Magnetic Properties of Co and Ni Molecule-based Magnets

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Introduction

In past experiments on $NiCl_2$-$4SC(NH_2)_2$, $CoCl_2$-$4SC(NH_2)_2$, and $CoCl_2$-$2SC(NH_2)_2$, interesting magnetic and ferroelectric properties have been found including magnetic field-induced antiferromagnetism with a field-induced quantum critical point that belongs to the universality-class of Bose-Einstein Condensation [1], and magneto-electric effects [2,3]. In these materials, the metal ion is surrounded by thiourea molecules. The thiourea molecules are electrically polar and also change their orientation when the crystal lattice is distorted by magnetostrictive effects when the magnetic field acts on the Ni or Co spins. Thus a magnetostrictive mechanism for magneto-electric coupling results. Here we screen new members of this class of materials with thiourea and urea, which is also electrically polar.

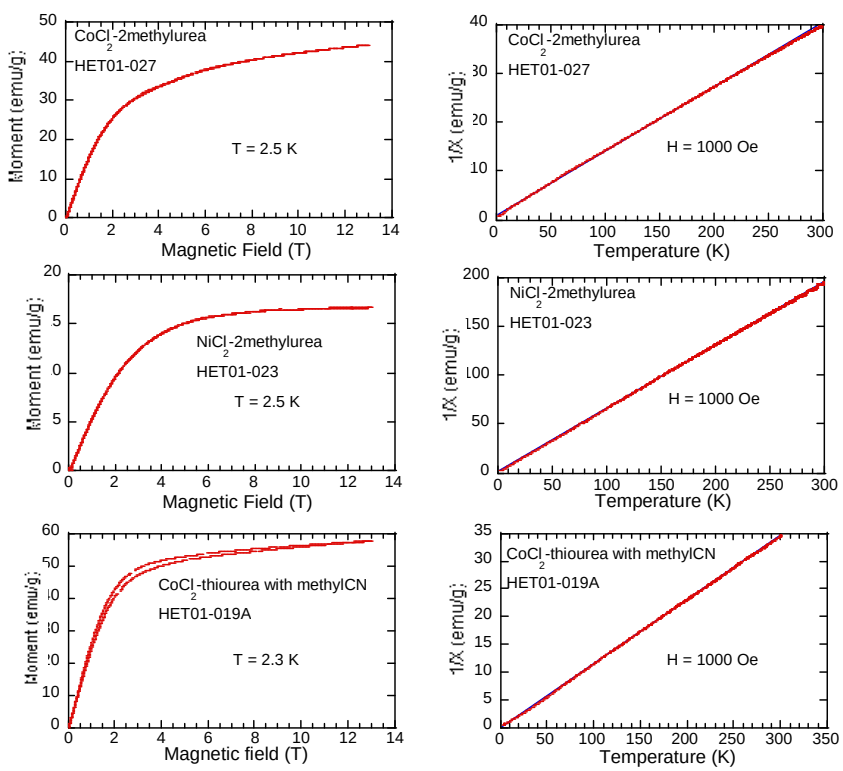
Experimental

Collections of single crystals of of $CoCl_2$-2methylurea **(1)**, $NiCl_2$-methylurea **(2)**, and $CoCl_2$-thiourea were characterized via magnetization measurements down to 2 K and up to 13 T using a Vibrating Sample Magnetometer option in a Physical Properties Measurement System at the NHMFL-LANL. Collections of randomly-oriented single crystals were measured.

Results

Magnetization as a function of magnetic field, and inverse magnetic susceptibility vs. temperature are plotted in **Figure 1**. The inverse susceptibility is fitted by a Curie-Weiss relation, and is linear for all three samples down to 2.3 K with an intercept near zero temperature, indicating no crystal electric field effects or magnetic exchange interactions above ~2 K. The CoCl2-2methylurea sample shows a small (~1 K) negative Curie-Weiss temperature that could indicate magnetic coupling on that scale. The magnetization vs. magnetic field appears paramagnetic. A small hysteresis is observed in $CoCl_2$-thiourea with methylCN, however in light of the unremarkable temperature dependence, it is likely due to sample motion. CoCl2-2methylurea shows an intercept of the Curie

Figure 1: Magnetization vs magnetic field, and inverse magnetization vs. temperature for $CoCl_2$-2methylurea, $NiCl_2$-methylurea, and $CoCl_2$-thiourea with methylCN.



Conclusions

These materials do not show magnetic order, magnetic exchange, or crystal-electric field effects above 2 K.

Acknowledgements

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References

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[2] V. S. Zapf, *et al.,* Phys. Rev. B. 83, 140405(R) (2011).
[3] E. D. Mun, *et al.*, in progress (2012).