Difference Between Glass Transition Temperature and Melting Temperature

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Key Difference – Glass Transition Temperature vs Melting Temperature

Investigation of thermal properties of elastomers is essential to decide their final application and manufacturing process parameters. The thermal properties of elastomers can be examined using different test parameters such as transition temperatures, useful temperature range, heat capacity, thermal conductivity, temperature dependence of mechanical properties and coefficient of linear thermal expansion. There are two types of temperature parameters that come under transition temperatures namely, glass transition temperature (T_g) and melting temperature (T_m). In polymer industry, these temperatures are used for the identification of materials and their quality parameters. The transition temperature of polymers can be assessed very accurately by using advanced instruments like dynamic mechanical analyzer (DMA) and differential scanning calorimeter (DSC). **At glass transition temperature, a reversible change in phase from viscous to glassy or *vice versa* occurs in the amorphous regions of the polymer due to a change in temperature, whereas at melting temperature, the crystalline or semi-crystalline regions of a polymer change to a solid amorphous phase.** This is the key difference between glass transition temperature and melting temperature.

What is Glass Transition Temperature?

The glass transition temperature is the temperature at which a viscous or rubbery state of an amorphous or semi-crystalline polymer changes to a brittle, glassy state. This is a reversible transition. Below glass transition temperatures, polymers are hard and rigid like glass. Above glass transition temperature, polymers show viscous or rubbery properties with less rigidity. Glass transition is a second order reaction as there is a change in the derivatives. The changes in polymer above and below occur due to the molecular motion due to energy changes. This temperature is greatly influenced by the structure of the molecules. Moreover, it also depends on the frequency of cyclic deformation, the effect of compounding ingredients such as plasticizers, fillers, etc., and rate of change of temperature.

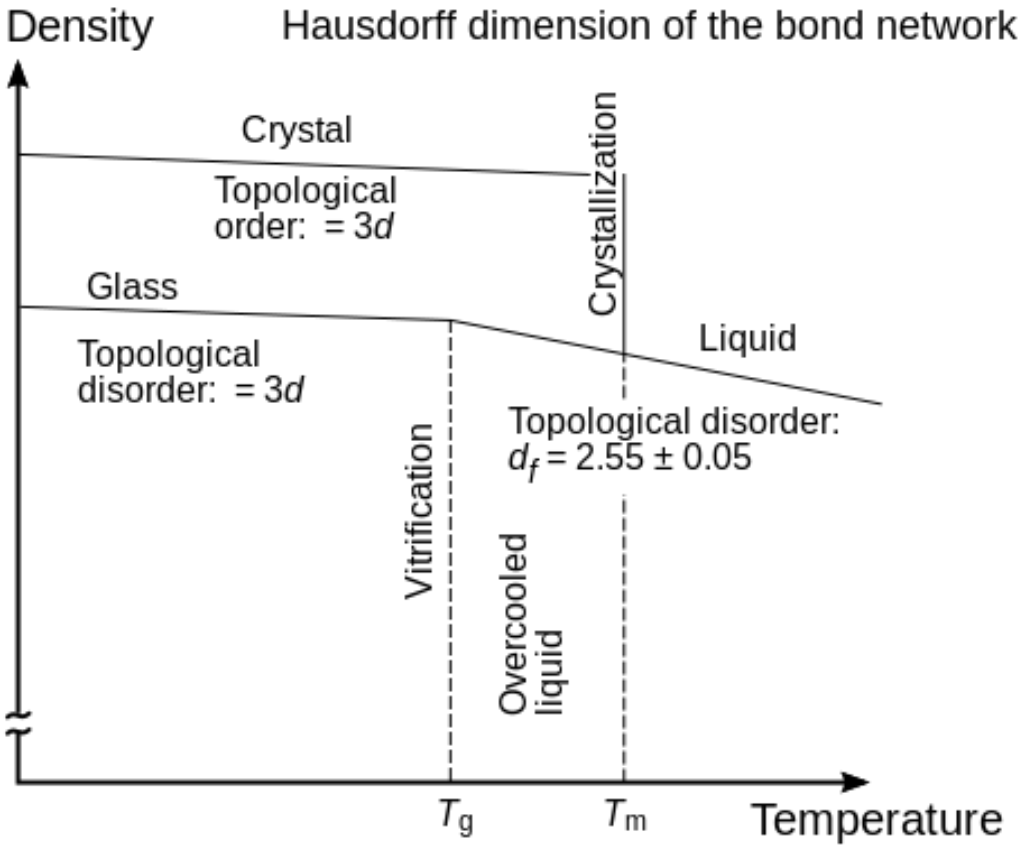

Figure 01: Density on Temperature

As per experimental observations, it is found that in a symmetrical polymer, glass transition temperature is half of its melting temperature, while in an unsymmetrical polymer, glass transition temperature is 2/3 of its melting value (in degrees of Kelvin). However, these relationships are not universal and have deviations in many polymers. Glass transition is important to determine the working range of polymer, evaluating flexibility and nature of the response to mechanical stress.

What is Melting Temperature?

Melting is another important parameter of thermal transitions in polymers. Usually, melting temperature is the temperature at which a phase transition occurs; for example, solid to liquid or liquid to vapor.

Figure 02: Melting

However, as far as polymers as concerned, the melting temperature is a temperature at which a transition from a crystalline or semi-crystalline phase to a solid amorphous phase takes place. Melting is a first order endothermic reaction. The enthalpy of melting of the polymer can be used to calculate the degree of crystallinity, given that the melting enthalpy of 100% of the same polymer is known. Knowing the melting temperature is also very important as it gives an idea about the working range of a polymer.

What is the Difference Between Glass Transition Temperature and Melting Temperature?

Glass Transition Temperature vs Melting Temperature	
Glass transition temperature is the temperature at which a viscous or rubbery state of an amorphous or semi-crystalline polymer changes to a brittle, glassy state.	Glass transition temperature is the temperature at which a viscous or rubbery state of an amorphous or semi-crystalline polymer changes to a brittle, glassy state.

Order of Reaction	
Glass transition is a second order reaction.	Melting is a first order reaction.
Above T_g or T_m	
Amorphous regions become rubbery, less rigid and not brittle	Crystalline regions transform into solid amorphous regions.
Below T_g or T_m	
Amorphous regions become glassy, rigid and brittle.	Stable crystalline regions
Relationship (as per experimental observations)	
Tg =1/2 Tm (for symmetrical polymers)	Tg =2/3 Tm (for unsymmetrical polymers)

Summary – Glass Transition Temperature vs Melting Temperature

Both glass transition and melting temperatures are very important thermal transition properties of polymers. Above glass transition temperature, polymers have rubbery properties, whereas, below this temperature, they have glass properties. Glass transition occurs in amorphous polymers. Melting is the change of phase from crystalline to solid amorphous. Melting temperature is important to calculate the degree of crystallinity. Both temperatures values are extremely useful to determine the quality and working range of polymers.

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