

Technologies for Safe Handling of Carbon Disulphide in Viscose Process

What is Viscose Fibre?

Invented in the 1890s, by French scientist *Hilaire de Chardonnet*, Viscose, also known as rayon, is a nature-based fibre made from sustainably sourced wood. The first commercial viscose rayon was produced by a British company in 1905. The 'artificial silk' attained the name "Viscose Rayon" in 1924.

To transform the goodness of natural cellulose contained in wood from a raw form to a usable one (viscose), the cellulose needs to be extracted, dissolved, and extruded into fibres. Carbon disulphide (CS_2) is used as a solvent to dissolve cellulose contained in pulp to form a solution called viscose, which is regenerated into pure and fine cellulosic fibres. The viscose fibres are popular choices for fashion garments as well as hygiene products such as wipes.

Viscose is one of the most sustainable fibres available today. It is nature based; produced with low environmental impact, and biodegradable. Newer technologies have helped in addressing the risks related to manufacturing viscose with the use of CS_2 . While the advanced technologies available today make it safe to manage the risks of CS_2 , it is important to understand the risks related to health and safety and how these can be addressed by control technologies. This article describes control technologies used at Birla Cellulose viscose manufacturing facilities, enabling safe handling of chemicals and management of the process in an eco-friendly manner.

Health Impacts of CS_2

CS_2 is a colourless, highly volatile, and flammable liquid chemical compound. It has a sweet aromatic odour and is heavier than water. It is typically stored under a layer of water in a tank or container.

Extensive researches have been carried out on the impact of CS_2 exposure on human health. A study by the World Health Organisation (WHO) documents these researches and compares the health impacts at different levels of exposure. The WHO study states that a chronic exposure of CS_2 at concentrations above 30 mg/m³ (ppm) for 10 years or more can lead to observable adverse health impacts including increased risk of Coronary Heart Diseases (CHD). The health impacts of CS_2 below the concentration of 20 ppm have not been validated with reliable data, and any health impact of concentration below 10 ppm have not been reported, the study noted. Short-term accidental exposure of very high concentration of CS_2 may result in nausea and dizziness.

In the process of viscose fibre manufacturing, CS_2 is released along with small quantity of hydrogen sulphide (H_2S). These gases released during the regeneration process can enter the environment, causing harm if not collected and recovered for safety and environment considerations.

In the early development of the Viscose process, the main reasons for a high level of CS_2 exposures were low understanding of risks and non-availability of emission control and recovery technologies. As the knowledge around this area increased, there were better technologies developed to contain CS_2 and limit the exposures in the safe range.

The WHO study notes that between 1955 and 1965, the average concentration of CS_2 in the viscose plant was around 250 mg/m³, which reduced to around 20-30 mg/m³ by the 1990s. Based on scientific studies, Occupational Safety and Health Administration (OSHA) has recommended permissible exposure limit-time weighted average (PEL-TWA) of 20 ppm for CS_2 . This means, the average exposure level in an eight-hour shift on a shop floor should not exceed 20 ppm.

For the communities surrounding the manufacturing sites, WHO recommends the safe CS₂ concentration in ambient air to be below 100 microgram/m³.

Development of Technologies for Safe Use of CS₂

By late 1970s, the risks of CS₂ exposure to the workers and the surrounding community were well understood. This awareness resulted in extensive work on development of technologies to control and mitigate risks. By the turn of the century, newer technologies emerged that enabled running of the viscose process in a way that had excellent controls to minimise the emission of gases such as CS₂ and H₂S into the environment. Implementation of these technologies resulted in creating a safe working environment by following the WHO and OSHA norms.

Technologies for Control of CS₂ and H₂S

At Birla Cellulose sites, a combination of several closed-loop technologies is used in the viscose manufacturing process. In addition to closed-loop technologies, there are engineering controls that ensure safe handling of CS₂ and H₂S at all times.

CS₂ is used in the viscose manufacturing section. When viscose is regenerated into fibres, CS₂ is released during the spinning process along with H₂S. The usage point of CS₂ is shown in the chart titled “Dissolution in CS₂” and the CS₂ release point is shown in the chart titled “Coagulation and Regeneration” in the process diagram.

