Viscosity of $Ag_x((GeS_2)_{50}(Sb_2S_3)_{50})_{100-x}$ glass-forming system

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Introduction

Chalcogenide glasses are materials that have great application potential. Due to their properties, they can be used as optical fibers, sensors, lenses, or in integrated circuits and in rewritable memories [1, 2]. Viscosity is one of the most important physical property of glass-forming materials. The knowledge of viscosity is important for glass working, manufacturing, or long-term stability of glasses. Viscosity also affects the cold crystallization process which takes place in the undercooled melt region. There are many methods for measuring viscosity. Two of them, penetration method and parallel-plate method, using thermomechanical analyzer (TMA). Mostly, the temperature dependence of the viscosity is studied. According to our knowledge, the viscosities of $Ag_x((GeS_2)_{50}(Sb_2S_3)_{50})_{100-x}$ system has never been investigated.

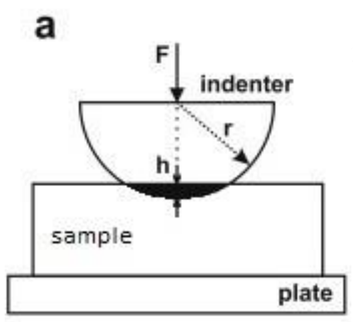
Experimental

- Sample preparation
  - Pure elements (5N purity)
  - Evacuated fused silica ampoules
  - Rocking furnace
  - Amorphous character confirmed by X-ray diffraction
- Thermomechanical analysis
  - TMA CX 03 R.M.I.
  - Linseis PT1600
  - Penetration and parallel-plate methods

Measuring methods

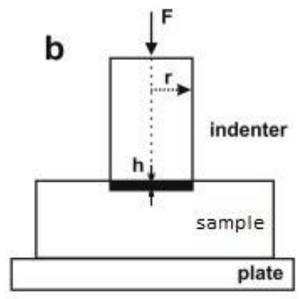
Penetration method (10^7-10^{13} Pa.s)

Hemispherical indenter



$$\eta = \frac{9}{32\sqrt{2R}} \cdot \frac{Ft}{h^{3/2}}$$

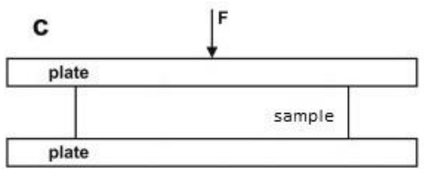
Cylindrical indenter



$$\eta = \frac{F}{8R(dh/dt)}$$

Parallel-plate method (10^6-10^8 Pa.s)

$$\eta = \frac{2\pi F d^5}{3V\, dd/dt(2\pi d^3 + V)}$$

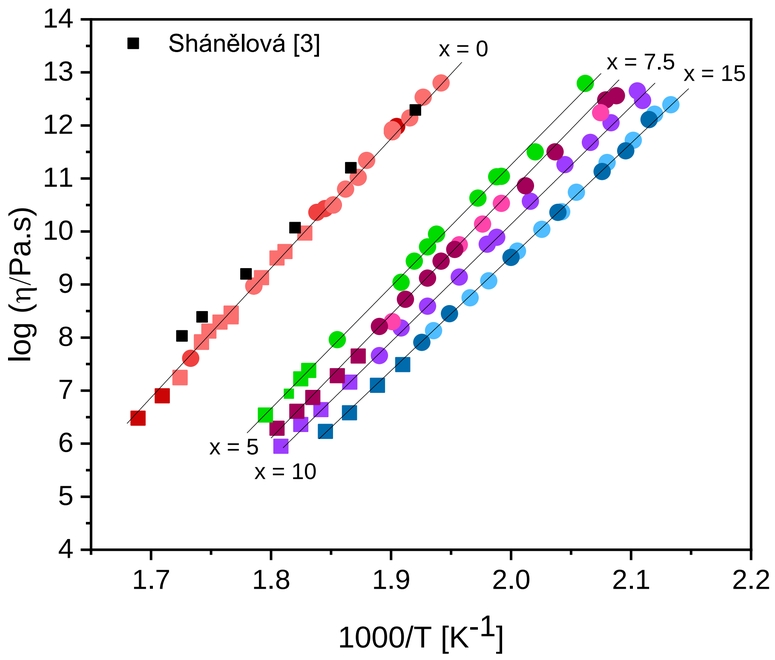


Results

Viscosity measurement

- Viscosities of $Ag_x((GeS_2)_{50}(Sb_2S_3)_{50})_{100-x}$ were determined in the viscosity region 10^6-10^{13} Pa.s
- Measured by penetration and parallel-plate methods
- The viscosity data described by Arrhenius equation

