Sulfuric Acid

H_2SO_4 (liquid)

D Direct Use Chemical P Precursor Chemical

Inputs to Manufacturing Process:
Sulfur Oxygen

Derivative Water Treatment Chemicals:
Aluminum Sulfate Ferric Sulfate
Fluorosilicic Acid Ferrous Sulfate
Phosphoric Acid Zinc Orthophosphate

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

Understanding Chemical Supply Chains

Map of Suppliers & Manufacturers

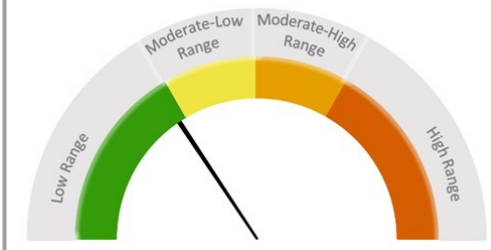
Product Family:
Sulfur

CAS No.:
7664-93-9

Shelf Life:
36 Months

RISK OF SUPPLY DISRUPTION (Assessed in 2022)

RISK RATING: Low



RISK DRIVERS

Competing use in fertilizers accounts for the majority of consumption of domestic production. Sulfuric acid is commonly used across many industries. Concerns are primarily due to periodic reductions in production of raw material (sulfur).

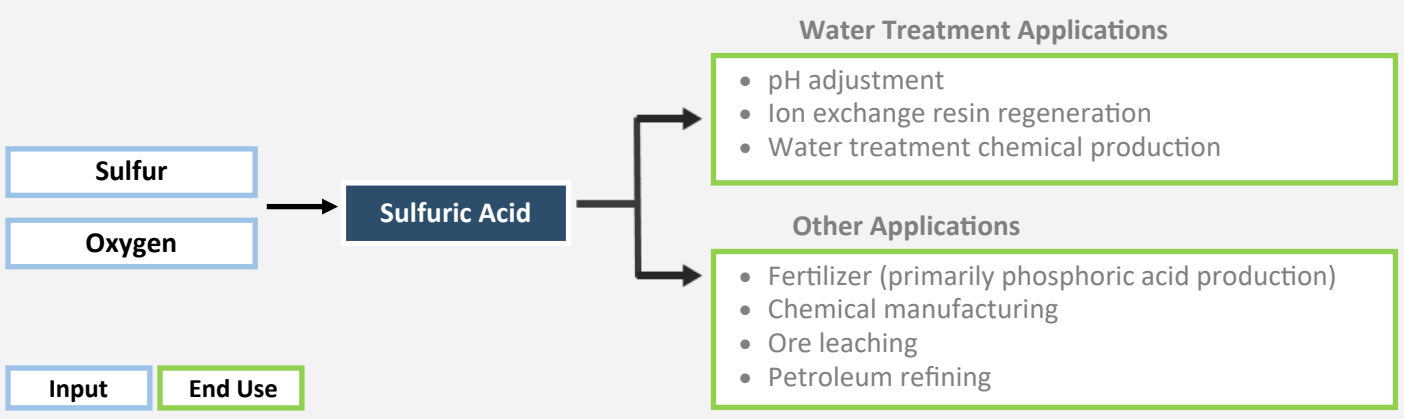
RISK SCORE PARAMETERS

Criticality: High. Essential for pH adjustment and production of water treatment chemicals.

Likelihood: Low. Previous significant price increases, but no supply disruptions.

Vulnerability: Low. Distributed domestic manufacturing and supply. While the majority of domestic manufacturing is used to produced fertilizer, sulfuric acid is widely available.

MANUFACTURING PROCESS



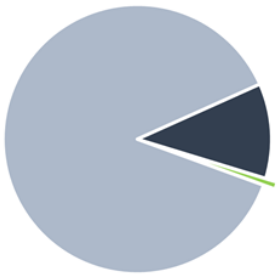
DOMESTIC PRODUCTION AND CONSUMPTION, AND INTERNATIONAL TRADE

Domestic Manufacturing Locations (2015):
98, distributed throughout the U.S.

International Trade (2019)

Primary Trading Partner (Imports): Canada

Primary Trading Partner (Exports): Canada



Domestic Consumption (2019): 25,596 M kg

- Domestic Production (22,845 M kg)
- Imports for Consumption (2,970 M kg)
- Export of Domestic Production (220 M kg)

Product Description

Sulfuric acid (H_2SO_4) is an inorganic, strong acid that is widely used for pH adjustment. It is one of the most widely produced chemicals in the world, and is a key input in the production of phosphoric acid. The primary manufacturing process in the U.S. is requires elemental sulfur. The majority of sulfuric acid manufactured in the U.S. is used in fertilizer formulations.

