Acrylamide

C_3H_5NO

(liquid)

P Precursor Chemical

Inputs to Manufacturing Process:
Acrylonitrile

% of Total Domestic Consumption Attributed to Water Sector:
Approximately 45%

Product Family:
Petroleum Byproducts

CAS No.: 79-06-1

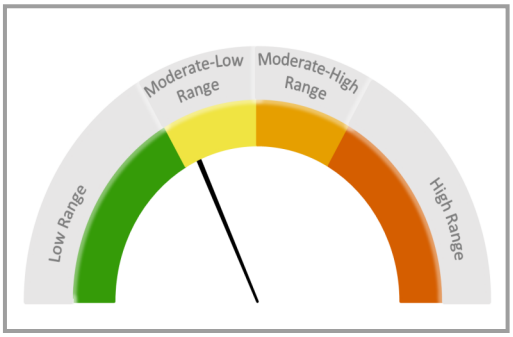
Derivative Water Treatment Chemicals:
Polyacrylamides

Understanding Chemical Supply Chains

Shelf Life: 6 Months

RISK OF SUPPLY DISRUPTION (Assessed in 2022)

RISK RATING: Moderate-Low



RISK DRIVERS

Supply chain challenges include dependence on production of other, higher value petroleum byproducts, and a history of significant price increases and force majeure in supply to the water sector. The key input, acrylonitrile is a byproduct of petroleum refining and availability is tied to production along the Gulf Coast.

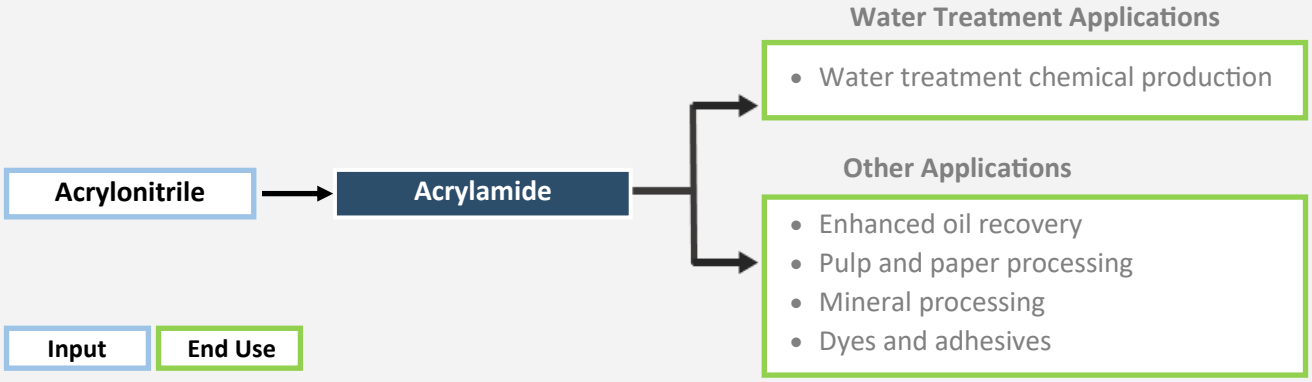
RISK PARAMETERS

Criticality: High. Essential precursor for production of polyacrylamide, used in coagulation and sludge dewatering.

Likelihood: Moderate-Low. A history of price increases and force majeure have impacted availability and price.

Vulnerability: Low. Domestic manufacturing is distributed but limited, imports are widely available.

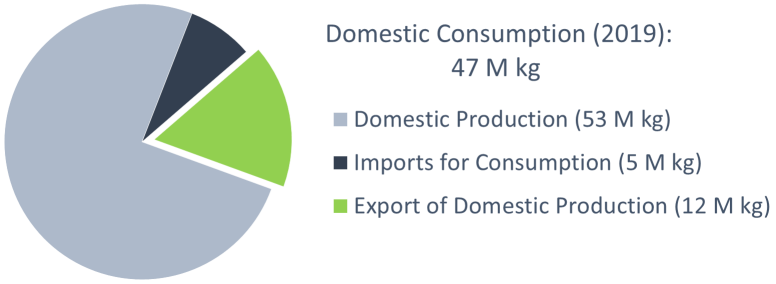
MANUFACTURING PROCESS



DOMESTIC PRODUCTION AND CONSUMPTION, AND INTERNATIONAL TRADE

Domestic Manufacturing Locations (2019):
6, in Georgia, Louisiana, Mississippi, and Virginia.

