# K.T.S.P. Mandal's

# Hutatma Rajguru Mahavidyalaya, Rajgurunagar

# Department of Chemistry

# T.Y.B.Sc. Sem-V

# Industrial chemistry paper-505

Associate Prof. Kolekar S.S.

As per new revised choice based credit system syllabus w.e.f. June 2021



Manufacture of SulphuricAcid Physico-Chemical Principles (For Contact Process), Important Uses of Sulphuric Acid,

Sulphuric acid is one of the most important chemicals produced by chemic industry. The progress of chemical industries is measured by the amount of sulphuric ac consumed. Sulphuric acid is used in the manufacture of fertilizers, leather, refining petroleum, dyeing of fabrics, electrorefining processes, industrial explosives, plastics etc.

## Manufacture of Sulphuric acid by Contact Process

Contact process for the manufacture of sulphuric acid involves following three steps –

Preparation of $SO_2$ from Sulphur or pyrite.

Conversion of $SO_2$ to $SO_3$ by atmospheric oxygen in presence of platinized asbestos or $V_2O_5$ catalyst.

Absorpton of $SO_3$ by water to form $H_2SO_4$.

**Raw material**

The raw material required for contact process is mainly Sulphur or metallic sulphide. Iron sulphide such as pyrite FeS2 are used. Non ferrous sulphides such as CuS, PdS, Nis and ZnS may be used. Dry air and steam are also used in the process.

**Description of Plant and Process**

The plant used in the contact process consists of five main parts

(i) Sulphur or Pyrite Burners (ii)
(ii) Purifying unit (iii)
(iii) Testing box (iv)
(iv) Contact converter (v)
(v) Absorption unit.

**Sulphur or Pyrite Burners**: Sulphur or iorn pyrite ($FeS_2$) is burnt with a good supply of air to produce sulphur dioxide, in a furnace called burner.

**Purifying Unit**: When pure Sulphur and pure air are used for production of sulphur dioxide, purification is not essential However, sources like pyrite contain impurities like dust, moisture and they need purification

**Testing Box**:

This is a rectangular box, darkened from inside, it is also called a Tyndall box. In order to be sure that the gases are free from dust and As2O3 particles and gases are led in the testing box. It is viewed through a hole perpendicular to the path of light. A strong beam of light is thrown against the gases. Solid particles (impurities) if present male path of light visible due to scattering of light by them.

**Contact Converter**: In this part, the sulphur dioxide is oxidized to sulphur trioxide atmospheric oxygen in presence of platinized asbestos or $V_2O_5$ catalyst at 500° to 600°C

**Absorption Unit**:

Sulphur trioxide released from converter cannot be directly absorbed in water because it results in the formation of dense sulphuric acid fog (mist), due to exothermic reaction.

$$H_2O + SO_2 \longrightarrow H_2SO_4 + 101\ kJ$$

The sulphuric acid fog consisting of small droplets of sulphuric acid molecules encloses water molecules as well as sulphur trioxide molecules. These droplets cannot be dissolved in water by any means.

## Physico- Chemical Principles (For Contact Process)

$$2SO_2 + O_2 \rightleftharpoons 2SO_3 + 196KJ$$

The reaction is reversible and the forward reaction is exothermic There is decrease in volume when sulphur trioxide is formed Hence according to Le Chatelier's principle, low temperature, high pressure and increased concentration of $SO_2$ or $O_2$ should favors the formation of sulphur trioxide. However, at low temperature, the rate of the reaction slow Hence, in practice an optimum temperature is kept Further, a catalyst in used to increase the rate of the reaction. The conditions used to get better yield of $SO_3$ are

**Effect of Temperature**: The oxidation of $SO_2$ to $SO_3$ is an exothermic process Experimentally, it is found that rise in temperature decreases the conversion of $SO_2$ to $SO_3$

| Temperature $^0C$ | 434 | 500 | 550 | 645 |
|---|---|---|---|---|
| % of $SO_3$ (at 1.5 atm) | 99 | 93 | 85 | 60 |

