Sulfur

Raw Material

S

(solid)

Source of Raw Material: Byproduct of Petroleum Processing, Natural Gas Processing, and Coking

% of Total Domestic Consumption Attributed to Water Sector: Less than 1%

Product Family: Sulfur, Fossil Fuels

CAS No.: 7704-34-9

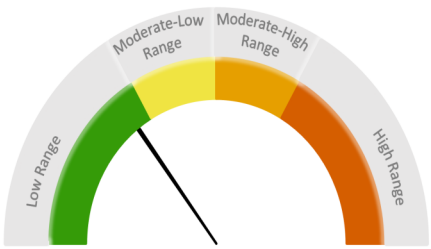
Derivative Water Treatment Chemicals: Sulfuric Acid, Sulfur Dioxide

Understanding Chemical Supply Chains

Shelf Life: 60+ Months

RISK OF SUPPLY DISRUPTION (Assessed in 2022)

RISK RATING: Low



RISK DRIVERS

Price and availability of sulfur, the majority of which is recovered as a byproduct of petroleum processing, are closely tied to demand for petroleum products. A significant quantity of sulfur is produced in geographically concentrated areas and the majority of sulfur is intended for use in sulfuric acid manufacturing, both of which can increase vulnerability.

RISK PARAMETERS

Criticality: High. Essential for the production of chemicals necessary for water treatment.

Likelihood: Low. There are no known previous disruptions in supply, however fluctuation in production are tied to demand for petroleum products.

Vulnerability: Low. The U.S. is a leading producer of sulfur, the majority of which is used to manufacture sulfuric acid.

PRODUCTION PROCESS

Recovery from petroleum refining, natural gas processing, and coking → **Sulfur**

Water Treatment Applications

- Water treatment chemical production

Competing Applications

- Sulfuric acid
- Chemical production
- Fertilizers
- Insecticides and pesticides

Input | End Use

DOMESTIC PRODUCTION AND CONSUMPTION, AND INTERNATIONAL TRADE

Domestic Production Locations (2019):
95, located throughout the U.S.

International Trade (2019)
Primary Trading Partner (Imports): Canada
Primary Trading Partner (Exports): Mexico

Domestic Consumption (2019): 9,400 M kg

- Domestic Production (8,706 M kg)
- Imports for Consumption (2,980 M kg)
- Export of Domestic Production (2,370 M kg)

EPA

Product Description

Sulfur (S), a widely used naturally occurring element, is not used directly in water treatment. It is a primary input in the production of sulfuric acid and sulfur-based chemicals including sulfur dioxide.

Use in Water Treatment

None.

Use as a Precursor to Other Water Treatment Chemicals

Sulfur is used to manufacture sulfur dioxide and sulfuric acid.

Other Applications

Sulfur has a wide range of applications. The leading use of sulfur is to produce sulfuric acid. It is also widely used in chemical production such as sulfites, fertilizers, insecticides, pesticides, plastics, enamels, gunpowder, and matches (NCBI, 2021; USGS, 2022).

Primary Industrial Consumers

In 2018, approximately 91% of sulfur consumed in the U.S. was used in the production of sulfuric acid, much of which is used in fertilizer production. Agriculture, including fertilizer and production of other agricultural chemicals, accounted for approximately 67% of elemental sulfur consumption in 2018 (USGS, 2022).

Manufacturing, Transport, & Storage

Manufacturing Process

The majority of elemental sulfur produced in the U.S. is recovered as a byproduct of petroleum refining, natural gas processing, and the coking processes through a series of thermal and catalytic steps starting with oxidation of hydrogen sulfide. A series of oxidation steps burn hydrogen sulfide with oxygen to form sulfur dioxide. The sulfur dioxide and hydrogen sulfide are then reacted at a specified ratio to form elemental sulfur. After cooling and condensation, sulfur is recovered as a liquid (DOE, 2022; USGS, 2022). The general equations for the steps of this process are shown in Figure 1.

Step 1

Hydrogen Sulfide + Oxygen → Sulfur Dioxide + Water

$2H_2S + 3O_2 \rightarrow 2SO_2 + 2H_2O$

Step 2

Hydrogen Sulfide + Sulfur Dioxide → Sulfur + Water

$2H_2S + SO_2 \rightarrow 3S + 2H_2O$

Figure 1. Chemical Equations for the Reactions to Manufacture Sulfur

Product Transport

Elemental sulfur, which may be sold as a liquid or solid, is routinely transported by ship, rail, truck, and pipeline (USGS, 2022).

Storage and Shelf Life

Sulfur is stable and non-reactive over a wide range of temperatures. When stored properly, sulfur can have a shelf life in excess of 60 months (Hess, 2012; USDA, 2018).

Domestic Production & Consumption

Domestic Production

Production data was collected from USGS, while trade data was collected from the U.S. International Trade Commission (USITC) Dataweb, as shown in Table 1. Both production and trade data are specific to sulfur.