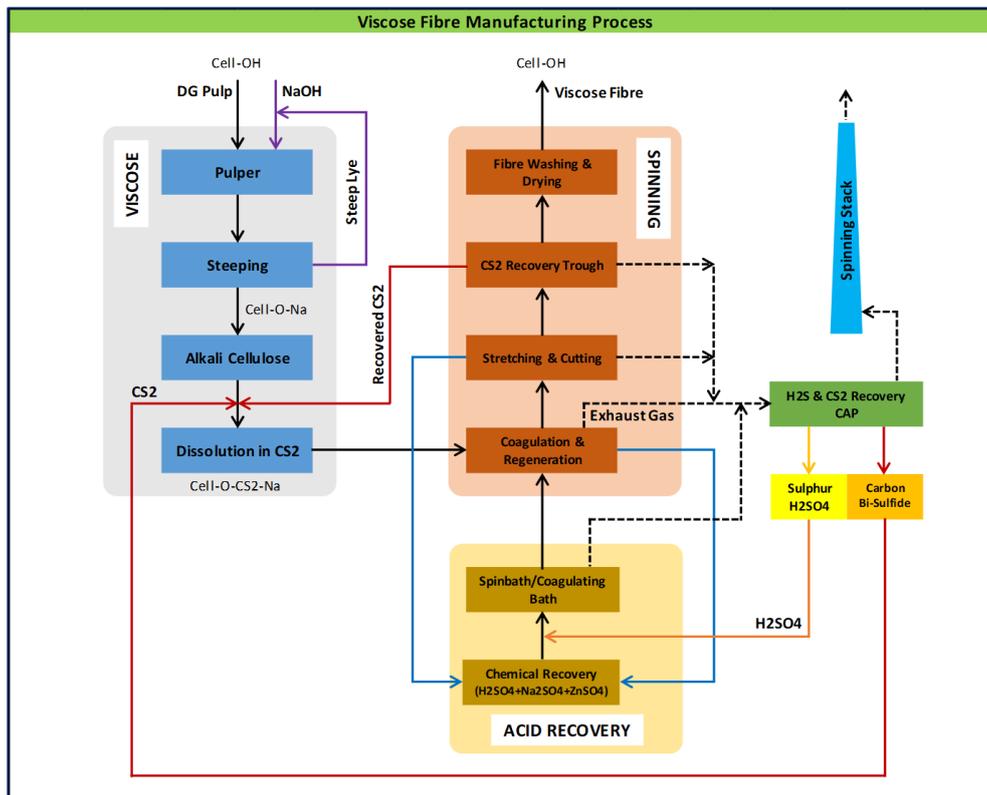


Figure 1 – Viscose Fibre Manufacturing Process

From the health and safety point of view, it is important to implement the controls in these two sections (Dissolution and Coagulation & Regeneration) specially. The acid recovery section tanks can have some dissolved gases that need to be collected and directed to control technologies. The gases that are collected and treated, need to be finally exhausted through a tall chimney to take care of dispersion over a large area.

At Birla Cellulose sites, there are several controls applied to ensure a safe work environment at all locations where the CS₂ gas is present. Some of the key technologies that have been applied are:

