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BRIEFING

The Evolving Carbon Disulfide Landscape

How CS_2 is redefining its industrial applications and shaping emerging green production routes.

Introduction

Carbon Disulfide (CS_2) is a versatile industrial chemical used primarily in rayon, cellophane, rubber processing, and agrochemicals. Its unique solvency and reactivity make it vital across textiles, agriculture, and specialty chemicals.

In this briefing, we explore the evolving market dynamics, emerging green production routes, and new application opportunities shaping the future of CS_2.

Production Process of CS2

Traditional Processes:

1. **Charcoal and Sulfur Vapor:**
   Historically, CS_2 was manufactured on an industrial scale by reacting carbon, typically in the form of charcoal, with sulfur vapor at high temperatures between 750°C and 900°C.

2. **Natural gas and Sulfur (mainly used in the U.S.)**
   In this process, the CS_2 is produced through a catalytic reaction where the natural gas is passed over a bed of sulfur.

Modern Processes:

1. **Process:**

   Methane from natural gas reacts with liquid sulfur at 550–650 °C over catalysts (e.g., silica or alumina) to produce CS_2 and H_2S.

   Reaction: $2\ CH_4 + S_8 \rightarrow 2\ CS_2 + 4\ H_2S$

2. **Separation & Purification:**

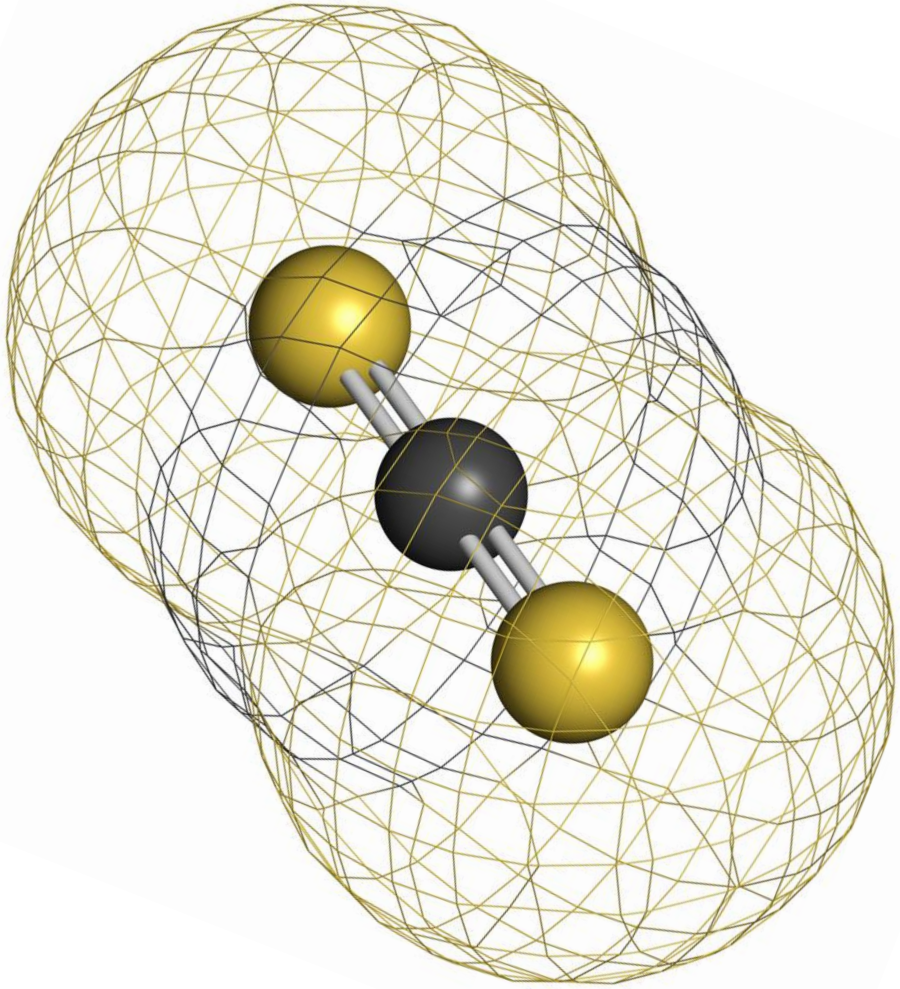
   Excess sulfur and H_2S are recovered; crude CS_2 is purified via fractional distillation and caustic washing to 99.99% purity.

