Environmental Assessment

1. **Date**: May 12, 2020

2. **Name of Applicant/Notifier**: Hydrite Chemical Co.

3. **Address**:

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4. **Description of the Proposed Action**:

A. Requested Action

The action identified in this FCN is to provide for the use of the food-contact substance (FCS), an aqueous mixture of peroxyacetic acid (PAA), hydrogen peroxide (HP), acetic acid (AA), 1-hydroxyethylidine-1,1-diphosphonic acid (HEDP), and, optionally, dipicolinic acid (DPA) and/or sulfuric acid (SA). The FCS mixture is intended to be used as an antimicrobial agent in the commercial sterilization of aseptic filling systems and glass and plastic food packaging and their closures prior to filling, except for use on food packaging used in contact with infant formula or human milk or on aseptic filling equipment used to fill such packaging.

B. Need for Action

This FCS is intended for use as an antimicrobial agent for the commercial sterilization of aseptic filling systems and glass and plastic food packaging and their closures prior to filling as described in Item 4A. Previous authorizations for this use have allowed processing plants more flexibility in using and managing antimicrobial interventions across the entire production process. The current FCN is needed only to allow market access for the Notifier identified herein.

C. Locations of Use/Disposal

The antimicrobial agent is intended to be used for the commercial sterilization of aseptic filling systems and glass and plastic food packaging and their closures prior to filling. The FCS will be used in processing plants throughout the United States. The waste process water containing the FCS generated at such facilities is expected to enter the wastewater treatment unit at the plants. It is assumed that very minor quantities of the mixture are lost to evaporation throughout the process. It is assumed for the purposes of this Environmental Assessment that treated wastewater will be discharged directly to surface waters in accordance with the plants' National Pollutant Discharge Elimination System (NPDES) permit. This assumption can be considered a worst-case scenario since it does not account for any further treatment that may occur at a Publicly Owned Treatment Works (POTW).

5. Identification of Chemical Substances that are the Subject of the Proposed Action:

Chemical Identity

The subject of this notification is an aqueous mixture of peroxyacetic acid (CAS Reg. No. 79-21-0), hydrogen peroxide (CAS Reg. No. 7722-84-1), acetic acid (CAS Reg. No. 64-19-7), 1-hydroxyethylidene-1,1-diphosphonic acid (CAS Reg. No. 2809-21-4), and/or dipicolinic acid (CAS Reg. No. 499-83-2) and optionally sulfuric acid (CAS Reg. No. 7664-93-9). Peroxyacetic acid formation is the result of an equilibrium reaction between acetic acid and hydrogen peroxide.

$$CH_3CO_2H + H_2O_2 \rightleftarrows CH_3CO_3H + H_2O$$

6. Introduction of Substances into the Environment:

A. As a Result of Manufacture

Under 21 C.F.R § 25.40(a), an environmental assessment should focus on relevant environmental issues relating to the use and disposal from use, rather than the production, of FDA-regulated articles. Information available to the Notifier suggests no extraordinary circumstances, in this case, indicating any adverse environmental impact as a result of the manufacture of the antimicrobial agent. Consequently, information on the manufacturing site and compliance with relevant emissions requirements is not provided here.

B. As a Result of Use and Disposal

Process water containing the FCS will be treated at an on-site wastewater treatment facility and/or at a POTW. HEDP and DPA, the only stable components of the FCS, will partition between the treated process water and the treated sludge, as described more fully below. Only extremely small amounts, if any, of the FCS constituents are expected to enter the environment due to the landfill disposal of sludge containing minute amounts of HEDP and DPA in light of the EPA regulations governing municipal solid waste landfills. EPA's regulations require new municipal solid-waste landfill units and lateral expansions of existing units to have composite liners and leachate collection systems to prevent leachate from entering ground and surface water, and to have ground-water monitoring systems (40 C.F.R. Part 258). Although owners and operators of existing active municipal solid waste landfills that were constructed before October 9, 1993 are not required to retrofit liners and leachate collections systems, they are required to monitor groundwater and to take corrective action as appropriate.

It is assumed, for the purposes of this Environmental Assessment, that treated wastewater will be discharged directly to surface waters in accordance with a National Pollutant Discharge Elimination System (NPDES) permit. This assumption may be considered a worst-case scenario since it takes no account of further treatment that may occur at a Publicly Owned Treatment Works (POTW).

Treatment of the process water at an on-site wastewater treatment facility and/or at a POTW is expected to result in complete degradation of peroxyacetic acid, hydrogen peroxide, and acetic acid.[1] Specifically the peroxyacetic acid will break down into oxygen and acetic acid, while hydrogen peroxide will break down into oxygen and water. Acetic acid is rapidly metabolized by ambient aerobic microorganisms to carbon dioxide and water.[2] Therefore, these substances are not expected to be introduced into the environment to any significant extent when the FCS is used as intended.

