

Propionic Acid

Handling/Processing

Identification of Petitioned Substance

Chemical Name (IUPAC):

Propanoic acid

CAS Number:

79-09-4

Other Names:

Propionic acid

Methylacetic acid

Ethylformic acid

Ethanecarboxylic acid

Carboxyethane

Other Codes:

EINECS 201-176-3

RTECS UE 5950000

UN 1848

EC 607-089-00-0

Trade Names:

Luprosil

Prozoin

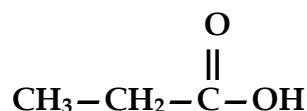
Tenox P grain preservative

Tenox P

Characterization of Petitioned Substance

Composition of the Substance:

Propionic acid is a three-carbon carboxylic acid, $\text{CH}_3\text{CH}_2\text{COOH}$, which occurs naturally as the free acid or in the form of its esters. It can be produced by chemical synthesis or by fermentation. The chemical structure of propionic acid is shown below:

**Properties of the Substance:****Product Chemistry (EPA, RED, 1991)**

Physical State	Oil liquid
Appearance	Colorless
Odor	Rancid, pungent odor
Molecular Weight	74.08
Boiling Point (760 mmHg)	141 °C
Melting Point	-22.4 °C
Solubility	Complete in water, ethanol, chloroform, diethyl ether
Vapor Pressure	3 mm Hg at 20 °C
Specific Gravity	0.99 at 20 °C
Dissociation Constant	1.32×10^{-5} at 25 °C
pH	Around 5 (- log K=4.87) based on the dissociation constant

50 **Specific Uses of the Substance:**

51
 52 Propionic acid is an active ingredient for use as fungicides and bactericides on stored grains, hay, storage
 53 areas for silage and grains, poultry litter, and drinking water for poultry and livestock. According to the
 54 petition, there is 48% of propionic acid in their product (DMX-7) which is used primarily for animal feed
 55 preservation as a mold inhibitor. It is used in shipping and storage and is applied either as a solution or on
 56 an absorbent (vermiculite) to prevent mold in corn gluten meal, corn, rice and other grains. Propionic acid
 57 is applied with a spray nozzle. Application rates of propionic acid depend on the moisture content of the
 58 grain at the time it is placed in storage, and also varies depending on whether the grains are in "open"
 59 storage or "closed" storage. The following information is provided in the petition:

<u>Moisture Level</u>	<u>Amount of DMX-7</u>
61 Up to 14%	Minimum 2 pounds per ton
62 16%	Minimum 3 pounds per ton
63 18%	Minimum 4 pounds per ton

64
 65 **Approved Legal Uses of the Substance:**

66
 67 1. The U.S. Environmental Protection Agency (EPA) approved propionic acid under 40 CFR Part 180—
 68 Tolerances and Exemptions from Tolerances for Pesticide Chemicals In food. It is stated as "§180.1023
 69 Propanoic acid; exemptions from the requirement of a tolerance." It is exempted from the requirement of a
 70 tolerance on all crops when used as an active/inert ingredient in accordance with good agricultural
 71 practice in pesticide formulations applied to growing crops, to raw agricultural commodities (before and
 72 after harvest), and to animals (including applied as bactericide/fungicide to livestock drinking water,
 73 poultry litter, and storage areas for silage and grain). Propionic acid has an EPA Pesticide Chemical (PC)
 74 Code Number: 077702; and Registration No. 8596-24— fungicide for external application.

- 75
 76 2. The U.S. Food and Drug Administration (FDA) approved propionic acid under:
- 77 • "Animal Drugs, Feeds, and Related Products" listed on "Substances Generally Recognized As
 - 78 Safe" in "Chemical Preservatives", 21 CFR §582.3081. Propionic acid is generally recognized as safe
 - 79 (GRAS) when used in accordance with good manufacturing or feeding practice; and
 - 80 • "Food for Human Consumption" listed on "Direct Food Substances Affirmed as Generally
 - 81 Recognized As Safe", 21 CFR §184.1081. Propionic acid is used, as an antimicrobial agent and a
 - 82 flavoring agent, in food with no limitation other than current good manufacturing practice.

83
 84 **Action of the Substance:**

85
 86 Propionic acid is permitted in animal feed and human foods primarily as a mold inhibitor. It tends to be
 87 highly specific against molds, with the inhibitory action being primarily fungistatic rather than fungicidal.
 88 Propionic acid acts against microorganisms by inhibiting the cellular uptake of substrate molecules (Jay,
 89 2005).