3. **Efficiency & Sustainability:**

   Lower temperature than the charcoal method, catalytic process, and closed-loop H_2S recovery (Claus plant) reduces emissions.

4. **Risks:**

   Highly flammable and toxic; requires robust safety and environmental controls.



Major Applications of CS_2

1	**Viscose Rayon & Cellophane**	**~60-70% of global CS_2 production** is used in manufacturing viscose rayon fibers and cellophane films. Reacts with cellulose to form cellulose xanthate, enabling spinning into fibers (rayon for textiles, non-wovens) or films (cellophane for packaging)
2	**Rubber Industry**	Dithiocarbamates and some xanthates act as vulcanization accelerators, crucial for improving rubber's strength, elasticity, and durability
3	**Mining**	Xanthates (made from CS_2) are indispensable froth flotation agents for separating valuable metal ores (e.g., copper, zinc, lead) from gangue. Highly effective and cost-efficient.
4	**Chemicals and Agrochemicals**	Precursor for various organosulfur compounds used in pharma, highly specialized solvents, and some niche applications. Dithiocarbamates are widely used as fungicides and pesticides for crop protection.
5	**Others**	Used as solvents for fats, resins, sulfur, bromine, iodine, and phosphorus in specialized industrial processes

Source: >>, FutureBridge analysis

Major Producers of CS_2

Major producers are located in China and are focused on supplying to the textile, packaging, and rubber industries. The global CS_2 market was about 2.2 million tons in 2022 and is projected to reach 3 million tons by 2032.

The market is concentrated, with production largely dictated by demand from the viscose rayon, rubber chemical, and mining sectors. Asia-Pacific is the largest consuming and producing region.

Producer	Country/Region	Main Locations	Estimated Capacity*	Notes
Shanghai Baijin Chemical Group	China	Shanghai	350–400 KT/year	Largest global producer, export leader
Jiangsu Jinshan Chemical	China	Jiangsu	250–300 KT/year	Major APAC supplier
ShanXiJinxinghua Chemical	China	Shanxi	150–200 KT/year	Focus on rubber and rayon sectors
PT. Indo Raya Kimia	Indonesia	Indonesia	100–150 KT/year	Largest in SE Asia
Arkema Group	France/ Global	France, USA	100 KT/year (global)	Specialty and technical grades
Merck KGaA	Germany/ Global	Germany, USA	50–80 KT/year	Pharma/research focus
Akzo Nobel N.V.	Netherlands/ Global	Netherlands, China	Not disclosed	Global supplier, specialty chemicals
Nouryon	Netherlands/ Global	Netherlands, USA, Saudi Arabia	Not disclosed	Large global supplier
Gujarat Alkalies & Chemicals Ltd	India	Gujarat	25–50 KT/year	Leading Indian producer

Source: >>, FutureBridge analysis

* Capacities are approximate and based on available industry data

KT stands for kilo/thousand tons

Carbon Disulfide (CS2) Green Production Routes

The greenest current route for CS_2 production is the closed-loop viscose process with high solvent recovery and sulfur recycling, as implemented by leading producers like Birla Cellulose.

Innovations in Green CS_2 Production

- **Electrification & Renewable Energy** – Replacement of fossil fuels with renewable electricity for process heat and reactors to significantly reduce the carbon footprint.
- **Advanced Closed-Loop & Recovery Systems** – Implementation of next-gen closed loops with >99% CS_2 recovery, automated leak detection, and integration with carbon capture to minimize fugitive emissions.
- **Green Feedstocks & Chemistry** – Use of biomass-derived carbon (biochar, biogenic methane, CO_2 from processes like DOC/DAC) and green hydrogen (via electrolysis) to cut lifecycle emissions and reduce fossil dependency.
- **Process Intensification & Modularization** – Deployment of continuous-flow microreactors and modular units that enable high yield, energy efficiency, and localized production.
- **Digitalization & AI Optimization** – Application of AI and advanced control systems to optimize temperature, pressure, and feed ratios in real time, while using smart sensors for predictive maintenance and emission control.
- **By-Product Valorization & Circularity** – Conversion by-products like sodium sulfate into value-added chemicals and integrate CS_2 production with other low-carbon industrial ecosystems (e.g., green steel, cement).
- **Biogenic & Microbial Production (Long-Term)** – Explore CS_2 biosynthesis using microbes or enzymes, mirroring natural sulfur cycles, as a future ultra-low-impact production route (currently at research stage).