Sulfuric acid is listed as an optional ingredient in the FCS formulation. Sulfuric acid is used to catalyze the reaction between acetic acid and hydrogen peroxide, more rapidly producing a stable PAA mixture, and to modify the pH of the FCS.

Sulfuric acid dissociates readily in water to sulfate ions (SO_4^{-2}) and hydrated protons; at environmentally-relevant concentrations, sulfuric acid is practically totally dissociated.[3] As part of the natural sulfur cycle, sulfate is either incorporated into living organisms, reduced via anaerobic biodegradation to sulfides, deposited as sulfur, or re-oxidized to sulfur dioxide and sulfate.[4] Therefore, any terrestrial or aquatic discharges of sulfate associated with the use described in this FCN are not expected to have any significant environmental impact, as sulfate is a ubiquitous anion that is naturally present in the ecosystem and virtually indistinguishable from industrial sources.[5] The remainder of the environmental assessment will therefore consider only the environmental introduction, fate, and potential effects of the stabilizers, HEDP and DPA.

Introduction of HEDP and DPA into the environment will result from use of the FCS for the commercial sterilization of aseptic filling systems and glass and plastic food packaging and their closures prior to filling, and the subsequent disposal of waste water into the processing plant wastewater treatment facility. When the FCS is used at the maximum level allowed under the proposed action, HEDP and DPA would be present in water at levels less than 205 parts per

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[1] Environmental Protection Agency, Reregistration Eligibility Decision: Peroxy Compounds (December 1993), p. 18.

[2] U.S. High Production Volume (HPV) Chemical Challenge Program: Assessment Plan for Acetic Acid and Salts Category; American Chemistry Council, June 28, 2001.

[3] *See* The Organization for Economic Cooperation and Development (OECD) SIDS Voluntary Testing Programme for International High Production Volume Chemicals (OECD SIDS), Sulfuric Acid, 2001 at https://hpvchemicals.oecd.org/UI/handler.axd?id=248f397d-64b3-4e14-8be9-473974e8dfdb.

[4] *See* Human and Environmental Risk Assessment (HERA) on ingredients of Household Cleaning Products, Sodium Sulfate, January 2006.

[5] *Id.*

million (ppm) and 9 ppm, respectively, due to the additional water used for the required sterile water rinse. Assuming, in the very worst-case, that all the water used in an aseptic packaging operation is treated with the FCS, the level of HEDP and DPA in water entering the plant's wastewater treatment facility, the environmental introduction concentration (EIC), would not exceed 205 ppm HEDP and 9 ppm DPA.

The treatment of wastewater at an onsite treatment facility or POTW will result in the absorption of approximately 80% of HEDP into sewage treatment sludge.[6] We differentiate the potential environmental introduction of HEDP to water and sewage sludge, respectively by applying this 80% factor. We also have incorporated a conservative 10-fold dilution factor for discharge to surface waters of the effluent from an onsite treatment facility or POTW to estimate the expected environmental concentrations (EECs).[7] We assume, as a worst case, no adsorption of DPA to wastewater sludge in sewage treatment plants. The estimated environmental concentrations, calculated as described above, are provided in the following table.

Stabilizer Component	Use Level	EIC_{Max}	EEC_{sludge}	EEC_{water}
1-Hyroxyethylidine-1,1-diphosphonic acid (HEDP)	205 ppm	205 ppm	164 ppm	4.1 ppm
Dipicolinic acid (DPA)	9 ppm	9 ppm	0 ppm	0.9 ppm

7. Fate of Emitted Substances in the Environment:

HEDP Fate in Terrestrial Environment

HEDP is expected to partition between water and sludge during wastewater treatment. Sludge resulting from wastewater treatment may end up landfilled or land applied. If land-applied, HEDP shows degradation in soil; as such, disposal on land should ensure mineralization and removal from the environment.[8] HEDP's half-life in soil is estimated to be 373 days, extrapolated from observed degradation of 20% after 120 days.[9] Phosphonates are also sensitive

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[6] HERA – Human & Environment Risk Assessment on Ingredients of European Household Cleaning Products: Phosphonates (June 9, 2004), *available at* www.heraproject.com – Phosphonates.

[7] Rapaport, Robert A., 1988 Prediction of consumer product chemical concentrations as a function of publicly owned treatment works, treatment type, and riverine dilution. Environmental Toxicology and Chemistry 7(2), 107-115.

[8] *See* Footnote 6, HERA Report at p. 18.

