1. Introduction

Prussian blue analogues (PBA) are subject of increasing interest mostly because of the possibility to produce molecule — based magnets working at room temperature and because of sensitivity of their magnetic properties on different types of external stimuli. PBA build a large family of cubic systems with face-centered (fcc) crystal structure [1, 2]. The magnetic coupling in these systems is determined by super-exchange interaction between metal ions $A^{2+}$ and $B^{3+}$ mediated through three dimensional network of C–N bridges, resulting in 3D orthogonal magnetic orbitals. The $J_{KE}$ mediated directly via overlapping orbitals and potential exchange mechanism ($J_{PE}$) mediating interaction between orthogonal magnetic orbitals. The $J_{KE}$ leads to antiparallel spin ordering via cyanide covalent bond i.e. antiferromagnetic interaction $J_{AF}$. The $J_{PE}$ leads to a parallel spin ordering that means ferromagnetic interaction $J_{F}$. This model has been already successfully tested on TM$^{2+}I_{III}[Cr(CN)_{6}]_{2}$·$z$H$_{2}$O, where TM$^{2+}$ is 3d ion, with the simplification that only the superexchange interactions between the nearest neighbour metal A and B ions have to be considered [2, 4]. Magnetic properties of mixed ferro-ferrimagnet (Ni$_{x}$Mn$_{1-x}$)$_{3}$[Cr(CN)$_{6}]_{2}$·$z$H$_{2}$O and pole inversion at the compensation temperature $T_{comp}$ for different values of $x$ were first reported in [5]. The possibility that the spontaneous magnetization might change sign at particular $T_{comp}$ was envisaged by Néel in the classical theory of ferrimagnets [6].

Recently we reported on magnetic structure, magnetic properties and effect of pressure on magnetization in mixed ferro-ferrimagnet (Ni$_{x}$Mn$_{1-x}$)$_{3}$[Cr(CN)$_{6}]_{2}$·$z$H$_{2}$O in [7, 8]. In our paper we study magnetic properties of the (Cu$_{x}$Mn$_{1-x}$)$_{3}$[Cr(CN)$_{6}]_{2}$·$z$H$_{2}$O molecule-based magnets, where $x = 0.0, 0.2, 0.25, 0.3, 0.35 0.4, 0.6, 0.8 and 1.0. Both the Curie temperature and saturated magnetization at first decrease with increasing value of $x$ reaching the minimal value of $T_{C}$ = 49.7 K and 0.17 $\mu$B for $x = 0.2$ and then increase with substitution. The pronounced hysteretic behavior between zero-field cooled and field cooled regimes was observed for all samples. Magnetization changes the sign of magnetic polarization in zero-field cooled magnetization curve at the compensation temperature $T_{comp}$ = 16 K for sample with $x = 0.4$. Our results indicate that the system behaves as mixed-ferri-ferrimagnetic system.

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2. Results and discussion

The typical temperature dependences of magnetization $\mu(T)$ which were measured in zero field cooled (ZFC) and field cooled (FC) regimes are shown in

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Fig. 1. Temperature dependence of magnetization measured in ZFC and FC regimes on the sample with $x=0.2$.

Fig. 2. Temperature dependence of magnetization measured in ZFC and FC regimes on the sample with $x=0.4$. Arrow points on the compensation temperature.

Fig. 3. Magnetization hysteresis loops of sample with $x=0.2$ measured at 1.8 K. The inset shows details of the magnetization curve at low magnetic fields.

In conclusion our magnetization measurements performed on the (Cu$_{x}$Mn$_{1-x}$)$_3$[Cr(CN)$_6$]$_2$$\cdot$zH$_2$O molecules-based magnets indicate that this system behaves as a mixed ferro-ferrimagnetic system and the compensation temperature can be observed. The dominant coupling of the system is $J_F$ which is opposite coupling than was observed on (Ni$_{0.38}$Mn$_{0.62}$)$_3$[Cr(CN)$_6$]$_2$$\cdot$zH$_2$O mixed ferro-ferrimagnetic compound.

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References