90
 91 The undissociated form of propionic acid is essential to the antimicrobial activity. It can penetrate the
 92 semi-permeable membrane of the bacterial cell wall and enter cytoplasm. After that, propionic acid
 93 dissociates at the internal pH of bacteria (around pH 7.0) and causes the internal pH of the microbe to
 94 decrease, which the bacteria are unable to tolerate. This phenomenon consumes energy and eventually
 95 stops the growth of the bacteria or even kills them.

97 **Status**

98
 99 **United States:**

100
 101 1. Environmental Protection Agency – propionic acid was first registered for pesticidal use in the early
 102 1970's. In 1975, EPA first exempted propionic acid from tolerances for residues following post-harvest
 103 application in grains or hays. As the active ingredient, propionic acid is a fungicide/bactericide used to (a)

104 preserve stored grains for animal and human consumption, (b) inhibit bacterial growth in drinking water
105 for poultry and livestock, (c) control mold and fungi in poultry litter and animal feed, and (d) sanitize pre-
106 cleaned food contact surfaces. Propionic acid is also identified as an inert ingredient, on the Agency's "List
107 4B", in pesticide formulations.

108
109 2. Food and Drug Administration— in May 1984, propionic acid was affirmed as Generally Recognized
110 As Safe (GRAS) for use as direct food additives (i.e., as chemical preservatives in animal feeds and
111 antimicrobial/flavoring agents in human food) with no limitation other than current good manufacturing
112 practice.

113 **International:**

114
115
116 1. The Canada Food Inspection Agency, Food and Drug Regulations – propionic acid as a preservative is
117 listed under Food Additives Permitted for Use in Canada. (Last modified 2006)

118 2. The European Union (EU) – propionic acid is listed under the Preservatives group in the List of
119 Additives Currently Permitted in Food.

120 3. The Joint FAO/WHO Expert Committee on Food Additives – propionic acid (INS¹: 280) functional
121 uses as preservative, antimould and antirope agent, or flavoring agent. (Latest evaluation 1997)

122 4. The EU Organic Regulation No 2092/91 – the use of propionic acid as a preservative in the production
123 of silage shall be only permitted when weather conditions do not allow for adequate fermentation.

124 5. The Codex Guidelines for Organically Produced Foods – propionic bacteria and its natural acid
125 product may be used as a silage additive when the weather conditions do not allow for adequate
126 fermentation, and with approval of the competent authority.

127

128 **Evaluation Questions for Substances to be used in Organic Handling**

129
130 **Evaluation Question #1: Is the petitioned substance formulated or manufactured by a chemical process?**
131 **(From 7 U.S.C. § 6502 (21).)**

132
133 According to the petition, the manufacture involves reacting ethylene (petroleum based) and synthetic gas (a
134 mixture of carbon monoxide and hydrogen, produced by partial oxidation of natural gas or oil with air under
135 controlled conditions) with a catalyst (rhodium or cobalt) to produce propionaldehyde. Propionaldehyde is
136 further oxidized to yield propionic acid by a treatment with air or pure oxygen in a carefully controlled reactor.
137 Propionic acid is then concentrated by distillation.

138
139 Propionic acid can also be synthesized from ethanol and carbon monoxide using boron trifluoride catalyst
140 (Merck, 2006).

141
142 **Evaluation Question #2: Is the petitioned substance formulated or manufactured by a process that**
143 **chemically changes the substance extracted from naturally occurring plant, animal, or mineral sources?**
144 **(From 7 U.S.C. § 6502 (21).)**

145
146 As described above, propionic acid is derived from petroleum raw materials. It is manufactured by
147 reacting ethylene, which was produced from petroleum, and carbon monoxide with a catalyst (rhodium or
148 cobalt) to produce the intermediate, propionaldehyde. Further oxidation yields propionic acid.

149
150 **Evaluation Question #3: Is the petitioned substance created by naturally occurring biological**
151 **processes? (From 7 U.S.C. § 6502 (21).)**

152
153 Propionic acid can be produced biologically from the metabolic breakdown of fatty acids containing odd numbers
154 of carbon atoms, and in the breakdown of some amino acids. It is formed in the oxidation of fatty acids and

¹ A number assigned to a food additive in accordance with the Codex Class Names and the International Numbering System (INS) for Food Additives.

