MAGNETIC PROPERTIES OF $TlMnS_2$ AND $TlMnSe_2$ COMPOUNDS.

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$TlMnS_2$ and $TlMnSe_2$ compounds have been synthesized and X-ray analysis was carried out. Magnetization and paramagnetic susceptibility of these compounds have been investigated in the temperature interval 77÷300K. It is shown that $TlMnS_2$ and $TlMnSe_2$ are low-dimensional magnetics and the antiferromagnetic exchange interaction takes place in them. Experimental values of the effective magnetic moment are -4.5 μ_B for $TlMnS_2$ and 4.7 μ_B $TlMnSe_2$, that is in agreement with theoretical values for the three-valence Mn ion.

Roentgenographic, thermal and magnetic investigations of compounds with the general crystallochemical formula $TlMeX_2$ (Me=Cr, Fe, Co; X=S, Se, Te) allowed paper's authors [1 - 7] to conclude about the low-dimension of these compounds.

For determination of influence of the 3-d configuration of Me ions on magnetic properties, in given work we have investigated the magnetization and paramagnetic sensibility of $TlMnS_2$ and $TlMnSe_2$ belonging to this class of compounds.

$TlMnS_2$ and $TlMnSe_2$ samples were synthesized in vacuum quartz ampoules by the solid state method of caking of binary compounds TlS (Se) and MnS (Se) which beforehand were put into the powdered state and weighed in the equimolecular relation. Synthesis was carried out in the following sequence. Ampoule with initial components was placed into the furnace where the temperature rises from room one up to 1000K with the rate 100deg/hour. At this temperature the ampoule was held for 30 hours, then it is cooled up to the room temperature with the same rate. For prevention of interaction of initial components with the internal wall of the quartz ampoule the last one was in the rotation during the synthesis process. Obtained samples were rubbed to the powder, pressed under the high pressure and undergone to the homogenizing annealing for 240 hours at 700K.

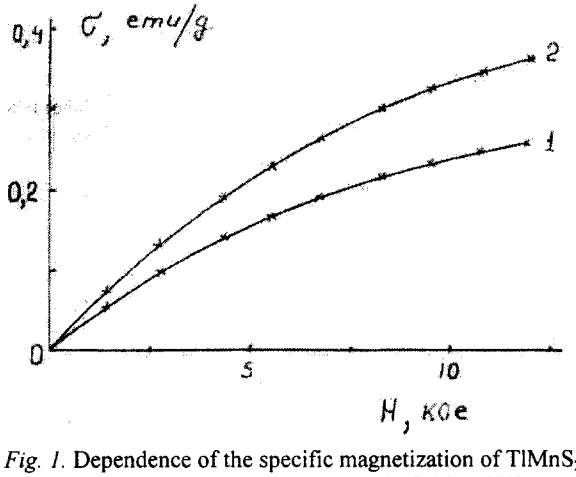

Fig. 1. Dependence of the specific magnetization of $TlMnS_2$ (1) and $TlMnSe_2$ (2) on the magnetic field at 77K.

X-ray analysis of samples was carried out on the diffractometer DRON-3M (CuK_α-radiation Ni- filter). Angle resolution of the photographing was ~0,1°. Continuous scanning regime was used. Diffraction angles were determined by the method of measurements on the intensity maximum. At experiments the determination error of reflection angles did not excess $\Delta\theta$ ± 0,02°.

Diffractograms of synthesized samples written down in the angle interval $10° \le 2\theta \le 70°$ at the room temperature, are definitely induced in tetragonal ($TlMnS_2$) and hexagonal syngonies with parameters of the crystalline lattice a=7.74; c=30.60Å, roentgen density ρ_x=6.40g/cm^3, atom number in the unit cell z=20 and a= 6.53, c=23.96Å, z=8, ρ_x=6.71g/cm^3, respectively.

Magnetization (σ) was measured on the pendular magnetometer Domenicalli, and the paramagnetic susceptibility (χ) was measured -by the Faraday method on the magnetoelectric balance.

Fig.1 presents the dependence of the specific magnetization of $TlMnS_2$ and $TlMnSe_2$ compounds on the magnetic field at 77K. As it is seen, the dependence $\sigma(H)$ at given temperature for both compounds has the form characteristic for the paramagnetic state. However the temperature dependence of the reverse paramagnetic susceptibility of these compounds (fig.2) follows to the Curie-Weice law with the extrapolation to the range of negative temperatures which testifys on existence of the antiferromagnetic exchange interaction. According to fig.2, the temperature of the magnetic transformation of both compounds is below 77K.

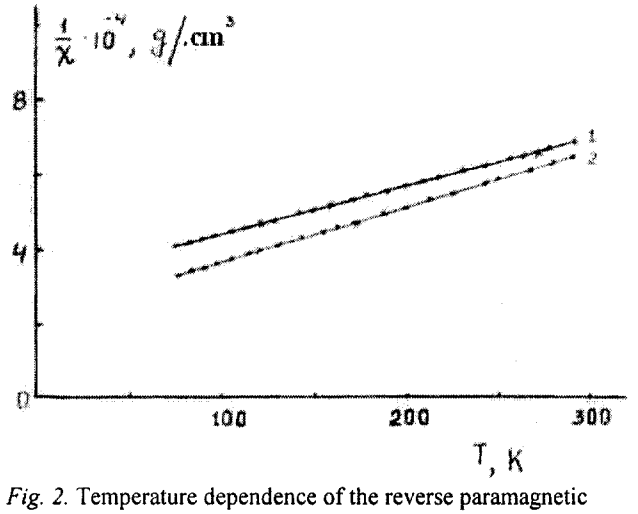

Fig. 2. Temperature dependence of the reverse paramagnetic susceptibility of $TlMnS_2$ (1) and $TlMnSe_2$ (2).

