Study on glass transition temperature of meta-phosphate glasses

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Glass arises by cooling of a melt or a high temperature solution with rate greater than the critical one in the so-called temperature range of glass transition. Glass formation is not any momentary process as crystallization is, but it is a consecutive one during which the melt viscosity increases, the melt structure starts rearranging and the values of enthalpy, entropy and volume decrease. The adequate temperature range of glass formation is characterized by the temperature of the glass transition - T_G, which as the midpoint of the temperature range of glass transition is determined by thermal analysis methods. Unfortunately, T_G determined in that way depends on the measurement conditions (heating or cooling and their rates) and conditions of glass preparation (thermal history of the glass). These facts disqualify application of T_G as a material constant giving fundamental information about condition of glass preparation. Therefore methods to reduce negative influence of measuring conditions on the T_G determination were searched for. The first researches who were interested in relations between T_G and heating rate during DSC measurements were probably Kovacs [1] and Lasocka [2]. However, the great achievement was attained by developing new extensions to conventional DSC - the Temperature-Modulated Differential Scanning Calorimetry (TMDSC) performed by the TA Instruments [3,4], the Pyris StepScan DSC Software (Perkin-Elmer) and the temperature modulated DSC named TOTEM by Mettler-Toledo [5].

These methods enable one to separate the measured heat flow into the temperature dependent reversing (thermodynamic) component and the time dependent nonreversing (kinetic) one. Using these methods, both T_G and ΔC_P values were obtained, which were independent of their conditions of measurement (heating or cooling) and glass preparation and thermal history of the glass as well. The values of T_G and ΔC_P only depend on the glass chemical composition and accordingly the T_G value determined in a such way can be considered as an actual material constant for the glass of given composition.

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