Properties of Sulfur

1. Melting/Freezing Point

Sulfur has several melting/freezing points that are commonly dependent upon solid allotrope under consideration (melted) which is shown in Table (2). The maximum intensity/concentration of sulfur can be achieved at a known temperature which represents the low freezing point and is known as the natural melting point. The freezing point of sulfur depends on the temperature and pressure of the mixture/melt.

Table (2) Melting point of various allotropes of sulfur

Allotrope of Sulfur	Melting Point (°C)
α-sulfur	110.06 115.1 112.8
β-sulfur	114.6 119.6 120.4 133
γ-sulfur	106.8 108 108.6
δ-sulfur	160
ω-sulfur	77 90 160 104
Fibrous	75 104
Hexasulfur	50
Heptasulfur	39
Cyclo-S_{12}	148
Cyclo-S_{18}	128
Cyclo-S_{20}	124

2. Viscosity

The viscosity of sulfur depends to a large extent on the temperature. For instance, at 160 °C the viscosity of sulfur decreases by up to 7–8 centipoise, after which viscosity of sulfur increases significantly (approximately 930 poise) at 190 °C and then plummets again. The increase/decrease in viscosity also depends on the concentration/intensity and total length of sulfur chains in the liquid. In view of this, decrement in viscosity (at 160 °C) can be attributed to increase in concentration/intensity and total length of sulfur chains while the decrement in viscosity (after 190 °C) can be justified by the decrease in total length of sulfur chains.

3. Density

Like viscosity, density of sulfur also depends on the temperature. The density of sulfur increases with decrease in temperature as shown in Figure 6. It is reported that as the temperature increases, the polymerization form will be changed from 8 membered rings of sulfur atoms to a long chain with around 106 million atoms which this new polymerization shape reduces the density of sulfur. However, there is a constant temperature at which the polymerization of sulfur changes its several properties (like viscosity and density). This temperature is known as Lambda Temperature. Sulfur is known as an element which has the largest number of solid allotropes and most of them have cyclic molecules with ring size range between 6 and 10. The density of various allotropes of sulfur in Lambda Temperature is given in the Figure 7.

