

Superabsorbent Polymers Production by Belt Reactor

PEP Review 2026-13

Rajesh Debnath, Associate Director, Process Economics Program

To learn more or to request a demo, visit www.spglobal.com/energy.

Table of contents

1 Introduction	9
Key properties and performance metrics of SAPs	9
Free swell capacity (CRC)	9
Absorbency under load	9
Permeability and gel blocking	10
Particle size distribution (PSD)	10
Applications and market relevance of SAP	10
Industrial production overview	10
Key challenges and opportunities	11
2 Summary	12
Scope and objective	12
Process overview	12
Technical assessment	13
Economic assessment	15
Effect of plant size	15
Environmental impact	17
Carbon footprint	17
Water footprint	17
3 Industry status	18
4 Technology review	19
Chemistry of SAPs	19
Acrylic acid structure and formula	19
Origin of acrylic acid	19
Chemical reaction for acrylic acid production	19
Significance in superabsorbents	19
Acrylic acid polymerization	20
Effect of temperature on polymerization	20
Solvent effects	21
Molecular weight and distribution	21
Types of superabsorbent polymer	21
SAP production routes	22
Inverse-suspension polymerization	23
Solution polymerization (gel polymerization)	23
Reactor technologies for solution polymerization	23
Kneader reactor	23
Continuous belt reactor	24
Monomer system and raw materials	24

Acrylic acid chemistry	24
Initiators, comonomers, and cross-linkers for SAP production	25
Acrylic acid handling and storage	25
Acrylic acid production routes	26
Acrylic acid industry value chain	27
Acrylic acid purification technologies	28
Rectification	28
Melt crystallization process	29
Process concept	29
Feed preparation and reaction control	29
Downstream processing and product conditioning of polymer gels	31
Belt reactor design and operation for SAP production	31
Design parameters	31
Operation	32
SAP properties	32
Applications of SAP	32
Biomedical application	33
Hygienic sector	33
Agriculture industry	33
Slurry dewatering	33
Cement and concrete application	33
Environmental considerations and future directions	34
Saplene™ — A mature technology platform for high-performance SAP	34
5 Process review and economic evaluation	36
Process description	38
Monomer preparation	39
Reactor conditions and temperature control	40
Reaction section	40
Reactor cooling	40
Downstream purification section	41
Product storage	42
Off-sites	42
Storage tank	42
Process discussion	50
CAA purification	50
Monomer neutralization	51
Polymerization reaction	51
Downstream purification	51
Material of construction	52
Environmental impact	52
Cost estimates	53

Fixed capital costs	53
Production costs	54
Economic discussion	58
Appendix A — Design and cost basis	61
Design conditions	62
Cost basis	62
Capital investment	62
Project construction timing	63
Available utilities	63
Production costs	64
Effect of operating level on production costs	64
Appendix B — Cited references	65
Appendix C — Process flow diagrams	68

Tables

Table 2.1 Cost summary — SAP via continuous belt reactor	16
Table 2.2 SAP via continuous belt reactor — Carbon and water footprint data	17
Table 4.1 Saplene™ reference list	35
Table 5.1 SAP via continuous belt reactor — Design basis and assumptions	37
Table 5.2 SAP from crude acrylic acid — List of storage tanks	42
Table 5.3 SAP from crude acrylic acid via belt reactor — Major stream flows	43
Table 5.4 SAP via continuous belt reactor — Major equipment list	48
Table 5.5 SAP via continuous belt reactor — Utility summary	50
Table 5.6 SAP via continuous belt reactor — Waste streams	52
Table 5.7 SAP via continuous belt reactor — Carbon and water footprint evaluation	53
Table 5.8 SAP via continuous belt reactor — Total capital investment	55
Table 5.9 SAP via continuous belt reactor — Capital investment by section	56
Table 5.10 SAP via continuous belt reactor — Variable costs	57
Table 5.11 SAP via continuous belt reactor — Production costs	58

