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Glass

Glass is a rigid super-cooled liquid with no definite melting point and a high viscosity that prevents crystallization. On heating, glass softens slowly and finally liquefies. Any substance that has been solidified from the liquid state without crystallization can be referred as glass.

The glass–liquid transition, or glass transition, is the gradual and reversible transition in amorphous materials (or in amorphous regions within semicrystalline materials), from a hard and relatively brittle "glassy" state into a viscous or rubbery state as the temperature is increased.

An amorphous solid that exhibits a glass transition is called a glass.

Glass is a non-crystalline, amorphous solid that is often transparent and has widespread practical, technological, and decorative usage in, for example, window panes, tableware, and optoelectronics. The most familiar, and historically the oldest, types of manufactured glass are "silicate glasses" based on the chemical compound silica (silicon dioxide, or quartz), the primary constituent of sand. The term glass, in popular usage, is often used to refer only to this type of material, which is familiar from use as window glass and in glass bottles.

Main Ingredients of glass

1. Silicon dioxide (SiO_2) is a common fundamental constituent of glass.

2. Sodium oxide (Na_2O) generally obtained from Na_2CO_3, "soda", which lowers the glass-transition temperature. The soda makes the glass water-soluble, which is usually undesirable,

3. Lime (CaO, calcium oxide) generally obtained from limestone, $CaCO_3$.

4. Magnesium oxide (MgO) and aluminium oxide (Al_2O_3) are added to provide for a better chemical durability. The resulting glass contains about 70 to 74% silica by weight and is called a soda-lime glass. Soda-lime glasses account for about 90% of manufactured glass.

Glass

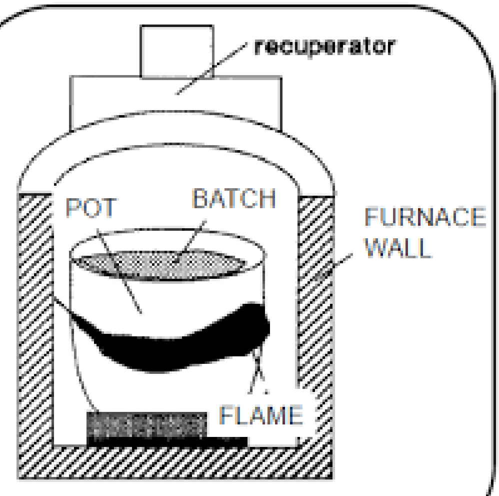
Manufacturing and processing of glass

1. Collection of raw materials: The raw materials such as silica in the form of white sand or quartz (SiO_2), soda ash (Na_2CO_3), lime stone ($CaCO_3$) and cullet (broken pieces) are ground separately and mixed in proper proportion. The fusion of cullet or broken glass is to bring down melting point og the charge. The process is made economical.

2. Preparation of batch: The raw materials, cullet and decolouriser are finely powdered in grinding machines. These materials are accurately weighed in correct proportions before they are mixed together. The mixing of these materials is carried out in mixing machines until a uniform mixture is obtained. Such a uniform mixture is known as the batch or frit and it is taken for further process of melting in a furnace.

Note: The batch of the starting materials (is called a charge) to be melted and loading it into the furnace is called charging the furnace. The intimate homogeneous mixture of raw materials is called batch.

3. Melting or Heating of charge: The Glass batch is melted either in a pot furnace or in a tank/ open hearth furnace furnace made of fireclay or platinum. The heating is continued until the evolution of carbon dioxide, oxygen, sulphur dioxide and other gases stops.



Example of a pot furnace

Glass

Manufacturing and processing of glass

Heating is done by burning producer gas mixed with air over the charge. The broken glass melts first and helps in the fusion of the rest of the charge. A high temperature of 1500 – 1800 °C is maintained to reduce the viscosity of glass melt and to obtain a homogeneous liquid.

The following reactions take place in the manufacture of glass:

$$CaCO_3 + SiO_2 \longrightarrow CaSiO_3 + CO_2$$

$$Na_2CO_3 + SiO_2 \longrightarrow Na_2SiO_3 + CO_2$$

$$K_2CO_3 + SiO_2 \longrightarrow K_2SiO_3 + CO_2$$

Heating is continued till the glass melt is free from gas bubbles like CO_2, SO_2 etc. Undecomposed raw materilas and impurities form a scum called glass gall which is skimmed off. The clear liquid is now allowed to cool after adding the necessary decolorisers or colouring agents. It is cooled to 700-1200 °C, so that it will have the proper viscosity for shaping.