Route/ Technology	Green Features/Benefits	Commercial Status
Closed-loop viscose process	95%+ CS_2 recovery, sulfur recycling, minimal emissions, water/energy efficiency	Widely adopted in modern plants (e.g., Birla Cellulose)
Methane (natural gas) + sulfur	Lower carbon intensity, sulfur recycling, potential for renewable energy integration	Commercial (select regions)
Green coke as carbon source	Reduces deforestation, uses refinery by-product, scalable	Patented, some adoption
Electrification of process heat	Enables use of renewable energy, reduces GHG footprint	Emerging, pilot scale
Biogenic/ microbial production	Potential for ultra-low-impact CS_2, but not yet industrially viable	Research stage

Source: >> FutureBridge analysis

Demand Opportunities: New and Emerging Applications of CS2

Emerging and new priority applications for carbon disulfide (CS_2) are diversifying beyond its traditional roles in viscose rayon, cellophane, rubber chemicals, and agrochemicals.

Application Area	Details & Drivers
Pharmaceuticals	• Growing use as a solvent and intermediate in the synthesis of proprietary pain, anti-infective, and anti-cancer agents • Demand for specialty organosulfur compounds and pharmaceutical intermediates is increasing
Eco-Friendly Materials	• Rising demand for sustainable and biodegradable products (notably viscose rayon and cellophane) as alternatives to plastics • CS_2 is essential in the production of these materials, which are favored for green packaging and textiles
Specialty Chemical Synthesis	• Used as a key reagent in the synthesis of advanced sulfur-containing intermediates for agrochemicals, dyes, and specialty polymers • Growing market for laboratory-grade solvents and custom synthesis
Advanced Containment & Processing	• Innovation in closed-loop and safer processing systems is enabling new business models and applications where CS_2's toxicity previously limited its use. • Chemical recycling and emission reduction techniques are creating new opportunities.
Polymer & Material Science	• Research into new polymer products and specialty materials for pharma and high-performance applications is expanding. • CS_2 is used in the production of certain specialty polymers and as a functionalization agent in material science.
Catalysis & Green Chemistry	• Emerging use of CS_2 in catalytic processes and as a reagent in green chemistry initiatives, including novel catalysts for hydrolytic desulfurization and other sustainable syntheses.

Latest Trends and Developments:

- Pharmaceuticals and specialty chemicals are forecasted to be the fastest-growing new segments, driven by demand for advanced intermediates and solvents.
- Eco-friendly materials (biodegradable cellophane, sustainable viscose) are gaining rapid traction as regulatory and consumer pressure mounts for alternatives to single-use plastics.
- Safer and greener processing (closed-loop, air filtration, chemical recycling) is enabling CS_2 to be used in new applications with stricter environmental and workplace safety requirements.
- R&D in catalysis and material science is opening new uses for CS_2 in advanced functional materials and green chemistry

Source: >>, >> FutureBridge analysis

Demand Threats: Current and Potential Substitutes of CS2

The Lyocell process (e.g., Lenzing's TENCEL) is the leading commercial alternative, replacing CS_2 with NMMO, a non-toxic, recyclable solvent. Enzymatic processes are under research for CS_2-free cellulose fiber production.

Application	Traditional Role of CS_2	Current Substitutes	Emerging/Research Substitutes	Notes/Drivers
Textiles (Viscose Rayon, Cellophane)	Solvent and reactant in viscose process	Lyocell (TENCEL) process using N-methylmorpholine N-oxide (NMMO); Modal; Bamboo fiber	Ionic liquid-based cellulose dissolution; Enzymatic/aqueous cellulose processes	Lyocell is the main commercial "greener" alternative; research into CS_2-free cellulose fiber production is accelerating.
Rubber Accelerators & Vulcanization	Precursor for xanthates, thiurams, dithiocarbamates	TBBS, CBS, MBTS (alternative accelerators with lower toxicity)	Green chemistry routes for sulfur cross-linking; bio-based accelerators	Substitution limited by performance needs; some alternatives are less hazardous but may not match CS_2-based chemistry.
Agrochemicals (Pesticides, Fumigants)	Precursor for dithiocarbamates, soil fumigants	Chloropicrin, metam sodium, biofumigants (mustard meal, neem extracts)	Microbial and plant-derived biopesticides, precision agriculture	Regulatory bans on some CS_2-derived pesticides in EU/US are accelerating the search for safer, targeted alternatives.
Solvents	Extraction of oils, fats, waxes; lab reagent	Supercritical CO_2, hexane, acetone, green solvents (ethyl lactate, dimethyl carbonate)	Deep eutectic solvents, bio-based solvents	Supercritical CO_2 and green solvents are preferred for food/pharma due to safety and sustainability.
Mining (Flotation Agents)	Xanthates for mineral separation	Dithiophosphates, thionocarbamates, green flotation reagents	Biodegradable surfactants, bioflotation agents	Environmental impact and tailings management drive adoption of less toxic alternatives.
Specialty Chemicals & Pharma	Intermediate for organosulfur compounds	Direct synthesis from elemental sulfur, alternative sulfur transfer reagents	Catalytic/enzymatic sulfur incorporation, green synthesis	Substitution is challenging for some specialty syntheses, but green chemistry is a focus area.