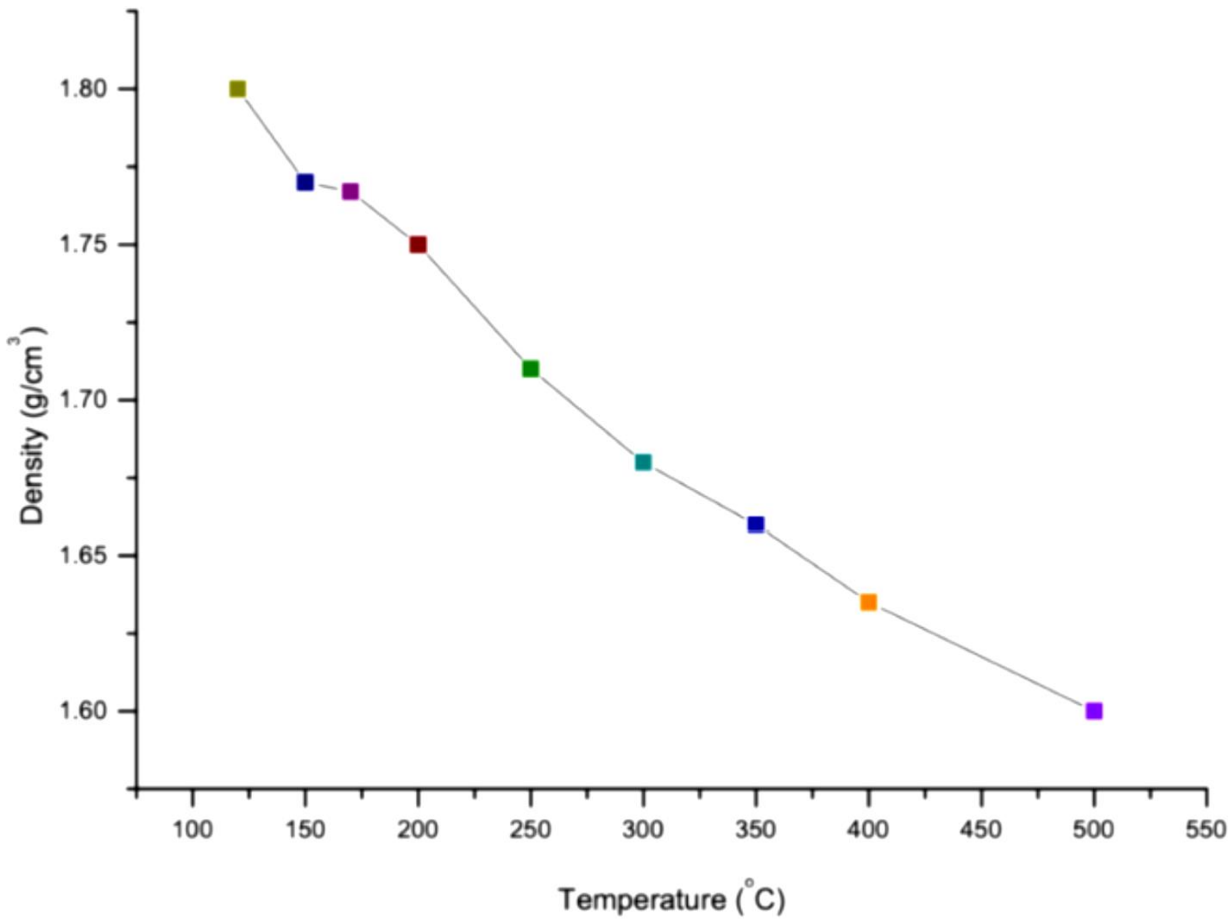

Figure 6. Density of sulfur in accordance with temperature and allotropes

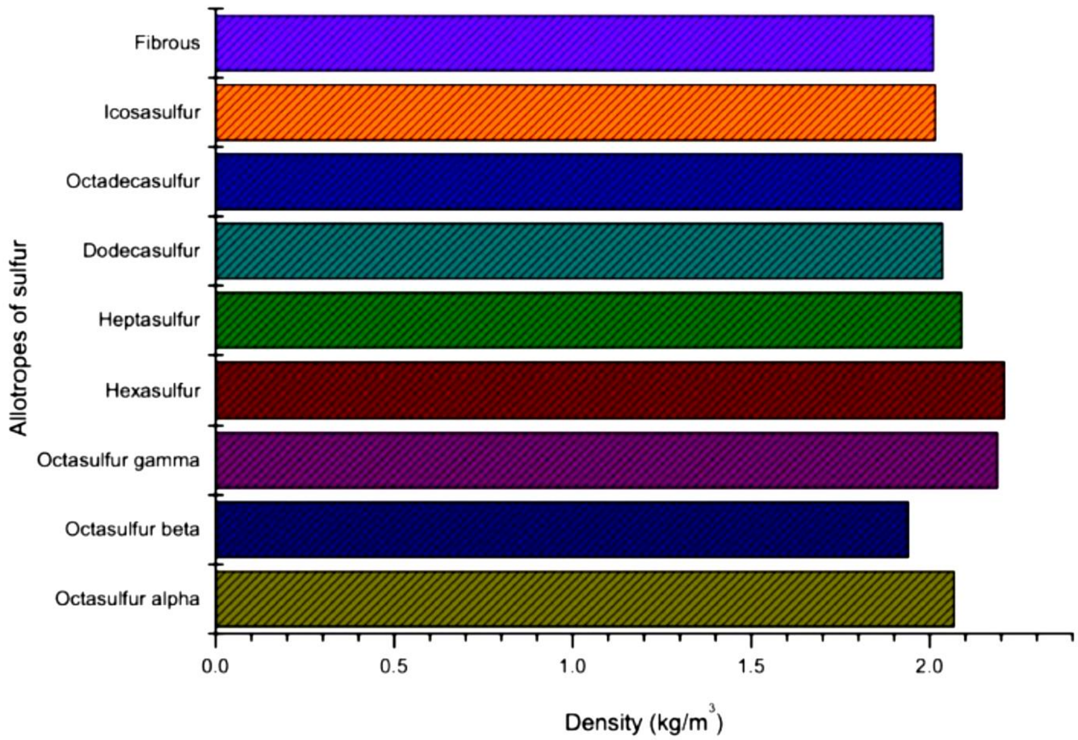

Figure 7. Density of sulfur in accordance with temperature and allotropes

4. Color

Different allotropes and melts of sulfur have different colors as shown in Table 3. For instance, pure sulfur at its melting point has a clear and a bright yellow color which continuously changes to deep/opaque red at its boiling point. As sulfur is recovered in the molten/melt state, the cooling rate plays an important role in defining the color of sulfur. For example, if the molten sulfur is cooled at the temperature 80 °C (boiling point) the color would be yellow; however, if the melt is cooled at temperature 209°C (in liquid nitrogen), red colored sulfur will be obtained.

Table 3. Colors of various allotropes of sulfur.

Allotrope of Sulfur	Color
Octasulfur alpha	Bright yellow
Octasulfur beta	Yellow
Octasulfur gamma	Light yellow
Hexasulfur	Orange to red
Heptasulfur	Light yellow
Anneasulfur	Deep yellow
Decasulfur	Yellow to green
Octadecasulfur	Lemon to yellow

5. Thermal Conductivity

Like density and viscosity, thermal properties of sulfur also suffer from discontinuity due to polymerization at Lambda Temperature. There is a linear relation between thermal conductivity and temperature. First, by increasing the temperature, the thermal conductivity of sulfur decreases till it reaches to the phase change from solid (monoclinic) to liquid sulfur; thereafter, after a fall, the thermal conductivity rises by increasing the temperature. Moreover, thermal conductivity of sulfur (solid/liquid) at respective atmospheric pressure is dependent on temperature. It is concluded that thermal conductivity of solid sulfur is greater than liquid sulfur.