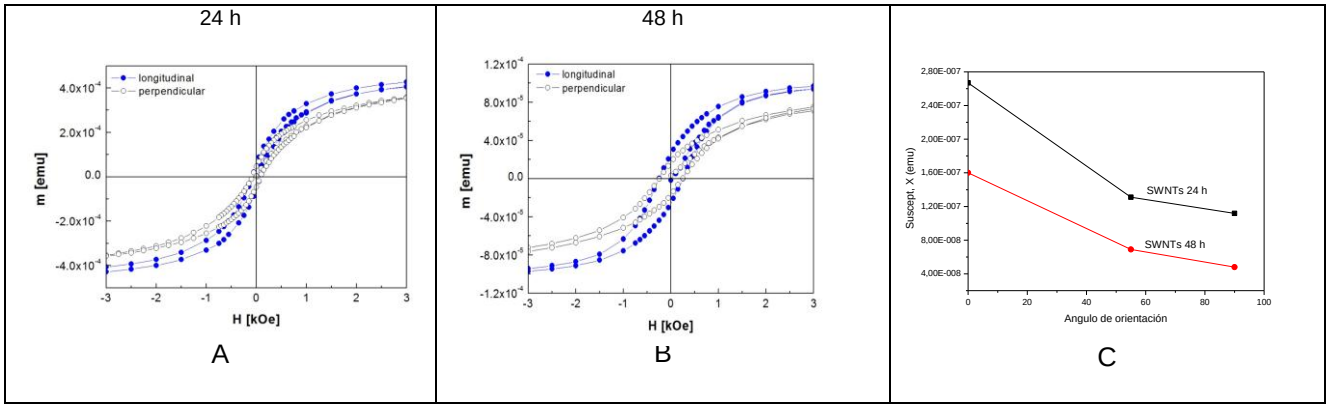


**Figure 1.** A, B: Hysteresis loops of oriented carbon nanotubes (SWNTs) in agarose for different orientation angle as measured by SQUID. C: Magnetic susceptibility of oriented SWNTs in agarose for different oxidation times as measured by VSM.