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



EPA

Product Description

Acrylamide (C_3H_5NO), an organic amide, is a widely used intermediate in production of polymers used across numerous industries. It is the precursor to a class of polymers (polyacrylamides) used in water treatment. Domestic production relies on supply of acrylonitrile, a petroleum-derived compound.

Use in Water Treatment

None.

Use as a Precursor to Other Water Treatment Chemicals

Acrylamide is not used directly in water treatment. Acrylamide is the primary input for production of polyacrylamides, which are used in water treatment as coagulants and dewatering agents. Water treatment is a primary use of polyacrylamides.

Other Applications

Acrylamide is an intermediate in the production of many organic chemicals. Most uses rely on production of polyacrylamide. Common applications include use in enhanced oil recovery, pulp and paper processing, mineral processing, production of dyes and adhesives, cosmetics, and laboratory research (electrophoresis) (ATSDR, 2012; NCBI, 2022).

Primary Industrial Consumers

Historically, the majority (94%) of domestically produced acrylamide has been used in captive consumption to produce polyacrylamide. Approximately 45% of the polyacrylamide produced has been intended for use in water treatment. Other significant applications include use in enhanced oil recovery, pulp and paper processing, and mineral processing (ATSDR, 2012; NCBI, 2022).

Manufacturing, Transport, & Storage

Manufacturing Process

There are multiple commercial methods available to produce acrylamide. All methods utilize acrylonitrile as the starting material. Domestic production takes place primarily through one of two methods. In the first method, acrylamide is produced by the hydrolysis of acrylonitrile with the bacterial enzyme nitrile hydratase. Bacteria which utilize acrylonitrile among other nitriles as the sole source of carbon and nitrogen produce an enzyme called nitrile hydratase which converts acrylonitrile into acrylamide. Nitrile hydratase is harvested from bacterial cultures and used in the industrial production of acrylamide (Asano et al., 1982). In the second method, acrylamide is produced by the hydrolysis of acrylonitrile through a catalytic hydration process whereby acrylonitrile is reacted with heat and water in the presence of a copper-based catalyst. Various copper-based catalysts may be used in this process. Most catalysts undergo degradation and lose activity over time, methods to remedy this include the addition of metallic salts or oxides (ATSDR, 2012; NCBI, 2022).

Product Transport

Acrylamide, primarily supplied as a solution, is commonly transported by truck, rail, barge, and ship.

Storage and Shelf Life

Acrylamide is stable under recommended storage conditions, but may polymerize over time at room temperature. When stored properly, acrylamide can have a shelf life of approximately six months, though stability may depend upon many factors (SNF, 2019).

Domestic Production & Consumption

Domestic Production

Production data was collected from the 2020 Toxic Substances Control Act (TSCA) Chemical Data Reporting (CDR) for the year 2019, while trade data was collected from the U.S. International Trade Commission (USITC) Dataweb, as shown in Table 1. While production and import data are specific to acrylamide, trade data for exports include acrylamide as part of a broader trade category of acyclic amides, 'not elsewhere specified' (NES).

Table 1. Acrylamide Production and Trade Data Sources

Production and Trade Data			
Category	**Data Source and Date**	**Identifier**	**Description**
Domestic Production	2020 TSCA Chemical Data Reporting	CAS No.: 79-06-1	Acrylamide
Imports and Exports	U.S. International Trade Commission	HTS Code: 2924.19.1110 HS Code: 2924.19	Acrylamide (Imports) Acyclic Amides, NES (Exports)

Total domestic manufacturing of acrylamide reported under the CDR was approximately 53 M kg in 2019 (EPA, 2020). Several leading manufacturers did not report production volume of acrylamide and claimed confidential business information (CBI). *SNF Holding*, which claimed CBI, indicated status as a leading worldwide producer of polyacrylamide, supplying 48% of worldwide consumption in 2020 (SNF, 2021). Reported domestic production of acrylamide takes place at six facilities located in Georgia, Louisiana, Mississippi, and Virginia. Acrylamide is primarily used as an intermediate in the manufacture of polyacrylamide, and the leading domestic manufacturers of acrylamide utilize the majority of their production in captive consumption to manufacture polyacrylamide (ATSDR, 2012).

Domestic Consumption

U.S. consumption of acrylamide in 2019 is estimated at 47 M kg. This estimate includes production of 53 M kg, import of 5 M kg, minus export of 12 M kg (EPA, 2020; USITC, 2022a), as shown in Figure 1.