1. The dissolving of cellulose in CS₂ is carried out in fully enclosed reactors under vacuum. The gas generated during start and stop of the process is exhausted through a gas collection system.
2. The cellulose (fibre) regeneration reactions are carried out in enclosed frames of the spinning machine. The gases released during the regeneration and chemical recovery system are collected by exhaust systems.
3. Much of the CS₂ released during the regeneration of viscose is collected and condensed in the equipment called recovery trough. The recovered CS₂ is reused in the process.
4. Gas mixtures rich in CS₂ and H₂S collected from spinning and acid recovery sections are directed to the chemical recovery section. There are several technologies applied for gas recovery such as CS₂ condensation, CS₂ adsorption on carbon (CAP), wet scrubbing system (WSA), conversion of H₂S to sulphur by redox system.
5. Work rooms are fitted with a powerful ventilation system.
6. Real-time CS₂ and H₂S monitoring systems and detection systems have been installed at critical locations in the plant capable of raising the alarm in case gas concentration begins to exceed the safety limit.
7. Workers are extensively trained on safety and health aspects, and provided appropriate personal protective equipment (PPE) such as a face/nose mask, safety goggles, and hand gloves suitable for the work they are doing.
8. The ambient air in the surrounding community outside the site is periodically monitored for quality, including CS₂ and H₂S concentration. These measurements are done in multiple directions to take care of the direction of airflow and carried out for long durations. The monitoring is carried out by a third party approved by the government.
9. Periodic health check-ups of all employees are carried out by government-authorized doctors.
10. All major processes have been converted to remote control by Distributed Control System (DCS) to minimise manual handling, wherever possible.
11. Real-time ambient air monitoring data is displayed at the factory gates for the benefit of the local community and to share information in a transparent way.

Some of these technologies (#2 & 3) are described in the EU BAT Standards (Reference Document for Best Available Technology for Production of Polymers). The newly released ZDHC Guidelines for responsible MMCF production also include a section on the guidance for ambient air monitoring (#7).

Likewise, in the Spinning department, machines with glass shutters and proper sealing in all joints have been introduced to avoid any vapour leakages. The shutters are always kept closed and opened only during any maintenance activity.

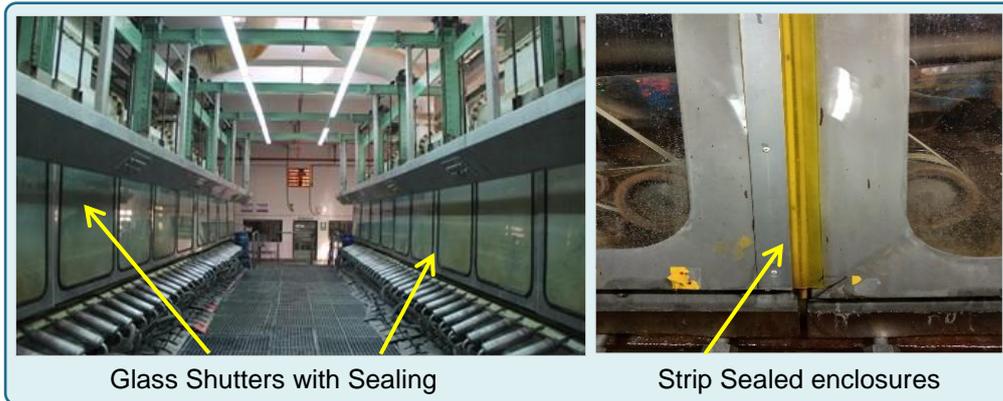


Figure 2 – The spinning machines equipped with BAT technologies of spinning machine

CS₂ and H₂S sensors with alarm systems are provided on all spinning machines to alert the working personnel in case of a leakage. Exhaust ducts and fresh air blowers are located at the machine area. The presence of CS₂ in the ambient air inside and outside each workstation is monitored. Tight control on emissions ensures that the gas levels remain within the safe limits. All these systems are continuously monitored, well maintained, and reviewed in all units to ensure a safe working environment.

Results and Way Forward

The applications of advanced technologies and control systems at Birla Cellulose viscose manufacturing sites have resulted in a safe work environment. The CS₂ and H₂S concentrations are continually monitored at the workplace, and the average exposure would be a small fraction of OSHA recommended safe limits. The ambient air concentrations measured around our sites have consistently been below the WHO prescribed safe limits, ensuring safety for the community living around these sites. The medical inspection records of past several years have not shown any pattern or cases related to adverse impact of health due to exposure of CS₂, H₂S, or other chemicals. This has demonstrated effectiveness of the control measures and the technologies applied. Birla Cellulose is committed to continually improve and adapt newer technologies and best practices in health and safety of people who work at its facilities and the surrounding communities.