Figures

Figure 2.1 Polymerization of acrylic acid	13
Figure 2.2 SAP production via continuous belt reactor — Block flow diagram	14
Figure 2.3 SAP from crude acrylic acid — A simplified process economic schematic	16
Figure 4.1 Chemical structure of polyacrylic acid	20
Figure 4.2 Chemical structure of sodium polyacrylate	20
Figure 4.3 Classifications of SAP	22
Figure 4.4 Structure of acrylic acid	24
Figure 4.5 Acrylic acid commercial production routes	27
Figure 4.6 Acrylic acid value chain	28
Figure 5.1 Block flow diagram — Commercial manufacture of SAP by belt reactor process integrated with CAA purification unit	37
Figure 5.2 SAP from crude acrylic acid — A simplified process economic schematic	38

Figure 5.3 SAP production via belt reactor — Variable costs	59
Figure 5.4 SAP production via belt reactor — Cost contribution	60

Appendix C Figures

Figure C1 CAA to GAA purification plant	69
Figure C2 SAP production via belt reactor — Monomer preparation and reaction section	70
Figure C3 SAP production via belt reactor — Gel cutting and drying section	71
Figure C4 SAP production via belt reactor — Gel classifying and surface cross-linking section	72
Figure C5 SAP production via belt reactor — SAP storage and transfer	73

Glossary

AA	Acrylic acid
AM	Acrylamide
AUL	Absorbency under load
AUP	Absorbency under pressure
BFW	Boiler feedwater
bhp	Brake horsepower
BLI	Battery limits investment
Btu	British thermal units
°C	Degrees Celsius
CAA	Crude acrylic acid
Capex	Capital expenditure
¢/gal	Cents per gallon
¢/kWh	Cents per kilowatt-hour
¢/lb	Cents per pound
¢/Mgal	Cents per thousand gallons
cm	Centimeters
CRC	Centrifuge retention capacity
¢/TR-h	Cents per refrigeration ton
CS	Carbon steel
CW	Cooling water
DM	Demineralized
\$/h	Dollars per hour
\$/Mgal	Dollars per thousand gallons
\$/Mlb	Dollars per thousand pounds
\$/MMBtu	Dollars per million British thermal units
\$/Mscf	Dollars per thousand standard cubic feet
\$/t	Dollars per metric ton
EGDGE	Ethylene glycol diglycidyl ether
°F	Degrees Fahrenheit
FOB	Free/freight on board
G&A	General and administrative
GAA	Glacial acrylic acid
gal	Gallons
GHG	Greenhouse gas
gpm	Gallons per minute
HDDA	1,6-Hexanediol diacrylate
HVAC	Heating, ventilation and air conditioning
IPN	Interpenetrating polymer network
IUPAC	International Union of Pure and Applied Chemistry
kcal	Kilocalories
kg	Kilograms
kg/h	Kilograms per hour
kJ/mol	Kilojoules per mole
KO	Knockout
KTPA	Kilotons per annum
kW	Kilowatts
kWh	Kilowatt-hour
lb	Pounds
lb/h	Pounds per hour
lb/lb	Pounds per pound
LP	Low-pressure
MEHQ	Hydroquinone monomethyl ether
min	Minutes
µm	Micrometers
Mlb/h	Thousand pounds per hour

mm	Millimeters
MMBtu/h	Million British thermal units per hour
m/min	Meters per minute
MMlb/y	Million pounds per year
mol%	Molar percent
Mol. wt.	Molecular weight
Mscf/h	Thousand standard cubic feet per hour
Opex	Operating expenditure
PAA	Polyacrylic acid
PEGDA	Polyethylene glycol diacrylate
PEP	Process Economics Program
PFD	Process flow diagram
ppm	Parts per million
PSD	Particle size distribution
psig	Pounds per square inch gauge
PTZ	Dibenzo-1,4-thiazine
ROI	Return on investment
SAP	Superabsorbent polymer
scf	Standard cubic feet
SPS	Sodium persulfate
SS	Stainless steel
TFC	Total fixed capital
t/h	Metric tons per hour
TPO	Diphenyl (2,4,6-trimethylbenzoyl) phosphine oxide
TR	Refrigeration tons
TR-h	Refrigeration ton-hour
t/t	Metric tons per metric ton
t/y	Metric tons per year
UV	Ultraviolet
wt%	Weight percent
WWT	Wastewater treatment
y	Years

Abstract

Superabsorbent polymers (SAPs) are polymer networks distinguished by their exceptional liquid-absorption capacity and highly porous structure, making them increasingly valuable across diverse industries. While their hydrophilic properties are extensively utilized in hygiene applications, SAPs also exhibit unique structural, thermal, and rheological characteristics that are being leveraged in biomedical, agricultural, slurry dewatering, and cement and concrete sectors. This review examines advancements in SAP production, with particular emphasis on the continuous belt reactor process. The process is based on free-radical gel polymerization of partially neutralized acrylic acid conducted on an endless conveyor belt, offering enhanced efficiency and product consistency.

