Mössbauer Studies of Spin-Orbit Coupling in $LiCo_{0.99}{}^{57}Fe_{0.01}PO_4$

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The polycrystalline $LiCo_{0.99}{}^{57}Fe_{0.01}PO_4$ was synthesized by solid-state reaction method. The crystal structure was determined to be orthorhombic with a space group of *Pnma* by x-ray diffractometer (XRD). The temperature dependence of the magnetization was investigated by superconducting quantum interference device (SQUID) magnetometer. Although $LiCo_{0.99}{}^{57}Fe_{0.01}PO_4$ showed a typical anti-ferromagnetic behavior at temperatures below $T_N = 23$ K, a rapid increase in magnetization was observed at temperatures below 9 K. The microscopic magnetic properties of $LiCo_{0.99}{}^{57}Fe_{0.01}PO_4$ were characterized by ^{57}Fe external field Mössbauer spectroscopy. At temperatures below 9 K, the magnetic hyperfine field (H_{hf}) showed a rapid increase, while the electric quadrupole splitting (ΔE_Q) decreased rapidly. The H_{hf} and ΔE_Q under external field of 4.8 T changed significantly compared to the value without external magnetic field. These are originated from orbital angular moment contribution by spin-orbit coupling at temperatures below 9 K, while orbital angular moment is quenched by the crystalline field due to distorted $CoO_6(FeO_6)$ asymmetric structure at temperatures above 9 K.

Index Terms—**$LiCoPO_4$, Mössbauer spectroscopy, spin-orbit coupling, olivine.**