Use in Water Treatment

Sulfuric acid widely is used in water treatment for pH adjustment, and can also be used to regenerate ion exchange resin.

Use as a Precursor to Other Water Treatment Chemicals

Sulfuric acid is used to manufacture aluminum sulfate, ferrous and ferric sulfate, fluorosilicic acid, phosphoric acid, and zinc orthophosphate.

Other Applications

Sulfuric acid has a wide range of applications, and is used directly or indirectly in many industries. The largest single use of sulfuric acid is for the production of phosphoric acid for use in fertilizer. Other uses include industrial chemical manufacturing, extraction of metals from ores, oil refining, pickling and descaling steel, battery acid, wood pulping, and detergent manufacturing (ATSDR, 1998; The Mosaic Company, 2021; The Sulphur Institute, 2018).

Primary Industrial Consumers

The use of sulfuric acid for phosphate fertilizer manufacturing accounts for the majority of domestic consumption, historically estimated to range between 60-75% of domestic sulfuric acid consumption. Other significant uses are industrial and agricultural chemical manufacturing, ore leaching, and petroleum refining accounting for a combined 35% (McCoy, 2008; NCBI, 2022). Direct use in water treatment is a small percent (< 1%) of the domestic market.

Manufacturing, Transport, & Storage

Manufacturing Process

A significant quantity of sulfuric acid produced in the U.S. starts with molten sulfur or less commonly prilled (pelletized) sulfur. Other production methods include acid regeneration and smelter gas recovery.

The most common sulfuric acid manufacturing process proceeds in several steps, outlined in Figure 1. Molten sulfur is oxidized in the presence of dry air (often an oxygen-enriched air) to produce sulfur dioxide, which is cooled for introduction to the converter system. In the presence of a catalyst, sulfur dioxide is converted to sulfur trioxide, and the process gas is moved to an absorption step where sulfur trioxide is absorbed in sulfuric acid to form oleum (sulfur trioxide in sulfuric acid). The oleum, which is much more soluble in water than sulfur trioxide, is cooled and reacted with water to produce concentrated sulfuric acid.

Step 1

Sulfur + Oxygen → Sulfur Dioxide

$S + O_2 \rightarrow SO_2$

Step 2

Sulfur Dioxide + Oxygen → Sulfur Trioxide

$2SO_2 + O_2 \rightarrow 2SO_3$

Step 3

Sulfur Trioxide + Sulfuric Acid → Oleum

$SO_3 + H_2SO_4 \rightarrow H_2S_2O_7$

Step 4

Oleum + Water → Sulfuric Acid

$H_2S_2O_7 + H_2O \rightarrow 2H_2SO_4$

Figure 1. Chemical Equation for the Reaction to Manufacture Sulfuric Acid

Sulfuric acid can also be produced as a byproduct of smelting mineral ores containing sulfur. Roasting of metal sulfides to obtain the metal releases sulfur in the form of sulfur dioxide. Further metal processing, including leaching, requires sulfuric acid, which can be produced from the sulfur dioxide (The Sulphur Institute, 2018). Spent sulfuric acid may be reclaimed from petroleum refining, steel pickling, and chemical processing and further processed for resale (USGS, 2022).

Product Transport

Sulfuric acid is typically sold as a liquid in a range of concentrations, in bulk quantities and primarily delivered by specialized railcars to suppliers who repackage and sell the product directly to customers. Transport of sulfuric acid must adhere to the appropriate methods and regulations related to its status as a highly corrosive substance. Sulfuric acid produced by regeneration plants and smelting often requires transport to manufacturing or refining sites (The Sulphur Institute, 2018).

Storage and Shelf Life

Sulfuric acid should be stored in corrosion-resistant vessels in a cool place away from direct sunlight. When stored properly, sulfuric acid can have a shelf life of 36 months, depending on concentration and size of storage container (CORECHEM, 2021; The Sulphur Institute, 2018).

Domestic Production & Consumption

Domestic Production

Production data was collected from the EPA Toxic Substances Control Act (TSCA) Chemical Data Reporting (CDR), while trade data was collected from the U.S. International Trade Commission (USITC) Dataweb, as characterized in Table 1. Both production and trade data are specific to sulfuric acid.