155 from the side chain of cholesterol. In addition, bacteria of the genus *Propionibacterium* also can produce
156 propionic acid as the end product of the anaerobic metabolism. These bacteria are commonly found in the stomachs
157 of ruminants and play important roles in the development of the characteristic flavor of Swiss cheese. Several
158 carbon sources (such as glucose, xylose, maltose, sucrose, and whey lactose) have been used for propionic acid
159 fermentation, but the results are not economically viable (Kumar et al., 2006).

160
161 **Evaluation Question #4: Is there a natural source of the petitioned substance? (From 7 CFR § 205.600 (b) (1).)**
162

163 As stated above in Evaluation Question #3, propionic acid naturally occurs in animals and in dairy
164 products in small amounts. Propionic acid was first described in 1844 by Gottlieb who found it among the
165 degradation products of sugar. Propionic acid can also be obtained from natural gas by the Fischer-Tropsch
166 process, as a byproduct in the pyrolysis of wood, and by the action of microorganisms on a variety of
167 materials in small yields (Merck, 2006).

168
169 **Evaluation Question #5: Is there an organic agricultural product that could be substituted for the**
170 **petitioned substance? (From 7 CFR § 205.600 (b) (1).)**
171

172 Organic acids are known in the feed industry as an effective and affordable tool to control mold growth.
173 According to the published scientific data, a variety of organic acids (such as acetic acid, lactic acid,
174 propionic acid, or blends of acids) was used to help control mold contamination.

175
176 In 1991, Higgins and Brinkhaus conducted a study to determine the relative efficacy of eight organic acids
177 (propionic, acetic, lactic, undecylenic, butyric, valeric, benzoic, and sorbic) against six molds (*Aspergillus*
178 *spp.*, *Geotrichum spp.*, *Mucor spp.*, *Fusarium spp.*, *Penicillium spp.*, and *Scopulariopsis spp.*) commonly found in
179 animal feeds. The results showed that valeric acid, propionic acid, and butyric acid displayed the highest
180 efficacy against all mold with the effective concentrations ranging from 0.05 to 0.25%. They concluded that
181 due to its high efficacy and its relatively good palatability at lower inclusion rates, as well as its relatively
182 low cost, propionic acid may reasonably be considered one of the most economical organic acids for field
183 application (Higgins et al., 1991). Similar results were obtained by Pelhate in a 1973 study. He examined
184 the relative efficacy of propionic, sorbic, acetic, and formic acids and found propionic acid to be the most
185 effective of these four organic acids (Pelhate, 1973).

186
187 However, there is no information available to suggest that an organic agricultural commodity or product
188 could be substituted for the petitioned substance, propionic acid. The petition mentioned that acetic acid
189 or butyric acid is an alternative, which can be used in place of propionic acid, but both acids have a
190 distinctive pungent odor. For example, butyric acid has a rotten butter odor at ppm levels in air.

191
192 **Evaluation Question #6: Are there adverse effects on the environment from the petitioned substance's**
193 **manufacture, use, or disposal? (From 7 CFR § 205.600 (b) (2).)**
194

195 In the environment, propionic acid acts as a carbon source for various microbes and is metabolized to
196 carbon dioxide and water. Since propionic acid has little outdoor use and is metabolized (bio-degradation)
197 into carbon dioxide and water, there is no adverse effect on the environment. The available ecotoxicity
198 studies indicate that propionic acid is only slightly toxic to birds, fish, aquatic invertebrates and mammals.
199 Since it has limited outdoor use and low toxicity, its hazard to nontarget organisms is expected to be
200 minimal. EPA has waived all environmental fate and ecological effects data requirements (RED, 1991).
201 Propionic acid is also identified on the EPA's List 4B as inert ingredients. For those ingredients listed on
202 List 4B, EPA has sufficient data to reasonably conclude that the current use pattern in pesticide products
203 will not adversely affect public health or the environment.

204
205 **Evaluation Question #7: Does the petitioned substance have an adverse effect on human health as**
206 **defined by applicable Federal regulations? (From 7 CFR § 205.600 (b) (3).)**
207

208 Propionic acid is rapidly absorbed from the mammalian gastrointestinal tract and utilized by most organs
209 and tissues. It is a normal metabolite in the human body. It can be further metabolized to glucose,

210 carbohydrates, amino acids, and lipids; and eventually eliminated from the body as carbon dioxide in the
211 Krebs cycle². Therefore, it is not bioaccumulable. People also consume naturally occurring propionic acid
212 in common foods, such as butter and cheese, and as an added ingredient in other foods. Technical
213 propionic acid is of moderate to low acute toxicity via the oral, dermal, and inhalation routes of exposure
214 (toxicity category III), and is not a skin sensitizer. However, propionic acid is highly irritating to the eyes
215 and skin (toxicity category I).