Table 1. Sulfur Production and Trade Data Sources

Production and Trade Data			
Category	**Data Source**	**Identifier**	**Description**
Domestic Production	U.S. Geological Survey	CAS No.: 7704-34-9	Sulfur
Imports and Exports	U.S. International Trade Commission	HS Code: 2503.10	Sulfur

Total U.S. domestic production of sulfur was approximately 8,706 million kilograms (M kg) in 2019 (USGS, 2021). In 2019, elemental sulfur was recovered at petroleum refineries, natural-gas-processing plants, and coking plants at 95 operations in 27 states (USGS, 2022). As of 2018, large oil refineries along the Gulf Coast produced a significant portion of the domestic recovered sulfur. In 2018, the leading producers of recovered sulfur were *ExxonMobil Corp.*, *Valero Energy Corp*., and *ConocoPhillips Co*., and *Marathon Petroleum Corp*. The top seven producers accounted for 72% of recovered sulfur in 2018. The leading production states in 2018 were Texas, Louisiana, and California (USGS, 2022).

Domestic Consumption

U.S. consumption of sulfur in 2019 is estimated at 9,400 M kg. This estimate includes production of 8,706 M kg, import of 2,980 M kg, minus export of 2,370 M kg (USGS, 2021), as shown in Figure 2.

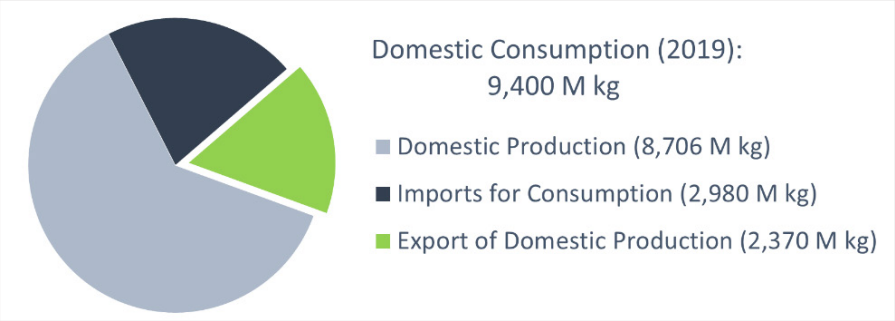


Figure 2. Domestic Production and Consumption of Sulfur in 2019

Trade & Tariffs

Worldwide Trade

Worldwide import and export data for sulfur are reported through the World Bank's World Integrated Trade Solutions (WITS) software, as a category specific to sulfur. In 2021, the U.S. ranked fifth worldwide in total exports and fourth in total imports of sulfur. In 2021, Qatar ranked first worldwide in total exports and China ranked first worldwide in total imports (WITS, 2022), as shown in Table 2.

Table 2. WITS Worldwide Export and Import of Sulfur in 2021

2021 Worldwide Trade Sulfur (HS Code 2503.10)			
Top 5 Worldwide Exporters		Top 5 Worldwide Importers	
Qatar	3,099 M kg	China	8,535 M kg
Canada	2,739 M kg	Morocco	6,719 M kg
Russian Federation	1,806 M kg	Brazil	2,328 M kg
South Korea	1,372 M kg	**United States**	**1,899 M kg**
United States	**1,113 M kg**	India	1,777 M kg

Domestic Imports and Exports

Domestic import and export data are reported by USITC in categories specific to sulfur. Figure 3 summarizes imports for consumption[1] and domestic exports[2] of sulfur between 2015 and 2020. During this period, the overall quantity of imports steadily decreased, with the greatest volume of imports occurring in 2015. The volume of exports, considerably smaller than the volume of imports, remained relatively steady. Over this five-year period, Mexico and Morocco took the place of Brazil as the primary recipients of domestic exports while the primary source of imports shifted from Saudi Arabia to Canada, with a much smaller quantity consistently originating from Mexico throughout this period (USITC, 2021).