Table 1. Sulfuric acid Production and Trade Data Sources

Production and Trade Data			
Category	**Data Source**	**Identifier**	**Description**
Domestic Production	2020 TSCA Chemical Data Reporting	CAS No.: 7664-93-9	Sulfuric Acid
Imports and Exports	U.S. International Trade Commission	HS Code: 2807.00	Sulfuric Acid

Total U.S. domestic manufacturing of sulfuric acid was approximately 22,845 million kilograms (M kg) in 2019 (EPA, 2020). The majority of domestic commercial manufacture of sulfuric acid takes place at phosphate rock processing facilities located throughout the contiguous U.S. (The Mosaic Company, 2021; Potash, 2015). Many of these facilities are owned by a relatively small number of companies including *the Mosaic Company (Mosaic*) and *PCS Phosphate (*EPA, 2020). *Mosaic* reported production of approximately 10,000 M kg of sulfuric acid in 2019, and the majority was reported used on-site for production of phosphoric acid. *Mosaic* purchased the majority of sulfur used to produce the sulfuric acid from North American oil and natural gas refiners (The Mosaic Company, 2021). Domestic manufacturing of sulfuric acid is widely distributed throughout the U.S. The number of domestic manufacturing locations shown in Figure 2 represents operating facilities as of 2015. Supply of NSF/ANSI Standard 60 certified sulfuric acid for use in drinking water treatment is also widely distributed throughout the U.S. (NSF International, 2021). For a more current listing of manufacturing locations and supplier locations, visit the U.S. Environmental Protection Agency's (EPA's) Chemical Locator Tool (EPA, 2022a).