Source: >>, >> FutureBridge analysis

Use of CS2 In the Polymer Industry

CS_2 is not typically polymerized itself but is indispensable as a building block for synthesizing a wide range of organosulfur compounds that act as intermediates, additives, and functional agents in the polymer industry:

CS_2 acts as an electrophilic sulfur source, enabling the incorporation of sulfur atoms into organic frameworks.

Its reactions with nucleophiles (amines, alkoxides, thiolates) are thermodynamically favorable, often more so than analogous reactions with CO_2, allowing for efficient and selective synthesis of sulfur-rich compounds

- Dithiocarbamates and xanthates derived from CS_2 are essential for cross-linking and modifying the properties of synthetic and natural rubbers
- Trithiocarbonates and related compounds from CS_2 chemistry are used as building blocks for advanced polymeric materials, including those with metal-binding or catalytic properties
- Precursor for RAFT Agents: CS_2 is used to synthesize trithiocarbonate-based RAFT (Reversible Addition–Fragmentation chain Transfer) agents, which are widely employed for controlled/living radical polymerization of various monomers, enabling precise control over polymer architecture

Compound Formed	Reaction Type	Applications
Xanthates ($ROCS_2^-$)	Alkoxide + CS_2	Viscose rayon, rubber additives, flotation agents
Dithiocarbamates	Amine + CS_2	Vulcanization accelerators in rubber
Trithiocarbonates (CS_3^{2-})	Sodium sulfide + CS_2	RAFT polymerization, specialty polymers
RAFT Agents	CS_2-derived trithiocarbonates	Controlled/living radical polymerization

Is Carbon Disulfide used as a Monomer?

- CS_2 can undergo polymerization under specific conditions (e.g., photolysis or high pressure), resulting in an insoluble polymer known as "Bridgman's black," which contains trithiocarbonate linkages. However, this is a niche application and not a mainstream industrial polymerization process.
- As a Monomer in Functional Polymers: Recent research highlights the use of CS_2 as a "C1 resource" for synthesizing functional polymers, either by direct (co)polymerization or by reacting with other monomers to form sulfur-containing polymers. This is an area of active research, but not yet a major commercial application.

Source: >>, >> FutureBridge analysis

As the former Chief Scientist of Kimberly-Clark, I worked with FutureBridge as a client for over six years. Their approach consistently impressed me - combining personalized, value-oriented communication with deep industry expertise. They quickly earned our trust through transparency, practical insights, and a strong focus on outcomes.

FutureBridge stood out not only for its ability to understand the nuances of the chemicals industry and consumer products space, but also for the clarity and integrity of its engagement model. Their reputation for innovation, data-driven decision-making, and collaborative culture made them an ideal partner.

That conviction led me to take the next step—not just as a client, but by joining FutureBridge as a Partner to help other companies unlock the same value and accelerate innovation with confidence.

Pete Dulcamara

Former Chief Scientist @Kimberly-Clark

Partner @FutureBridge

Our Chemicals, Materials & Natural Resources Team

Dr Sarah Hickingbottom

VP & Global Practice Head

Sarah joined FutureBridge to lead the Chemicals & Materials Practice in April 2024 bringing over 20 years of research, strategic consulting and hands-on innovation scale-up experience spanning the world's chemicals, fuels and agricultural industries.

Rajesh Kumar

Director

Rajesh is a materials expert with 16 years of diverse experience across manufacturing, consulting, and advisory services. With a strong technical foundation and strategic insight, he has successfully driven innovation programs, and business growth in leading organizations.

Click Here To Shape Your CS_2 Strategy

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