OPTICAL AND ELECTRICAL PROPERTIES
OF $Co_3(BO_3)_2$ AND $Ni_3(BO_3)_2$

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The paper presents the results of investigation of some physical properties of Co and Ni-borate. The crystal structure and magnetic properties have been described earlier. In the present investigation the optical spectra in the visible region are recorded and electrical conductivities and dielectric permittivities are measured.

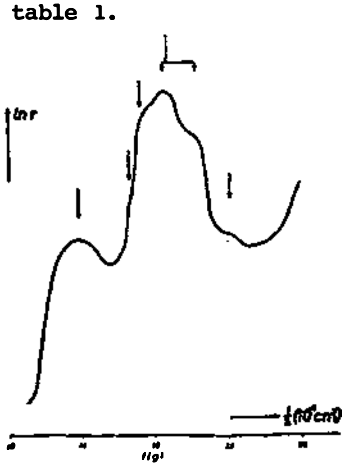
INTRODUCTION

The crystal structure of borates $Co(BO_3)_2$ and $Ni(BO_3)_2$ are known [1, 2, 3] , Besides, the magnetic properties and the magnetic structure of these compounds are determined [3,4] . In the crystals of these borates the Co^{2+} and Ni^{2+}-ions are surronded by the coordination octahedra formed by the 0-atoms from BO_3^{3-}-ions. This is new investigation which gives additional information on the properties of the Co^{2+} and Ni^{2+} ions in such surroudning.

The synthesis of these compounds in accomplished by the procedure described in [3]. The polycrystalline samples obtained are identified by the method of x-ray diffraction.

OPTICAL SPECTRA

The optical spectra of $Co_3(BO_3)_2$ and $Ni_3(BO_3)_2$ in the region of wavelengths from 350 to 1000 nm are recorded by the method of diffuse reflection spectrophotometry (figs. 1. and 2.). The interpretation of these spectra is made by the use of the Tanabe-Sugano method [5]. The results of the assignated electronic transition are given on table 1.



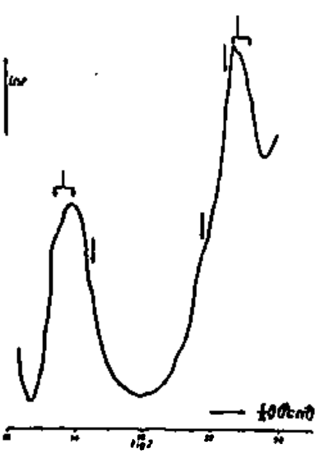
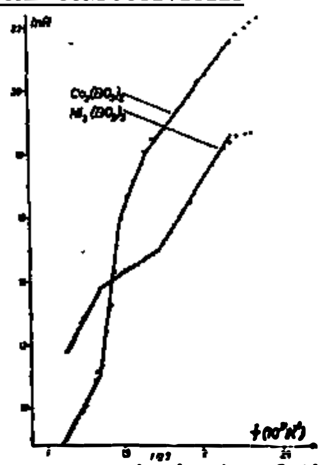


Table 1. Electronic transitions, their energies and values of β and 10 Dq for the recorded spectra

fig. 1.: $Co_3(BO_3)_2$		fig. 2.: $Ni_3(BO_3)_2$	
transition	energy (cm^{-1})	transition	energy (cm^{-1})
$^4T_{1g}(^4F) \rightarrow {}^4A_{2g}$	13950	$^3A_{2g}(^3F) \rightarrow {}^3T_{1g}(^3F)$	13300
$^2T_{1g}$	16600	^1E_g	15700
$^2T_{2g}$	17250	$^1T_{2g}$	21600
$^4T_{1g}(^4P)$	18650	$^1T_{1g}$	23000
$^2A_{1g}$	22200	$^3T_{1g}(^3P)$	23800
β	0,89	β	0,85
10 Dq	7200 cm^{-1}	10 Dq	7650 cm^{-1}

The calculated electronic transitions are indicated in figs. 1. and 2. by arrows. On table 1. the values for the bond character coefficient β and for the crystal field parameter 10 Dq are given also. These values correspond to those obtained for the octahedral complexes CO_6 and NiO_6 in other compounds [6] .

ELECTRICAL CONDUCTIVITIES



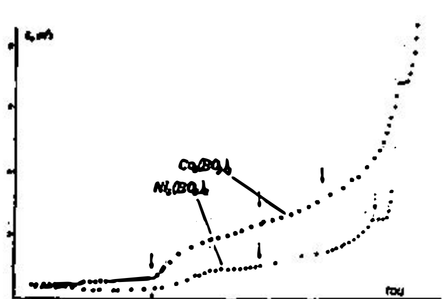
The dependence of the electrical resistance (R) temperature is measured by the use of a digital electrometer. The measurements are performed for the temperature range 300 - 800 K (fig. 3). The dependence lnR on 1/T for both compounds is characterized by the existence of narrow temperature regions with different activation energies (E). The limits of these regions and the corresponding values of activation energies are given on table 2

On the basis of the realized experiments it is difficult to conclude what kind of microscopic processes are responsible for this sort of dependence R(T). For the time being it is sure only that the similar changes are found in the investigation of dielectric properties of these compounds (fig. 4.)

Table 2. Activation energies E for the dependence R(T)					
$Co_3(BO_3)_2$			$Ni_3(BO_3)_2$		
region limits		E(eV)	region limits		E(eV)
$\frac{1}{T}(10^3K)$	T(K)		$\frac{1}{T}(10^3K)$	T(K)	
2,2 1,68	454 595	0,55	2,2 1,71	454 584	0,63
1,68 1,48	595 676	1,0	1,71	584	0,28
1,48 1,345	676 743	3,15	1,345	743	
<1,345	>743	0,86	<1,345	>743	0,74

DIELECTRIC PERMITTIVITIES

The dielectric permittivities (ε_r) measured by the use of one resonant bridge circuit (at 800 Hz) The results of these measurements performed during the heating up to T = 800 K are presented in fig. 4. At room temperature for the Co - compound ε_r = 50 and for the Ni - compound ε_r = 45. Steep increase of ε_r is caused by heating. At T = 790 K for Co - borate ε_r = 850, and at T = 760 K for Ni-borate ε_r = 350. At higher temperatures the dielectric losses become too large to made the measurements by the used method reliable. In fig. 4. the arrows indicate the breaks in the parabolic shape of the dependence ε_r(T). These breaks lie at the temperatures which approximatelly correspond to the breaks in the dependence ln R=f(1/T).



FINAL REMARKS

For the explanation of experimentally obtained forms of dependences ε_r(T) and R(T) the additional facts are necessary. The large values of ε_r might be probably connected with large polarizability of the complexes CoO_6 and NiO_6 present in the structure of examined borates. Such properties have been predicted several years ago [7]. The actual origin of established properties will be investigated in the nearest future.

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