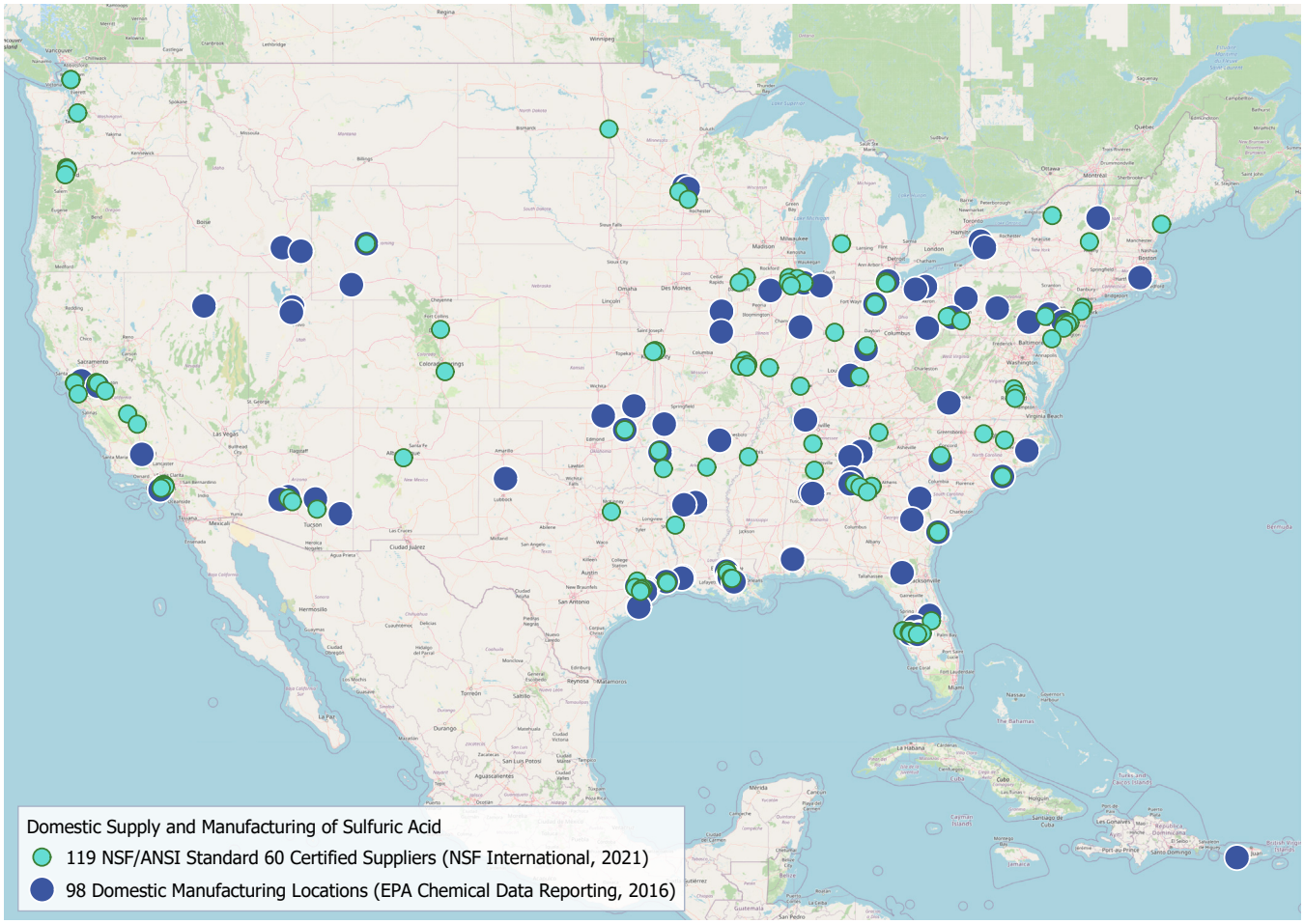


Figure 2. Domestic Supply and Manufacturing of Sulfuric Acid

Domestic Consumption

U.S. consumption of sulfuric acid in 2019 is estimated at 25,596 M kg. This includes production of 22,845 M kg, import of 2,970 M kg, minus export of 220 M kg (EPA, 2020; USITC, 2021), as shown in Figure 3.

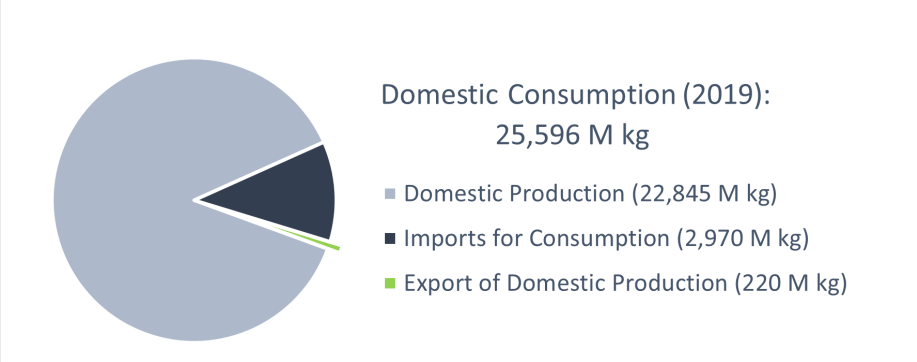


Figure 3. Domestic Production and Consumption of Sulfuric Acid in 2019

Trade & Tariffs

Worldwide Trade

Worldwide import and export data for sulfuric acid are reported through the World Bank's World Integrated Trade Solutions (WITS) software, as a category specific to sulfuric acid. In 2021, U.S. ranked 12th worldwide in total exports and first in total imports of sulfuric acid. In 2021, China ranked first worldwide in total exports (WITS, 2022), as shown in Table 2.

Table 2. WITS Worldwide Export and Import of Sulfuric Acid in 2021

2021 Worldwide Trade Sulfuric Acid (HS Code 2807.00)			
Top 5 Worldwide Exporters		Top 5 Worldwide Importers	
China	3,000 M kg	**United States**	**3,252 M kg**
Canada	1,904 M kg	Chile	2,451 M kg
Germany	1,136 M kg	Morocco	2,109 M kg
Peru	1,110 M kg	India	1,874 M kg
Mexico	970 M kg	Philippines	1,522 M kg

Domestic Imports and Exports

Domestic import and export data are reported by USITC in categories specific to sulfuric acid. Figure 4 summarizes imports for consumption[1] and domestic exports[2] of sulfuric acid between 2015 and 2020. During this period, the overall quantity of imports and exports remained relatively steady, with imports for consumption exceeding domestic exports. Over this five-year period, Canada was the primary recipient of domestic exports and the primary source of imports (USITC, 2021).

[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.

