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A study of spin canting in $Li_3Fe_2(PO_4)_3$ with Mössbauer spectroscopy under 5 T

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$Li_3Fe_2(PO_4)_3$ has been actively studied as a Lithium ion battery cathode material for the next-generation energy storage application. Here, we have investigated the changes of magnetic coupling between two different magnetic sub-lattices in $Li_3Fe_2(PO_4)_3$ with x-ray diffraction (XRD), superconducting quantum interference device (SQUID), and Mössbauer spectroscopy measurements. The experimental XRD pattern was analyzed using Rietveld refinement, confirming single phase. In order to investigate the magnetic property, the SQUID measurement under applied field of 5 T was performed between 4.2 and 295 K. From the temperature-dependent zero-field-cooled and field-cooled magnetization curves, we observed the magnetization decreasing with increasing temperature up to $T_{min} = 13$ K, at which the magnetization showed a minimum value. With continuing increase in temperature, the magnetization starts increasing with a maximum value at $T_{max} = 28$ K and beyond T_{max}, the magnetization decreases with the further increase in temperature. Based on the experimentally measured Mössbauer spectra, we identified that the ratios of first and sixth to second and fifth absorption lines were identical around T_{min}, while with increasing temperature the area of second and fifth absorption line rapidly decreased up to T_{max}. Our study suggests that the spin canting angle between the applied field and hyperfine field of $Li_3Fe_2(PO_4)_3$ is constant up to T_{min}. However, the spin canting angle starts decreasing with increasing temperature, reaching a minimum value at T_{max}, and beyond T_{max} it is increasing. We expect that around T_{max}, the ferrimagnetically coupled spin arrangement is appeared to be collinear along the applied field direction under applied field of 5 T.
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