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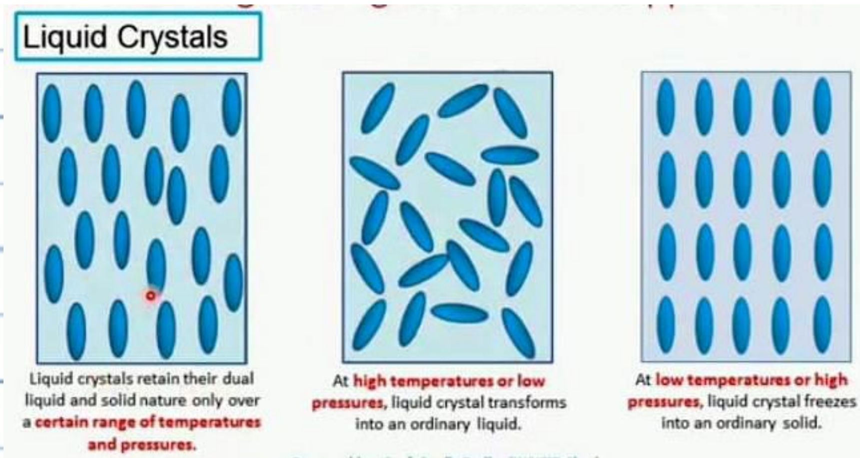
Liquid crystal (LC)

Liquid crystal (LC) phases represent a unique state of matter characterized by both mobility and order on a molecular and at the supramolecular levels. This behaviour appears under given conditions, when phases with a characteristic order intermediate to that of a three dimensionally ordered solid and a completely disordered liquid are formed. Liquid crystals (LCs) have been defined as "orientationally ordered liquids" or "positionally disordered crystals" that combine the properties of both the crystalline (optical and electrical anisotropy) and the liquid (molecular mobility and fluidity) states.



Liquid Crystals : Mesomorphic phases

- There are many liquid crystal phases which can be distinguished on the basis of their different optical properties.
- These are also called as mesomorphic phases.
- When viewed under microscope, using polarized light source, different liquid crystal phases appear to have distinct texture.
- Each patch in a texture corresponds to a domain where liquid crystal molecules are oriented in a different direction.
- Within a domain the molecules are well ordered.

Liquid crystals are usually divided into three classes-smectic, nematic and cholesteric.

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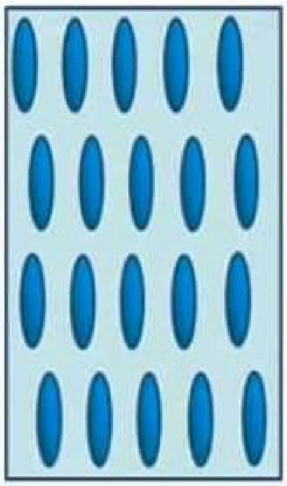
Liquid crystal (LC)

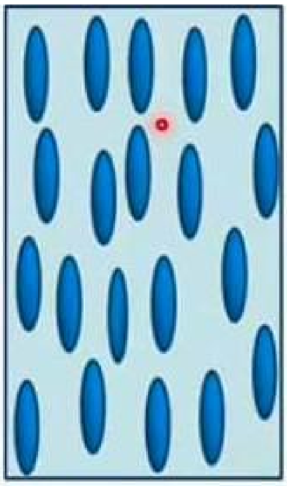
Smectic Phases :

- Smectic phases are found at lower temperatures.
- Aligned molecules are arranged in different layers.
- These form well defined layers that can slide over one another like soap.
- Molecules are ordered along one direction.
- The axes of the molecules are perpendicular to the plane of the layers



Nematic phase :

- Molecules do not have positional order but they have long range orientational order.
- The molecules flow and their center of mass positions are randomly distributed as in a liquid, but they all point in same direction within each domain.
- Nematics have fluidity similar to that of liquids; but they can be easily aligned by an external magnetic or electric field.
- An aligned nematic is characterized by optical properties due to orientational order which can be altered by using electric field or magnetic field.
- This makes them very useful liquid crystal displays.



Cholesteric Phase :

- Aligned molecules are arranged in different layers.
- This phase exhibits twisting of molecules perpendicular to the director, with the molecular axis parallel to the director.
- The axes of the molecules are parallel to the plane of the layers.