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Estimation of Particle Size Distribution Using Magnetization Data

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Abstract : Magnetic nanoparticles possess fascinating properties which make their behavior unique in comparison to corresponding bulk materials. Superparamagnetism is one such interesting phenomenon exhibited only by small particles of magnetic materials. In this state, the thermal energy of particles become more than their magnetic anisotropy energy, and so particle magnetic moment vectors fluctuate between states of minimum energy. This situation is similar to paramagnetism of non-interacting ions and termed as superparamagnetism. The magnetization of such systems has been described by Langevin function. But, the estimated fit parameters, in this case, are found to be unphysical. It is due to non-consideration of particle size distribution. In this work, analysis of magnetization data on NiO nanoparticles is presented considering the effect of particle size distribution. Nanoparticles of NiO of two different sizes are prepared by heating freshly synthesized $Ni(OH)_2$ at different temperatures. Room temperature X-ray diffraction patterns confirm the formation of single phase of NiO. The diffraction lines are seen to be quite broad indicating the nanocrystalline nature of the samples. The average crystallite size are estimated to be about 6 and 8 nm. The samples are also characterized by transmission electron microscope. Magnetization of both sample is measured as function of temperature and applied magnetic field. Zero field cooled and field cooled magnetization are measured as a function of temperature to determine the bifurcation temperature. The magnetization is also measured at several temperatures in superparamagnetic region. The data are fitted to an appropriate expression considering a distribution in particle size following a least square fit procedure. The computer codes are written in PYTHON. The presented analysis is found to be very useful for estimating the particle size distribution present in the samples. The estimated distributions are compared with those determined from transmission electron micrographs.

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