It is observed that the yield of $SO_3$ decreases at higher temperature. At 400°C the conversion of $SO_2$ to $SO_3$ Is nearly 100% but the rate of attainment of this equilibrium is very slow. The rate of reaction at 500°C is 10 times as fast as that at 400°C. At 550°C, it is the fastest. But we have seen that increase of temperature decreases the yield of $SO_3$ Thus there is a conflict between the favourable equilibrium conversion at low

temperature and the favourable rate at high temperature. The reverse reaction does not take place appreciably below 550°C. Hence the conversion is carried out in two stages. About 80% conversion is carried out in the first singe and 99% conversion is carried out in the second stage. In the first stage, the temperature is maintained at 595°C and in the second stage out coming gas has temperature 450°C. Then100% conversion is take placed, The optimum temperature range for the oxidation process is 450°C to 550°C

**Effect of Pressure:** Formation of sulphur trioxide takes place with decrease in volume. According to Le-Chatelier's principle, increase in pressure should give more yield of $SO_3$ However, $SO_3$ is strongly adsorbed on the surface of the catalyst and it is through this layer of adsorbed $SO_3$ that the gases $SO_2$ and $O_2$ have to diffuse and come in contact with the surface of the catalyst. Increase in pressure increases the thickness of the adsorbed layer of $SO_3$ and hence the gases $SO_2$ and $O_2$ find it difficult to come in contact and to react with each other on the surface of catalyst. Due to this reason, high pressure is not employed. The process is carried out at a pressure of 1.5 to 1.7 atmospheres.

**Effect of Concentration**: According to Le Chatelier's principle, an increase in concentration of $SO_2$ in preference to $O_2$ would have more effect on shift of equilibrium because concentration of $SO_2$ appears as a square term in the equation. However, in practice, the aim is to get maximum yield of $SO_3$from the given amount of $SO_2$, Therefore, oxygen is used in greater proportion. Thus, the gaseous mixture which enters the chamber has an approximate composition, 8% $SO_2$ and 10% $O_2$ and rest is $N_2$ gas. Usually, oxygen is mixed with $SO_2$ in the proportion 3:1 by volume.

**Effect of Catalyst:** For oxidation of sulphur dioxide to sulphur trioxide different catalysts have been tried so that the equilibrium can be reached in short time. The platinized asbestos and $V_2O_5$ (also called vanadium) are preferably used as catalyst. This catalyst can bring about 95-96 %

conversion of $SO_2$ to $SO_3$ at an optimum temperature of 450°C. The activity of the catalyst is reduced with the use and life of the catalyst becomes short. About 90% of the original Pt metal can be recovered from the wornout catalyst.

**The favourable conditions for the better yield of $SO_3$ are**

a) Temperature 450°C to 550°C.

b) Pressure: 1.5 to 1.7 atmosphere

c) Catalyst: platinized asbestos or $V_2O_5$

d) Proportion of SO2 to O2 is 1:3

**Important Uses of Sulphuric Acid**

1. Sulphuric acid is extensively used in laboratory and in industry.
2. Hydrogen peroxide is obtained by the hydrolysis of persulphuric acid.
3. It is used as a catalyst and as a dehydrating agent in esterification reactions.
4. It is used in preparation of explosives such as trinitrotoluene (TNT), trinitrophenol (Picric Acid)
5. It is used in the intermediate compounds in the preparation of dyes such as nitrobenzene, nitrotoluene nitroglycerine, trinitro-cellulose requires concentrated $H_2SO_4$ and conc. $HNO_3$

vi. It is used in the manufacture of synthetic fertilizers like superphosphate of lime, triple phosphate and ammonium sulphate,

References: According to the new revised syllabus of Savitribai Phule Pune University from June 2021, Text book of Industrial chemistry for T.Y. B.Sc. course (CH- 505), Sem-V Manali Publication, Nirali Publication and google images