$$\eta = \eta_0 \cdot \exp\left(\frac{E_\eta}{R \cdot T}\right)$$



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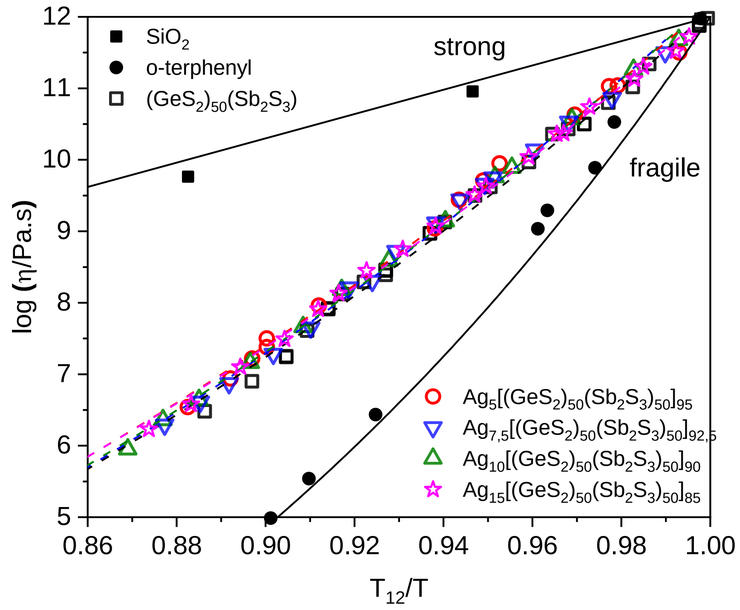
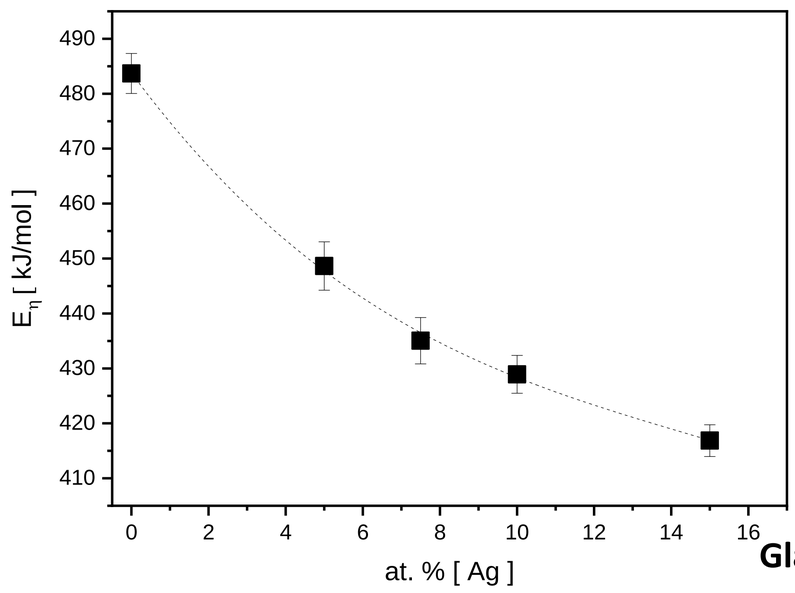
Normalized Arrhenius plot

- Described by Angell [4]
- log η vs normalized temperature T_{12}/T
- Slope of dependence in normalized Arrhenius plot corresponds to kinetic fragility

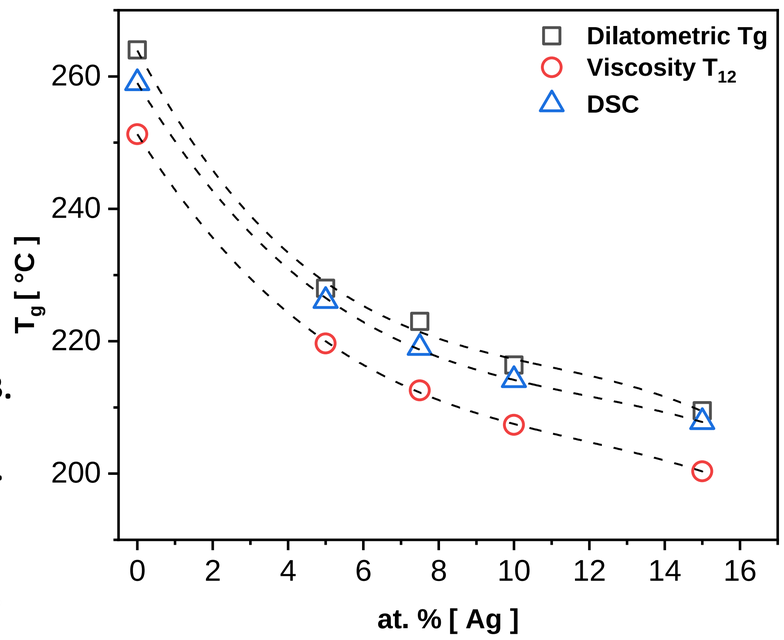
$$m = \frac{d\log\eta}{d(T_{12}/T)} = \frac{E_\eta}{RT_{12}ln10}$$



Activation Energy



Glass transition temperature



Reference

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[3] Shanelova, J., P. Kostal, J. Malek. J. Non-Cryst. Solids. 2006, 352(36-37), 3952-3955.
[4] C. A. Angell. J. Phys. Chem. Solids. 1988, 49(8), 863-871.