This review addresses the technical and economic aspects of producing commercial-grade SAP by belt reactor, a process similar to Lummus Technology's Saplene™ process, with a plant capacity of 110.24 million pounds per year (MMlb/y) [50,000 metric tons per year (t/y)]. Saplene™ process is a water-based, UV-initiated gel polymerization process carried out in a continuous belt reactor. The process flow diagram, material balance, major equipment list with specifications, cost information for battery limits and off-sites, variable costs, capital and operating expenditures, and total production cost are included in this assessment. The Process Economics Program's independent interpretation of the commercial process, based on data from publicly available sources, including technical articles and patents, serves as the basis for the economic evaluation provided in this review. It may not accurately depict the actual plant layout, either whole or in part.

Contacts

Rajesh Debnath

Associate Director, Process Economics Program
rajesh.debnath@spglobal.com

Rajiv Narang

Executive Director, Global Head, Process Economics Program
rajiv.narang@spglobal.com

CONTACTS

Europe, Middle East, Africa: +44 (0) 203 367 0681

Americas: +1 800 332 6077

Asia-Pacific: +60 4 296 1125

www.spglobal.com/energy

www.spglobal.com/en/enterprise/about/contact-us.html

© 2026 by S&P Global Inc. All rights reserved.

S&P Global, the S&P Global logo, S&P Global Energy, and Platts are trademarks of S&P Global Inc. Permission for any commercial use of these trademarks must be obtained in writing from S&P Global Inc.

You may view or otherwise use the information, prices, indices, assessments and other related information, graphs, tables and images ("Data") in or on this publication only for your personal use or, if you or your company has a license for the Data from S&P Global Energy and you are an authorized user, for your company's internal business use only. You may not publish, reproduce, extract, distribute, retransmit, resell, create any derivative work from, use in any artificial intelligence system, and/or otherwise provide access to the Data or any portion thereof to any person (either within or outside your company, including as part of or via any internal electronic system or intranet), firm or entity, including any subsidiary, parent, or other entity that is affiliated with your company, without S&P Global Energy's prior written consent or as otherwise authorized under license from S&P Global Energy. Any use or distribution of the Data beyond the express uses authorized in this paragraph above is subject to the payment of additional fees to S&P Global Energy.

S&P Global Energy, its affiliates and all of their third-party licensors disclaim any and all warranties, express or implied, including, but not limited to, any warranties of merchantability or fitness for a particular purpose or use as to the Data, or the results obtained by its use or as to the performance thereof. Data in this publication includes independent and verifiable data collected from actual market participants. Any user of the Data should not rely on any information and/or assessment contained therein in making any investment, trading, risk management or other decision. S&P Global Energy, its affiliates and their third-party licensors do not guarantee the adequacy, accuracy, timeliness and/or completeness of the Data or any component thereof or any communications (whether written, oral, electronic or in other format), and shall not be subject to any damages or liability, including but not limited to any indirect, special, incidental, punitive or consequential damages (including but not limited to, loss of profits, trading losses and loss of goodwill).

ICE index data and NYMEX futures data used herein are provided under S&P Global Energy's commercial licensing agreements with ICE and with NYMEX. You acknowledge that the ICE index data and NYMEX futures data herein are confidential and are proprietary trade secrets and data of ICE and NYMEX or its/their licensors/suppliers, and you shall use best efforts to prevent the unauthorized publication, disclosure or copying of the ICE index data and/or NYMEX futures data.

Permission is granted for those registered with the Copyright Clearance Center (CCC) to copy material above for internal reference or personal use only, provided that appropriate payment is made to the CCC, 222 Rosewood Drive, Danvers, MA 01923, phone +1-978-750-8400. Reproduction in any other form, or for any other purpose, is forbidden without the express prior permission of S&P Global Inc. For article reprints contact: The YGS Group, phone +1-717-505-9701 x105 (800-501-9571 from the U.S.).

For all other queries or requests pursuant to this notice, please contact S&P Global Inc. via email at support.energy@spglobal.com.