Magneto-Raman Spectroscopy on Metal-organic Framework Material $[(CH_3)_2NH_2]Co(HCOO)_3$

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Introduction

Designing functional materials is one of the important goals of materials research. One of the routes towards achieving this goal involves using organic groups to synthesize wide variety of compounds with intriguing properties. Metal-organic framework is a class of compounds where organic groups are used in combination with transition metal ions to obtain multifunctional materials. Recently, it has been demonstrated that the family of compounds $[(CH_3)_2NH_2]M(HCOO)_3$ (with M=Ni, Mn, Co and Fe) exhibit multiferroic properties [1]. Several efforts have been made to understand the nature and strength of exchange interactions in a similar compound $[CH_3NH_3]M(HCOO)_3$ [2,3]. A sharp field-induced phase transition has been observed in $[CH_3NH_3]Co(HCOO)_3$ at fields above 20 T. The magnetic field needed to reach the saturation for the spin component of the magnetic moment of the Co^{2+} cations is dependent on the orientation of the crystal (26T along [010] and 21T along [101] and [10-1]). In our work, we performed detailed magneto-Raman investigations on a closely related compound $[(CH_3)_2NH_2]Co(HCOO)_3$ to reveal and understand the various magnetic transitions.

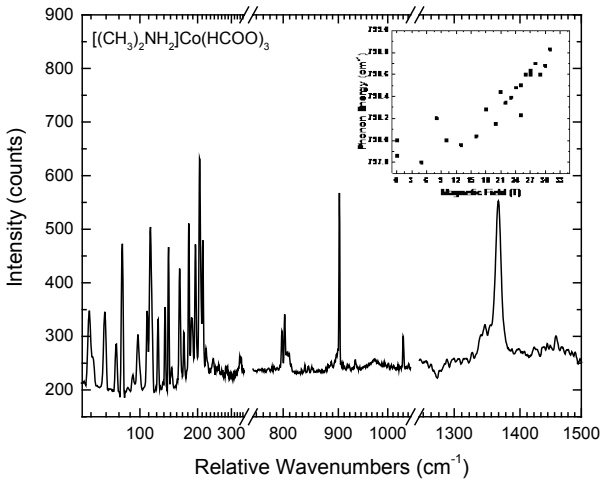

Fig. 1 Plot of Raman spectra of $[(CH_3)_2NH_2]Co(HCOO)_3$ at 2.3 K showing the entire phonon frequency range; Inset: Illustrates the field-dependence of the phonon at 800 cm^{-1} at magnetic fields up to 31 T.

Experimental

Magneto-Raman measurements on $[(CH_3)_2NH_2]Co(HCOO)_3$ were performed using a Trivista Raman spectrometer with 532 nm laser excitation. These measurements were done at 2.3 K and in magnetic fields of up to 31T using a resistive magnet. The sample was placed on a X-Y-Z actuator to obtain the best alignment as well as for position selectivity.

Results and Discussion

We attempted magneto-Raman experiments on $[(CH_3)_2NH_2]Co(HCOO)_3$ at magnetic fields up to 31 T at 2.3 K. Magneto-Raman data in the entire frequency range of phonons is shown in the Fig. 1. The inset illustrates field-induced shifts in the 800 cm^{-1} phonon energies. We observed continuous shift in the energy of this phonon up to maximum magnetic field of 31 T while the other phonons remained largely unaffected. The phonons observed in this frequency range in the infrared spectrum were assigned to bending and stretching modes of format [3]. More detailed analysis and interpretation of our experimental results in comparison to recently published magneto-infrared study will be performed.

Conclusions

We performed successful magneto-Raman investigation on $[(CH_3)_2NH_2]Co(HCOO)_3$ at magnetic fields up to 31 T. Only one of the phonon (at 800 cm^{-1}) exhibits magnetic field induced shifts clearly indicating the presence of magneto-elastic coupling in this multiferroic material.

Acknowledgements

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References

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