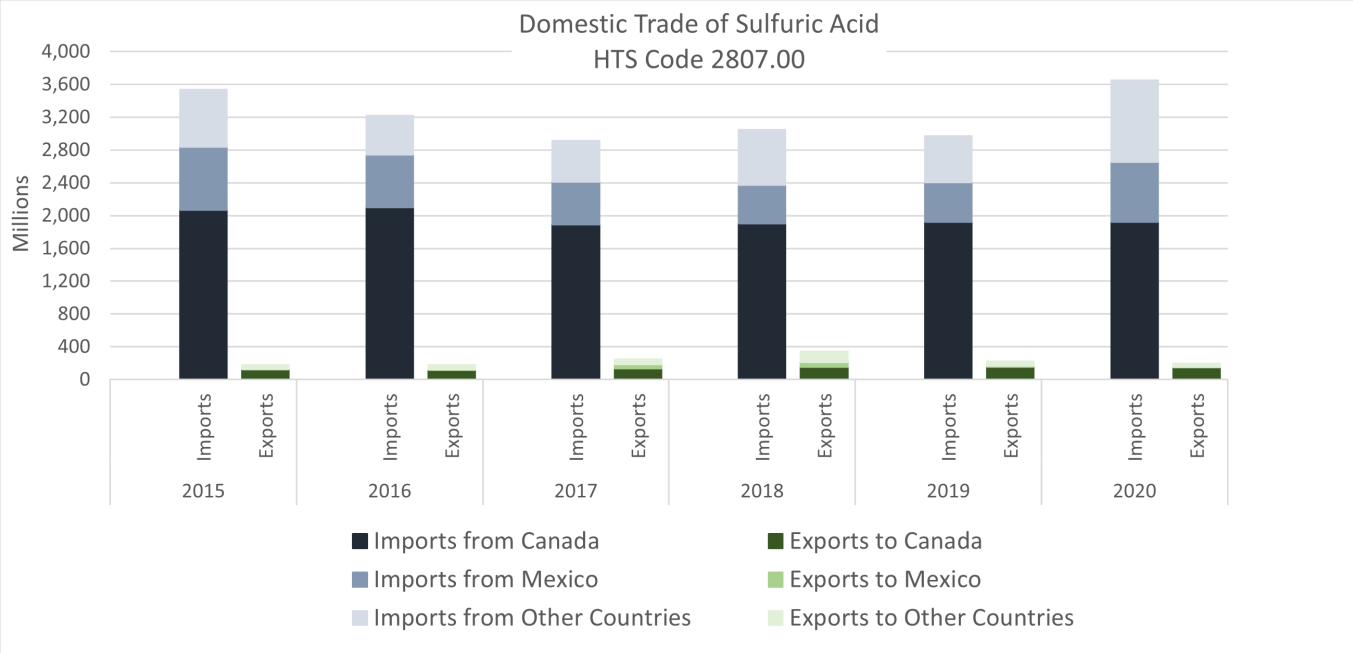


Figure 4. USITC Domestic Import and Export of Sulfuric Acid between 2015 and 2020

Tariffs

There is no general duty for import of sulfuric acid, however there is an additional 25% duty on imports from China (USITC, 2022), as summarized in Table 3.

Table 3. Domestic Tariff Schedule for Sulfuric Acid in 2020

HS Code	General Duty	Additional Duty – China (Section 301 Tariff List)	Special Duty
2807.00	None	25%	None

Market History & Risk Evaluation

History of Shortages

The U.S. is one of the leading worldwide producers of sulfuric acid, and there were no identified significant supply chain disruptions between 2000 and 2022. However, there is a history of price volatility. The majority of elemental sulfur, the primary input in sulfuric acid manufacturing, is recovered as a byproduct of natural gas and petroleum processing. As described in the history of shortages for the sulfur supply chain profile (EPA, 2022b), the price and availability of sulfur is closely tied to demand for fuels and petroleum products (USGS, 2022). While the majority of recovered elemental sulfur is directed to manufacturing of sulfuric acid, demand for sulfuric acid, is tied to demand for fertilizer. Between 2020 and 2022, theses drivers have led to price fluctuations for sulfuric acid.

Risk Evaluation

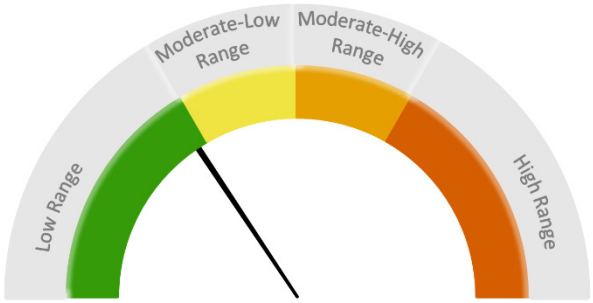
The complete risk assessment methodology is described in *Understanding Water Treatment Chemical Supply Chains and the Risk of Disruptions* (EPA, 2022c). The risk rating is calculated as the product of the following three risk parameters:

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 Sulfuric Acid

Risk Parameter Ratings and Drivers		
Criticality: High	**Likelihood: Low**	**Vulnerability: Low**
Sulfuric acid is essential to the water sector and has widespread application for pH adjustment. It is a precursor in the production of numerous critical water treatment chemicals.	The water sector did not experience sulfuric acid supply chain disruptions between 2000 and 2022. However, the water sector has experienced significant increases in price in the past. Concerns are primarily due to periodic reductions in production of	Strong domestic manufacturing provides some resilience to supply disruptions. While the majority of domestic manufacturing is used to produce fertilizer, sulfuric acid is widely available.
Risk Rating: Low		



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