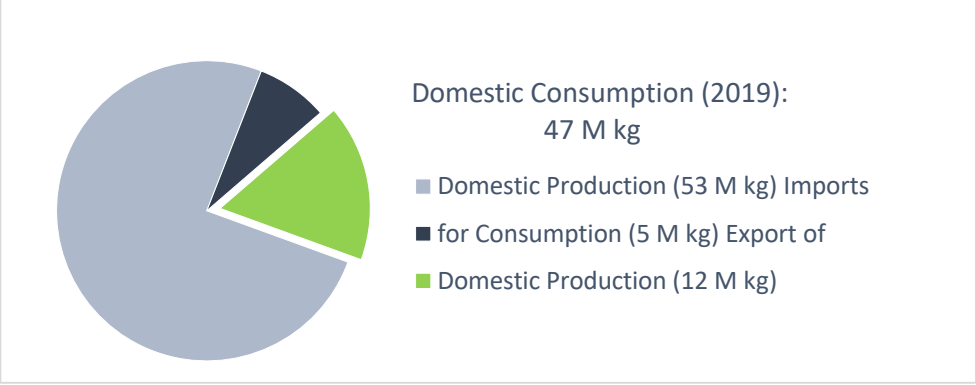


Figure 1. Domestic Production and Consumption of Acrylamide in 2019

Trade &Tariffs

Worldwide Trade

Worldwide import and export data for acrylamide are reported through the World Bank's World Integrated Trade Solutions (WITS), as a category representing acyclic amides and their derivatives, NES. In 2021, the U.S. ranked fourth worldwide in total exports and second in imports of acyclic amides and derivatives, NES. In 2021,

Germany ranked first worldwide in total exports while South Korea ranked first in total imports (WITS, 2022), as shown in Table 2. Export data for China, a significant producer of acrylamide, was not reported in 2021. Import and export data specific to acrylamide is unavailable from the referenced sources.

Table 2. WITS Worldwide Export and Import of Acyclic Amides and their Derivatives, including Acrylamide, in 2021

2021 Worldwide Trade Acyclic Amides and their Derivatives (HS Code 2924.19)			
Top 5 Worldwide Exporters		Top 5 Worldwide Importers	
Germany	99 M kg	South Korea	87 M kg
India	68 M kg	**United States**	**65 M kg**
Saudi Arabia	68 M kg	Germany	55 M kg
United States	**20 M kg**	France	44 M kg
Japan	35 M kg	Japan	41 M kg

Domestic Imports and Exports

Domestic imports and export data are reported by USITC in categories for acyclic amides. Figure 2 summarizes imports for consumption[1] and domestic exports[2] between 2015 and 2020. During this period, the overall quantity of exports decreased, while the quantity of imports varied. The quantity of domestic exports consistently exceeded imports for consumption. Over this five-year period, Mexico was the primary recipient of domestic exports while India overtook China as the primary sources of imports (USITC, 2022a).