216
217 In February 2002, EPA's Health Effects Division (HED) concluded that based on its low toxicity, limited use
218 pattern, and affirmation as a GRAS chemical when used as a food additive, propionic acid is not expected
219 to result in any adverse health effects via the food, drinking water, or residential exposure pathways.
220 There is a possibility of eye and skin irritation to occupational handlers; the use of personal protective
221 equipment is required. A review of the toxicology database, with an emphasis on sensitivity to infants and
222 children, shows no significant findings since the date of the original propionic acid Reregistration
223 Eligibility Document (RED) from 1991.

224
225 **Evaluation Question #8: Is the nutritional quality of the food maintained when the petitioned**
226 **substance is used? (From 7 CFR § 205.600 (b) (3).)**

227
228 There is no information available to demonstrate that either there is an impact on the nutritional value of
229 the food treated with propionic acid and of the products derived from livestock fed the feeds treated by
230 propionic acid, or adding propionic acid on grain/other feeds could affect feed digestibility in ruminants.
231 In addition, through communication with Dr. Limin Kung of University of Delaware, who is an expert in
232 this area, he does not believe propionic acid treated silages would impact digestibility of cows.

233
234 **Evaluation Question #9: Is the petitioned substance to be used primarily as a preservative? (From 7 CFR §**
235 **205.600 (b) (4).)**

236
237 As described by the petition, propionic acid is used primarily for animal feed preservation as a mold
238 inhibitor.

239
240 According to published scientific literature, propionic acid is used primarily for animal feed preservation
241 (including hay, silage, and grains) and in human foods (mainly in baked goods and cheeses). Propionic
242 acid can also be used as an intermediate in the synthesis of herbicides, cellulose acetate-propionate plastics
243 and pharmaceuticals.

244
245 **Evaluation Question #10: Is the petitioned substance to be used primarily to recreate or improve**
246 **flavors, colors, textures, or nutritive values lost in processing (except when required by law, e.g.,**
247 **vitamin D in milk)? (From 7 CFR § 205.600 (b) (4).)**

248
249 As stated in Evaluation Question #9, propionic acid is used primarily for animal feed preservation as a
250 mold inhibitor. There is no information available to suggest that propionic acid is used primarily to
251 recreate or improve colors, textures, or nutritive values lost in processing. Propionic acid can also be used
252 as a flavoring agent.

253
254 **Evaluation Question #11: Is the petitioned substance generally recognized as safe (GRAS) when used**
255 **according to FDA's good manufacturing practices? (From 7 CFR § 205.600 (b) (5).)**

256
257 Propionic acid is generally recognized as safe (GRAS), in 21 CFR §582.3081 and §184.1081, by FDA. It is
258 used as a chemical preservative (21 CFR §582.3081) in animal feeds and related products with good
259 manufacturing or feeding practice. Propionic acid is also used as an antimicrobial agent and a flavoring
260 agent (21 CFR §184.1081) in food for human consumption with no limitation other than current good
261 manufacturing practice.

² Krebs cycle is a series of chemical reactions of central importance in all living cells.

262

Evaluation Question #12: Does the petitioned substance contain residues of heavy metals or other contaminants in excess of FDA tolerances? (From 7 CFR § 205.600 (b) (5).)47

264

265

266

267

268

269

270

271

272

273

274

275

276

277

278

279

280

281

282

283

284

285

286

287

288

289

290

291

292

293

294

295

296

297

298

299

300

301

302

303

304

305

306

307

308

309

310

311

312

313

314

315

316

Commercially, the chemical process for manufacturing propionic acid starts with ethylene (petroleum based) and synthetic gas (a mixture of carbon monoxide and hydrogen, produced by partial oxidation of natural gas or oil with air under controlled conditions) with a catalyst (rhodium or cobalt). The distilled propionaldehyde is then treated with air or pure oxygen in a carefully controlled reactor to partially oxidize it to propionic acid. The resulting product is then distilled. The manufacturing process employed in the production of propionic acid, does not include any specific purification steps. Impurities occurring in propionic acid are comprised of unreacted starting materials (e.g., ethylene) as well as reaction by-products (e.g., propionaldehyde). Heavy metals may not occur in the final product due to the distillation process. In addition, there is no other published information to suggest that heavy metals or contaminants may be present in the petitioned substance.

