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Phosphate-tellurite vitreous materials with magnetic and magneto-optical properties, for Faraday rotators and the process for obtaining them

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Abstract: The invention relates to phosphate-tellurite glasses containing lithium oxide and titanium dioxide and, respectively, zinc oxide and to the process for obtaining them. The preparation process of phosphate-tellurite glasses ensures a high chemical and optical homogeneity of the materials. Tellurite glass materials are of particular importance in terms of their applications, namely, Faraday rotators, magnetic field transducers, magnetic field detectors, etc.

Introduction:

Aluminum-phosphate-tellurite glasses containing lithium oxide and titanium dioxide and, respectively, zinc oxide, used as Faraday rotators were prepared by using as raw materials oxides and salts. The phosphorus pentoxide and tellurium dioxide are introduced as network formers, and as network modifiers, lithium, aluminum, zinc and titanium oxides. The reactants are introduced in the quantities corresponding to the predetermined compositions, adding an additional amount in the case of lithium oxide and phosphorus pentoxide, taking into account their evaporation, in a proportion of 15% and 25%, respectively.

The homogenized and evaporated mixture is heat treated in order to eliminate the gaseous components, then it is melted in order to form the vitreous structure. Melting of the mixture of chemical compounds is accompanied by mechanical homogenization in order to eliminate gaseous inclusions and achieve high chemical and optical homogeneity of the glasses obtained in the end. The melted and homogenized glasses are cooled by casting in preheated molds, then, they are heat treated (annealed) in order to eliminate the mechanical stresses that occur in the casting process. Glassy materials are optically processed for physico-chemical characterization and, also for their use as Faraday rotators, having magnetic and magneto-optical properties. Relatively recently, the synthesis of some tellurite glasses belonging to the oxide systems TeO_2-ZnO, TeO_2-ZnO-Na_2O and TeO_2-ZnO-La_2O_3-Na_2O was presented. The synthesis took place in a sealed chamber of silicate glass and a stream of oxygen [1]. The variation of the Verdet constant in the range 450-1560 nm was measured, indicating the use of these glasses for Faraday rotators at a wavelength of 1070 nm. Recently, two scientific papers have been published on the magnetic and magneto-optical properties of phosphate-tellurite diamagnetic glasses, belonging to the compositional systems $45ZnO\text{-}10Al_2O_3\text{-}40P_2O_5\text{-}5TeO_2$ [2] and $35Li_2O\ 10Al_2O_3\text{-}5TiO_2\text{-}45P_2O_5\text{-}5TeO_2$ [3].

Materials:
Te-1: $35ZnO\text{-}10Al_2O_3\text{-}40P_2O_5\text{-}15TeO_2$
Te-2: $30Li_2O\text{-}10Al_2O_3\text{-}5TiO_2\text{-}45P_2O_5\text{-}10TeO_2$
Te-3: $25Li_2O\text{-}10Al_2O_3\text{-}5TiO_2\text{-}45P_2O_5\text{-}15TeO_2$

Methods: Unconventional wet method of reactant processing followed by melting (1100°C - 1225°C), mechanical homogenization, refining (gas bubbles removal), shaping by pouring the melt into pure spectral graphite mold, preheated, annealing (removal of residual stresses, 390°C - 420°C) and optical processing.

Results:

Property / Glass	Te-1	Te-2	Te-3
Low annealing temperature, T_{IR} (˚C)	394	394	393
Glass transition temperature, T_g (˚C)	429	427	426
High annealing temperature, T_{SR} (˚C)	440	436	436
Softening temperature, T_D (˚C)	453	446	450
Thermal expansion coefficient, $\propto_{20}^{300}$ **x10^{-6}** (K^{-1})	7.68	11.95	11.19

Glass / Property	Diamagnetic susceptibility, χ (cm^3/g), at 300 K	Faraday rotation angle, θ_F (º), at 633 nm	Verdet constant, V (min/Oe/cm), at 633 nm
Te-1	-64(2) ·10^{-8}	0.134	0.019
Te-2	-180·10^{-8}	0.098	0.015
Te-3	-370· 10^{-8}	0.127	0.019

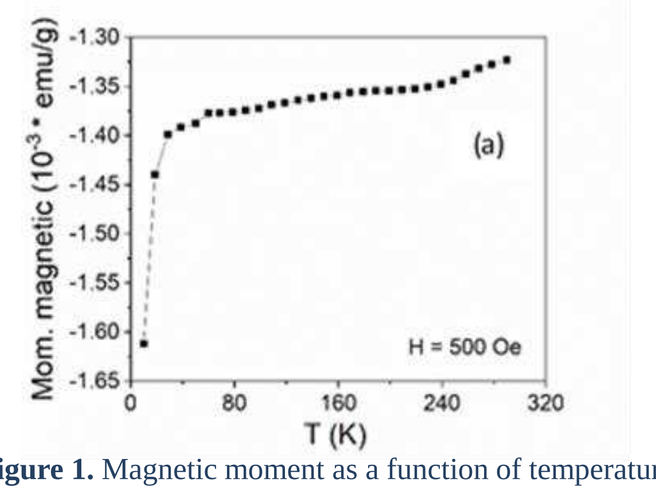

Figure 1. Magnetic moment as a function of temperature

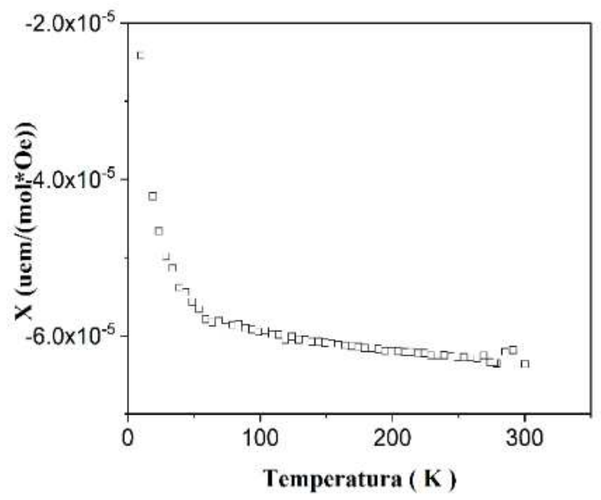

Figure 2. Magnetic susceptibility depending on temperature

Conclusions: The unconventional method ensures a high chemical and optical homogeneity of the phosphate-tellurite vitreous materials and lower melting and annealing temperatures as compared to the conventional glass. Optical transmission of aluminum-phosphate-tellurite bottles containing Li_2O, TiO_2 and ZnO, respectively, at wavelengths of 1700 nm, was higher than 88%.

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