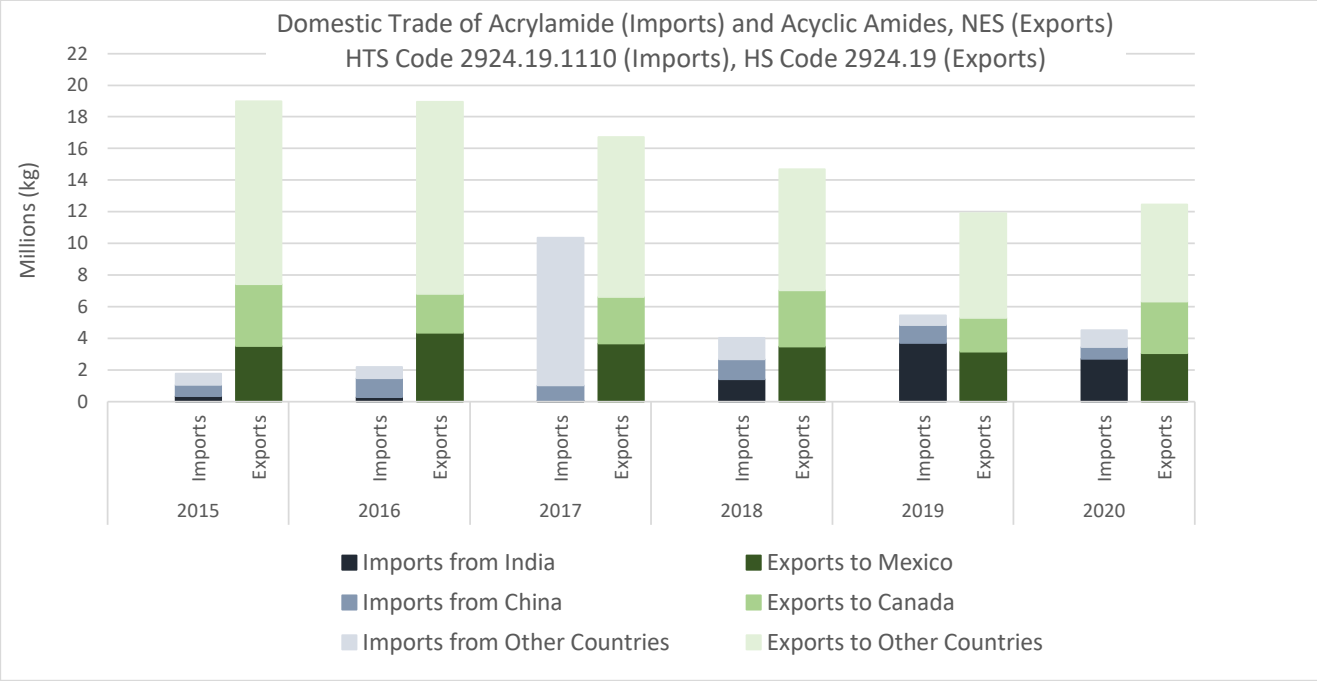


Figure 2. USITC Domestic Import and Export of Acrylamide between 2015 and 2020

[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

There is a 3.7% general duty on imports of acrylamide and a 25% additional duty on imports from China (USITC, 2022b), as summarized in Table 3.

Table 3. 2021 Domestic Tariff Schedule for Acrylamide

HTS Code	General Duty	Additional Duty - China (Section 301 Tariff List)	Special Duty
2924.19.1110	3.7%	25%	Free (A, AU, BH, CL, CO, D, E, IL, JO, K, KR, MA, OM, P, PA, PE, S, SG)[3]

Market History & Risk Evaluation

History of Shortages

There were repeated shortages of the primary raw ingredient of acrylamide, acrylonitrile, between 2000 and 2020 (Tullo, 2021). Acrylonitrile is produced from propylene, a byproduct of the petroleum refining process. The majority of domestic petrochemical feedstocks for production of acrylonitrile are located in proximity to refineries and ports along the U.S. Gulf Coast. Geographic concentration of the feedstock and production has, over the years, resulted in supply bottlenecks. Periodic weather disturbances to manufacturing, including winter storm Uri in February 2021 and Hurricane Ida in August 2021, temporarily halted manufacturing at primary domestic acrylonitrile manufacturing locations along the Gulf Coast and led to declarations of force majeure. This has resulted in persistent price increases and occasional shortages of downstream chemicals, including acrylamide.

Risk Evaluation

The complete risk evaluation 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:

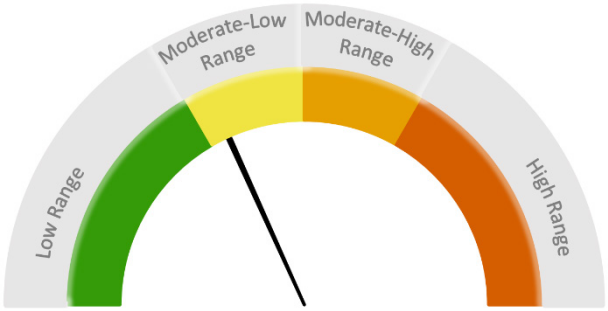
Risk = Criticality x Likelihood x Vulnerability	
Criticality	Measure of the importance of a chemical to the water sector
Likelihood	Measure of the probability that the chemical will experience a supply disruption in the future, which is estimated based on past occurrence of supply disruptions
Vulnerability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

[3] Symbols used to designate the various preference programs and trade agreements. A full list of special trade agreements and associated acronyms can be found at https://help.cbp.gov/s/article/Article-310?language=en_US and the General Notes Section of the Harmonized Tariff Schedule https://hts.usitc.gov/current

Table 4. Supply Chain Risk Evaluation for Acrylamide

Risk Parameter Ratings and Drivers		
Criticality: High	**Likelihood: Moderate-Low**	**Vulnerability: Low**
Acrylamide is not used directly in water treatment but serves as the raw material for production of polyacrylamide, used in coagulation and sludge dewatering.	A history of price increases and force majeure due to shortages of, or steep increase in, the cost of a key input, acrylonitrile, have impacted availability and price of polyacrylamide.	Domestic manufacturing takes place at multiple locations throughout the southeastern U.S., and imports are widely available.
Risk Rating: Moderate-Low		



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