References

Chemistry daily, Propionic acid. http://www.chemistrydaily.com/chemistry/Propionic_acid

Codex Alimentarius, General Standard for Food Additives (FSFA) Online, Food Additive Details, Propionic Acid (280). <http://www.codexalimentarius.net/gsaonline/reference/glossary.html>

FAO/WHO Export Committee on Food Additives, 1997. Propionic Acid, Summary of Evaluations Performed by the Joint FAO/WHO Export Committee on Food Additives. http://www.inchem.org/documents/jecfa/jecval/jec_2015.htm

Health Canada, Food & Nutrition, Food Additives. Food additives permitted for use in Canada, date modified: 2006-12-11. http://www.hc-sc.gc.ca/fn-an/securit/addit/diction/dict_food-alim_add_e.html

Higgins, C. and Brinkhaus, F., 1991. Efficacy of Several Organic Acids Against Molds. J. Applied Poultry Res. 8:480-487.

International Chemical Safety Cards (ICSC), Propionic Acid, peer- review: October 1997. <http://www.inchem.org/documents/icsc/icsc/eics0806.htm>

IUPAC Name: Propanoic Acid, chemical info. <http://www.chemindustry.com/chemicals/492026.html>

Jay, J. M., Loessner, M. J., and Golden, D. A., 2005. Food Protection with Chemicals and by Biocontrol, p. 301-350. In Modern Food Microbiology, 7th ed. Springer Science+Business Media Inc., New York, N.Y.

Kumar, S and Babu, B.V., 2006. A Brief Review on Propionic Acid: A Renewal Energy Source. Proceedings of National Conference on Environmental Conservation (NCEC-2006), September 1-3, 2006, pp 459-464.

List of Additives Currently Permitted in Food in the European Union and Their E Numbers. http://64.233.169.104/search?q=cache:zZZ9ME_ZHikJ:www.zooloo.co.il/love/food/elist_numbers.pdf+propionic+acid+EU&hl=en&ct=clnk&cd=30&gl=us

Nexant ChemSystems Reports, 1999. Propionic acid in Process Evaluation/Research Planning (PERP). http://nexant.ecnext.com/coms2/summary_0255-202_ITM

Merck, 2006. Propionic Acid in The Merck Index an Encyclopedia of Chemicals, Drugs, and Biologicals, 14th Ed., p. 7828 (Monograph No. 7825). Merck & Co., Inc., Whitehouse Station, NJ, 2006.