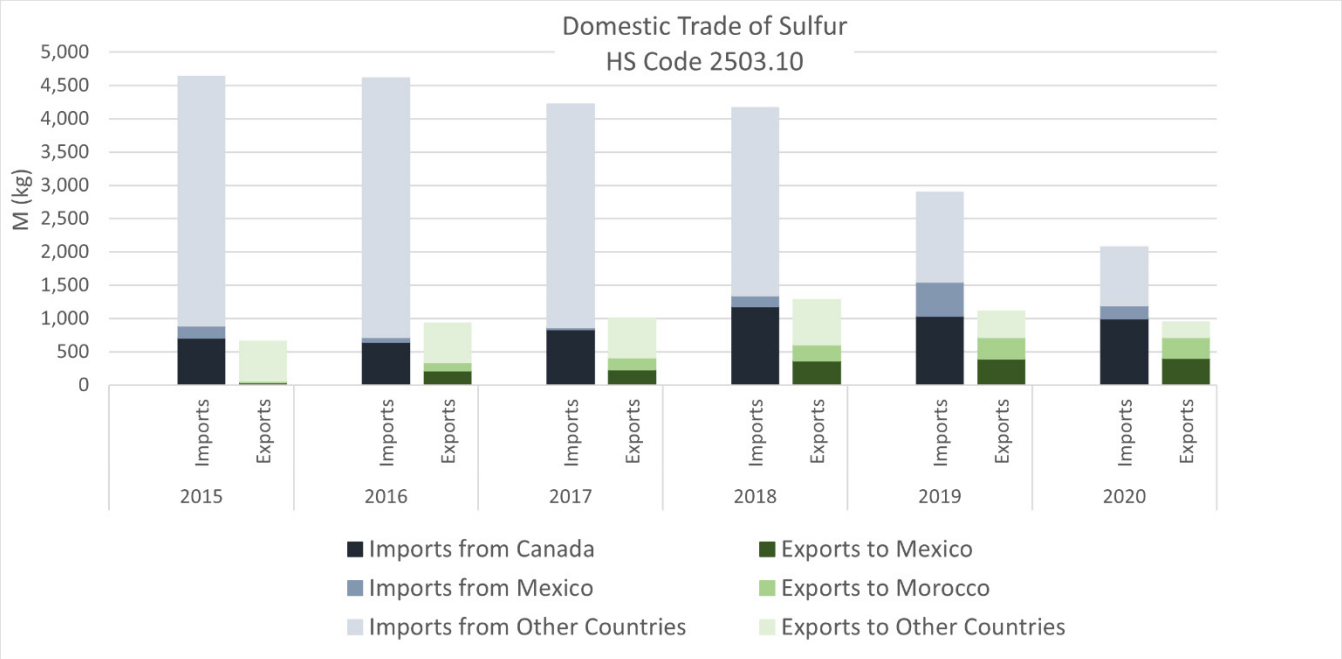


Figure 3. USITC Domestic Import and Export of Sulfur between 2015 and 2020

[1] Imports for consumption are a subset of general imports, representing the total amount cleared through customs and entering consumption channels, not anticipated to be reshipped to foreign points, but may include some reexports.
[2] Domestic exports are a subset of total exports, representing export of domestic merchandise which are produced or manufactured in the U.S. and commodities of foreign origin which have been changed in the U.S.

Tariffs

Imports of sulfur are primarily supplied from Canada. There is no general duty for import of sulfur, however there is an additional 25% duty on imports from China (USITC, 2022), as summarized in Table 3.

Table 3. 2022 Domestic Tariff Schedule for Sulfur

HS Code	General Duty	Additional Duty – China (Section 301 Tariff List)	Special Duty
2503.10	None	25%	None

Market History & Risk Evaluation

History of Shortages

The majority of elemental sulfur produced in the U.S. and worldwide is recovered as a byproduct of natural gas and petroleum processing. The price and availability of sulfur is closely tied to demand for fuels and petroleum products (USGS, 2022). Historically, economic downturns such as occurred in 2020 during the COVID-19 pandemic have driven down fossil fuel consumption, which in turn has led to reduced processing of crude oil, subsequently creating a very tight supply of sulfur. Severe weather has historically reduced sulfur production, as many domestic oil refining facilities are concentrated along the Gulf Coast, a region which has historically experienced many significant hurricanes. The U.S., a leading worldwide manufacturer of sulfuric acid, directs a majority of recovered elemental sulfur to production of sulfuric acid.

Risk Evaluation

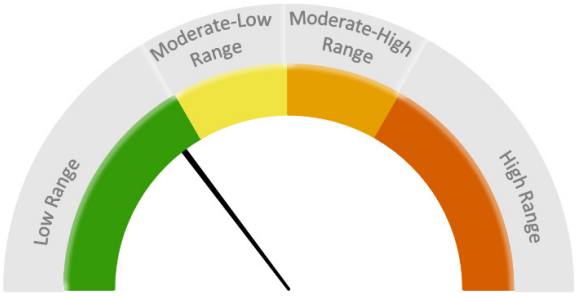
The complete risk assessment methodology is described in *Understanding Water Treatment Chemical Supply Chains and the Risk of Disruptions* (EPA, 2022). The risk rating is calculated as the product of the following three risk parameters:

Risk = Criticality x Likelihood x Vulnerability	
Criticality	Measure of the importance of a chemical to the water sector
Likelihood	Measure of the probability that the chemical will experience a supply disruption in the future, which is estimated based on past occurrence of supply disruptions
Vulnerability	Measure of the market dynamics that make a chemical market more or less resilient to supply disruptions

The individual parameter rating is based on evaluation of one or more attributes of the chemical or its supply chain. The ratings and drivers for these three risk parameters are shown below in Table 4.

Table 4. Supply Chain Risk Evaluation for Sulfur

Risk Parameter Ratings and Drivers		
Criticality: High	**Likelihood: Low**	**Vulnerability: Low**
Sulfur is essential to production of all sulfur-based water treatment chemicals.	There were no notable disruptions in the supply of sulfur between 2000 and 2022. However, there have been fluctuations in production and subsequent price increases due to decreased production of sulfur as a byproduct of fossil fuel refining.	The U.S. produces large quantities of sulfur, which reduces vulnerability. However, a significant quantity of sulfur is produced in geographically concentrated areas which can increase vulnerability.
Risk Rating: Low		



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