Experimental investigation of Cu(*en*)$(H_2O)_2SO_4$ embedded in the hexagonally ordered mesoporous silica SBA 15 with different pore sizes

R. Tarasenko,[1] P. Danylchenko,[1,2] I. Kozin,[1] E. Čižmár,[1] V. Girman,[1] V. Tkáč,[1] V. Zeleňák,[3] A. Orendáčová,[1] and M. Orendáč[1]

[1] *Institute of Physics, Faculty of Science, P.J. Šafárik University, Park Angelinum 9, 041 54 Košice, Slovak Republic*

[2] *Faculty of Mathematics and Physics, Charles University, Ke Karlovu 3, 121 16, Prague, Czech Republic*

[3] *Institute of Chemistry, Faculty of Science, P.J. Šafárik University, Moyzesova 11, 0414 54 Košice, Slovak Republic*

An experimental investigation was carried out on the Cu(*en*)$(H_2O)_2SO_4$ complex incorporated into the hexagonally ordered mesoporous silica SBA 15 with pore sizes ranging from 4 to 12 nm. A combined evaluation of experimental measurements of heat capacity, magnetic susceptibility, and magnetization, together with first-principles calculations, demonstrated that Cu(*en*)$(H_2O)_2SO_4$ forms a three-dimensional network of interacting zigzag square antiferromagnetic layers. This system exhibits long-range magnetic ordering below the Néel temperature $T_N \approx 0.9$ K. The dominant intralayer exchange interaction was estimated to be $J_1/k_B \approx 3.5$ K, whereas the interlayer coupling was found to be significantly weaker, with $J^{'} < 0.03\ J$. Furthermore, the magnetic-field response reveals universal behavior consistent with a field-induced topological Berezinskii–Kosterlitz–Thouless phase transition, as theoretically predicted for two-dimensional magnetic systems[1]. Silica materials prepared by 72 hour synthesis in a saturated Cu(*en*)$(H_2O)_2SO_4$ solution exhibited the highest pore filling, amounting to nearly 60 % of the available internal pore volume. Analysis of experimental data from transmission electron microscopy, thermal analysis, and nitrogen adsorption isotherms showed that, for all samples, the investigated complex is located not only within the pores but also partially on the silica surface. On the other hand, analysis of the temperature dependence of magnetic susceptibility and the field dependence of magnetization indicates a weakening of the exchange interactions between Cu(II) ions.

References:

[1] L. Lederová et al., Phys. Rev. B 95 (2017) 054436.

The financial support of projects VEGA 1/0149/26, VVGS-2026-3893, APVV-18-0197, APVV-23-0006 and APVV-22-0172 is acknowledged. Funded also by the EU NextGenerationEU through the Recovery and Resilience Plan for Slovakia under the project No. 09I03-03-V03-00034.