- 317 Pelhate, J., 1973. Stabilisation de la mycoflore de maïs-grains humides ensiles. Ann. Tech. Agric. 22:647-
318 661.
- 319
- 320 The Codex Guidelines for the Production, Production, Processing, Marketing and Labeling of Organically
321 Produced Foods. ftp://ftp.fao.org/codex/Publications/Booklets/Organics/organic_2007e.pdf
322
- 323 The EU Council Regulation No.2092/91 of 24 June 1991 on organic production of agricultural products and
324 indications referring thereto on agricultural products and foodstuffs.
325 <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CONSLEG:1991R2092:20071227:EN:PDF>
326
- 327 The Innovation Group, Chemical Profiles, Propionic acid. [http://www.the-innovation-](http://www.the-innovation-group.com/ChemProfiles/Propionic%20Acid.htm)
328 [group.com/ChemProfiles/Propionic%20Acid.htm](http://www.the-innovation-group.com/ChemProfiles/Propionic%20Acid.htm)
- 329
- 330 US EPA, Inert Ingredients Ordered by CAS Number-List 4B, Office of Pesticide Programs, August 2004.
331 www.epa.gov/oppr001/inerts/inerts_list4Bcas.pdf
332
- 333 US EPA, Propionic Acid: Health Effects Division (HED) Science Assessment for Tolerance Reassessment
334 Eligibility Decision. February 2002.
335 [http://www.regulations.gov/fdmspublic/component/main?main=DocumentDetail&d=EPA-HQ-OPP-](http://www.regulations.gov/fdmspublic/component/main?main=DocumentDetail&d=EPA-HQ-OPP-2008-0024-0005)
336 [2008-0024-0005](http://www.regulations.gov/fdmspublic/component/main?main=DocumentDetail&d=EPA-HQ-OPP-2008-0024-0005)
337
- 338 US EPA, Propionic Acid and Salts Summary Document Registration Review: Initial Docket, March 2008.
339 [http://www.regulations.gov/fdmspublic/component/main?main=DocumentDetail&d=EPA-HQ-OPP-](http://www.regulations.gov/fdmspublic/component/main?main=DocumentDetail&d=EPA-HQ-OPP-2008-0024-0003)
340 [2008-0024-0003](http://www.regulations.gov/fdmspublic/component/main?main=DocumentDetail&d=EPA-HQ-OPP-2008-0024-0003)
341
- 342 US EPA, Reregistration Eligibility Document (RED), Propionic Acid and Salts, List D, Case 4078, September
343 1991. US Environmental Protection Agency (EPA), Office of Pesticide Programs, Special Review and
344 Reregistration Division, Washington, DC.
- 345
- 346 US EPA, R.E.D. Facts, Propionic Acid, Pesticides and Toxic Substances (7508W), September 1991.
347 www.epa.gov/oppsrrd1/REDs/factsheets/4078fact.pdf
348
- 349 US EPA, 40 CFR §180.1023 Propanoic acid; exemptions from the requirement of a tolerance. April 29, 2008.
350 [http://ecfr.gpoaccess.gov/cgi/t/text/text-](http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?c=ecfr&sid=07b27dc4c663900385a796ea1353494e&rgn=div8&view=text&node=40:23.0.1.1.28.4.27.16&idno=40)
351 [idx?c=ecfr&sid=07b27dc4c663900385a796ea1353494e&rgn=div8&view=text&node=40:23.0.1.1.28.4.27.16&i](http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?c=ecfr&sid=07b27dc4c663900385a796ea1353494e&rgn=div8&view=text&node=40:23.0.1.1.28.4.27.16&idno=40)
352 [dno=40](http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?c=ecfr&sid=07b27dc4c663900385a796ea1353494e&rgn=div8&view=text&node=40:23.0.1.1.28.4.27.16&idno=40)
353
- 354 US Food and Drug Administration (FDA), 21 CFR Part 184, Direct Food Substances Affirmed as Generally
355 Recognized as Safe, §184.1081 Propionic acid. April 29, 2008. [http://ecfr.gpoaccess.gov/cgi/t/text/text-](http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?c=ecfr&sid=720aba1d6fa18b1eb918fe01edf6af71&rgn=div8&view=text&node=21:3.0.1.1.14.2.1.17&idno=21)
356 [idx?c=ecfr&sid=720aba1d6fa18b1eb918fe01edf6af71&rgn=div8&view=text&node=21:3.0.1.1.14.2.1.17&idno](http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?c=ecfr&sid=720aba1d6fa18b1eb918fe01edf6af71&rgn=div8&view=text&node=21:3.0.1.1.14.2.1.17&idno=21)
357 [=21](http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?c=ecfr&sid=720aba1d6fa18b1eb918fe01edf6af71&rgn=div8&view=text&node=21:3.0.1.1.14.2.1.17&idno=21)
358
- 359 US FDA, 21 CFR Part 582, Substances Generally Recognized as Safe, §582.3081 Propionic acid. April 29,
360 2008. [http://ecfr.gpoaccess.gov/cgi/t/text/text-](http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?c=ecfr&sid=192d36fa94f9bbf23e55ca947c4b9407&rgn=div8&view=text&node=21:6.0.1.1.23.4.1.4&idno=21)
361 [idx?c=ecfr&sid=192d36fa94f9bbf23e55ca947c4b9407&rgn=div8&view=text&node=21:6.0.1.1.23.4.1.4&idno=](http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?c=ecfr&sid=192d36fa94f9bbf23e55ca947c4b9407&rgn=div8&view=text&node=21:6.0.1.1.23.4.1.4&idno=21)
362 [21](http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?c=ecfr&sid=192d36fa94f9bbf23e55ca947c4b9407&rgn=div8&view=text&node=21:6.0.1.1.23.4.1.4&idno=21)
363
- 364 US Patent 3989747 – Production of propionic acid, November 2, 1976.
365 <http://www.patentstorm.us/patents/3989747/fulltext.html>.