

## Spin properties of ferritin within PVA nanofibers

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In this study, the morphological and the magnetic properties of ferritin-embedded poly(vinyl alcohol) (PVA) nanofibers were investigated. The monodispersed ferritin (MF) and the clustered one (CF) were embedded into the biocompatible PVA nanofibers using the electrospinning method. The morphological difference between the MF and the CF samples was studied by high-resolution transmission electron microscopy (HR-TEM) and scanning electron microscopy. A superconducting quantum interference device magnetometer was used to analyze the magnetic properties. The HR-TEM image shows that the giant cluster is composed of a large number of ferritin cores without destruction of the protein shell. Even though the size is significantly large, the CF sample exhibits superparamagnetic (SPM) behavior. The magnetic phase of CF was partly changed depending on the heat treatment temperature. To elucidate the electronic structures of the ferritin cores, x-ray absorption spectroscopy (XAS) was carried out with an energy resolution of 0.8 eV in total electron yield mode. From the XAS result, it was observed that the ionic state of Fe core has been changed from Fe<sup>2+</sup> to Fe<sup>3+</sup> after the heat treatment. These provide us a possibility of manipulating the size and the magnetic ordering inside a biocompatible superparamagnet.