From the temperature dependence of the reverse paramagnetic susceptibility we have calculated experimental values of the effective magnetic moment of compounds under investigation which are equal to 4.5 ($TlMnS_2$) and 4.7μ_B ($TlMnSe_2$). Calculation of the theoretical value of the effective magnetic moment (4.9μ_B) was carried out with account of the purely spin value of the magnetic moment of the three- valent Mn ion. Comparison shows good agreement

of experimental and theoretical results that is the indirect confirmation of the accepted ionic configuration of given compounds.

Interpretation of obtained experimental results, testifying on the antiferromagnetic interaction in $TlMnS_2$ and $TlMnSe_2$, can be done on the basis of the crystalline structure of these compounds. As it is known, this structure determines the periodicity of arrangement of spin magnetic moments where the exchange interaction is responsible for their mutual orientation. Taking into account this fact, we, apparently can imagine the crystalline structure of $TlMnS_2$ and $TlMnSe_2$ as sequentially alternating two-dimensional layers of ions Mn^{3+}, Tl^+ and S^{2-}(or Se^{2-}) parallel to the basal plane. Sufficiently large ratio c/a ~4 testifys on the laminated structure of these compounds. Ferromagnetic ordering have been carried out in the plane, including ions Mn^{3+}. Therefore layers of ions Mn^{3+} are two- dimensional ferromagnetic. Layers Tl^+ and S^{2-}(or Se^{2-}) have been arranged between the nearest layers of ions Mn^{3+}. Therefore ferromagnetic layers are connected with each other by weaker forces of the antiferromagnetic type. Co - existence of ferromagnetic (within layers) and antiferromagnetic (between layers) interactions leads to the resulting antiferromagnetic interaction in $TlMnS_2$ and $TlMnSe_2$.

We note that authors [6], following from the above-mentioned model consider that the ferrimagnetic ordering in compounds $TlCoS_2$ and $TlCoSe_2$ is the result of a noncomplete compensation of spin magnetic moments of ferromagnetic layers formed by Co ions.

Thus results of X-ray and magnetic investigations testify on the low - dimension of compounds $TlMnS_2$ and $TlMnSe_2$ and existence of the antiferromagnetic exchange interaction in them.

[1] *M.Rosenberg, A.Knulle, H.Sabrowsky, C.Platte.* J. Phys. Chem. Solids, 1982, 43, 2, 87.

[2] *G.I. Makovetski, E.I. Kasinski.* Non-organic materials. 1984, v. 20, №10, p. 1752.

[3] *M.A.Aljanov, N.G.Guseinov, G.D.Sultanov, M.D. Nadjafzade.* J. Phys. Stat. Sol. (b), 1990, 159, k107.

[4] *M. Aljanov, M. Nadjafzade, Z. Seidov, M. Gasumov.* Turkish Journal of Physics, 1996, 20, 9, 1071.

[5] *E.M. Kerimova, F.M. Seidov, S.N. Mustafaeva, S.S. Abdinbekov..* Non-organic materials, 1999, v.35, №2, p.157.

[6] *R.Z. Sadikov, E.M. Kerimova, Y.G. Asadov, R.K.* Veliev. FTT, 2000, v. 42, 8, p.1449.

[7] *S.N. Mustafaeva, E.M. Kerimova, A.I. Dzabbarli.* FTT, 2000, v. 42, №12, p. 2132.

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$TlMnS_2$ VƏ $TlMnSe_2$ BİRLƏŞMƏLƏRİNİN MAQNİT XASSƏLƏRİ

$TlMnS_2$ və $TlMnSe_2$ birləşmələri sintez olunmuş, onların rentgenoqrafik analizləri aparılmışdır. 77÷300 K temperatur intervalında maqnitlənmə və paramaqnit qavrayıcılığı tədqiq edilmişdir. Göstərilmişdir ki, $TlMnS_2$ və $TlMnSe_2$ kiçik ölçülü maqnetikdirlər və onlarda qarşılıqlı antiferromaqnit mübadiləsi mövcuddur. Effektiv maqnit momentinin –4.5 ($TlMnS_2$) və 4.7μ_B ($TlMnSe_2$) təcrübi qiymətləri Mn–in üçvalentli ionunun nəzəri qiymətləri ilə uyğun gəlir.

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МАГНИТНЫЕ СВОЙСТВА СОЕДИНЕНИЙ $TlMnS_2$ и $TlMnSe_2$

Синтезированы соединения $TlMnS_2$ и $TlMnSe_2$, проведен их рентгенографический анализ. В интервале температур 77÷300 К исследована намагниченность и парамагнитная восприимчивость. Показано, что $TlMnS_2$ и $TlMnSe_2$ являются низкоразмерными магнетиками и в них осуществляется антиферромагнитное обменное взаимодействие. Экспериментальные значения эффективного магнитного момента –4.5 ($TlMnS_2$) и 4.7μ_B ($TlMnSe_2$) - согласуются с теоретическим значением для трехвалентного иона Mn.

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