$K_{1.75}[NH_4]_{0.25}SO_4$ – New Crystal with Isotropic Point

P.A. Shchepanskyi[1,2], V.Yo. Stadnyk[1], R.S. Brezvin[1], I. Kityk[3] , M.Ya. Rudysh[1,2], M. Piasecki[2]

[1]*Ivan Franko National University of Lviv, 8 Kyrylo and Mefodiy Str., 79005 Lviv, Ukraine*
[2]*Jan Dlugosz University in Częstochowa, Al. Armii Krajowej 13/15, 42-200 Czestochowa, Poland*
[3]*Institute of Electronic and Control System, Faculty of Electrical Engineering, Czestochowa University of Technology, 17 Armii Krajowej Str., 42-200 Czestochowa, Poland*

Appearance of the isotropic point (IP) or the point of birefringence sign inversion (BSI) is known to be a result of temperature–spectral deformations of the optical indicatrix at which, for each wavelength at a fixed temperature, the crystal undergoes a transition from an optically uniaxial state to an isotropic state or from an optically biaxial state to uniaxial state.

Earlier, isotropic state was found in a number of dielectric ferroic crystals of the A_2BX_4 group (K_2SO_4, $LiKSO_4$, Rb_2SO_4, $(NH_4)_2BeF_4$, $RbNH_4SO_4$, $RbKSO_4$, $LiNH_4SO_4$) [1, 2] which covers wide temperature and spectral ranges but some of them possesses IP in an inconvenient for practice region of spectrum.

Interesting is search for new crystals of this group with IP. This search aims to expand the range of practically important materials for thermometry [3] and to associate the effect of structural elements substitution on already known temperature and spectral ranges of BSI existence in the crystal. Since cationic substitution leads to insignificant changes in the optical indicatrix parameters, one can expect it will lead to changes in the spectral or temperature range of existence of isotropic state, depending on the percentage of mixing substances.

Considering that K_2SO_4 possess IP, within upper described issue, interesting for us was to investigate the influence of partial isomorphic substitution $K \rightarrow NH_4$ on the existence of BSI.

To follow that aim a representative of mixed systems with the formula $(K_x[NH_4]_{x-1})_2SO_4$ $(0 < x < 1)$, $K_{1.75}[NH_4]_{0.25}SO_4$ single crystals was chosen. Thus, in this work, spectral dependences of refractive indices and birefringence as well as temperature and pressure changes of birefringence of $K_{1.75}[NH_4]_{0.25}SO_4$ crystals on a subject of revealing isotropic points were investigated.

Birefringence dispersion at room temperature was found to be normal in *Y* and *Z* directions and abnormal in *X* direction leading to the occurring of isotropic point which corresponds to the equality $n_x = n_y$ at the wavelength $\lambda \approx 1350$ nm. Such phenomenon is not observed for K_2SO_4 single crystals and thus is caused by the presence of NH_4 ions altering the dispersion character in *x* direction. From study of temperature dependences of birefringence for the $K_{1,75}[NH_4]_{0,25}SO_4$ crystals at wavelength $\lambda = 500$ nm decreasing of birefringence values for main crystal optics directions with temperature increasing is revealed. At temperatures $T_{01} \approx 541$ K and $T_{02} \approx 589$ K two IPs which correspond to the equalities $n_z = n_y$ and $n_z = n_x$, respectively, are detected.

From the investigation of birefringence dispersion under the action of uniaxial stresses it was also showed the displacement of IP and a possibility of inducing pseudo IPs in the crystal by applying uniaxial stresses which for wavelength $\lambda = 500$ nm are equal $\sigma_x \approx 8.3$ kbar, σ_x~$\sigma_y \approx 7.5$ kbar and σ_x~$\sigma_z \approx 10.5$ kbar.

[1] M. O. Romanyuk, *Crystal Optics*, IZMN, Kiev, 1997 (in Ukrainian).
[2] V. Stadnik and V. M. Gaba, *Refractometry of Dielectric Crystals with Incommensurable Phases,* Liga Press, Lviv, 2010 (in Ukrainian).
[3] M. O. Romanyuk & M. M. Romanyuk, *Ferroelectrics* **317**, (2005).