[9] *Id.*

to radical-mediated degradation, which may operate in the soil environment and serve as a method for the removal of phosphonate pollution.[10]

Land applications related to the proposed use will result in phosphorus concentrations in soil that are an insignificant fraction of total phosphorus concentrations introduced into the environment as fertilizers. For example, USDA reported that, in 2011, over 8.5 million tons of phosphate fertilizers were consumed in the U.S.[11]

If HEDP-containing sludge is disposed of in a landfill, HEDP would be expected to be controlled by the relevant EPA regulations and state or local guidelines, as described in Item 6.b.

HEDP Fate in Aquatic Environment

Wastewaters from aseptic packaging operations that contain the diluted FCS mixture are expected to be disposed of through the processing plant wastewater treatment facility or through a local POTW. Once HEDP enters the aquatic environment, it is quite stable, though hydrolysis and degradation are enhanced in the presence of metal ions, aerobic conditions, and sunlight.[12] Photolysis can serve as an important route for the removal of phosphonates like HEDP from the environment, with photodegradation half-lives varying from hours to days depending on the presence of cofactors such as oxygen, peroxides, and complexing metals like iron, copper, or manganese. For example, in the presence of iron, 40-90% degradation occurs within 17 days.[13]

In sediment/river water systems, the ultimate biodegradation of HEDP is estimated as 10% in 60 days, with a corresponding half-life of 395 days.[14] In such systems, phosphonates like HEDP can become tightly adsorbed onto the sediment, indicating that the major part of biodegradation may occur in the sediment, where a half-life of 471 days was observed for HEDP.[15] While hydrolysis half-lives are comparatively long (50-200 days) when compared with

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[10] Jaworska, J.; Van Genderen-Takken, H.; Hanstveit, A.; van de Plassche, E.; Feijtel, T. Environmental risk assessment of phosphonates, used in domestic laundry and cleaning agents in the Netherlands. *Chemosphere* **2002,** *47*, 655-665.

[11] USDA. (2013). Fertilizer Use and Price: Table 5 – U.S. consumption of selected phosphate and potash fertilizers, 1960-2011. Accessed March 11, 2016, *available at* http://www.ers.usda.gov/data-products/fertilizer-use-and-price.aspx.

[12] *See* Footnote 6, HERA Report at p. 16.

[13] *See* Footnote 6, HERA Report at p. 19.

[14] *See* Footnote 6, HERA Report at p. 16.

[15] *See* Footnote 6, HERA Report at p. 18.

photodegradation, hydrolysis may serve as a significant route of removal in soil and sediment environments.[16]

Dipicolinic Acid Fate in the Environment

Information in the scientific literature indicates that dipicolinic acid (DPA), a disubstituted pyridine, readily biodegrades in fresh and marine water, and in soil under both aerobic and anaerobic conditions.[17,18] In presenting a review on the microbial metabolism of pyridines, including 2,6-pyridinedicarboxylic acid (*i.e.*, DPA), Kaiser, *et al*. describe aerobic metabolism of 2,6 pyridinedicarboxylic acid to carbon dioxide, ammonium, and water, and anaerobic metabolism to dihydroxypyridine, which then rapidly photodegrades to organic acids (*i.e.*, propionic acid, acetic acid), carbon dioxide, and ammonium.[19] Further information indicates that DPA is soluble in water, with the estimated water solubility of 5,000 mg/L and an octanol-water partition coefficient estimated to be 0.57.[20] Based upon this information, it is reasonable to conclude that DPA will remain substantially with water and not be absorbed to sludge, and that DPA will be readily biodegraded during treatment at POTWs and on-site treatment facilities.

8. <u>Environmental Effects of Released Substances</u>:

HEDP Terrestrial Toxicity

HEDP present in surface water, or on land from applied sludge, is not expected to have any adverse environmental impact based on the terrestrial toxicity endpoints available for plants, earthworms, and birds. Specifically, the no observed effect concentration (NOEC) for soil dwelling organisms was greater than 1,000 mg/kg soil dry weight for earthworms in soil, while

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[16] *See* Footnote 10, Jaworska *et al*. (2002).

[17] Amador, J.A. and Tatlor, B.P., Coupled metabolic and photolytic pathway for degradation of pyridinecarboxylic acids, especially 2,6-pyridinedicarboxylic acid, Applied and Environmental Microbiology, 56(5): 1352-1356 (1990); Seyfried B. and Schnink, B. Fermentive degradation of 2,6-pyridinedicarboxylic acid (Pyridine-2,6- dicarboxylic acid) by a defined coculture of strictly anaerobic bacteria, Biodegradation, 1(1), 1-7 (1990); Kaiser, J.P., Feng, Y., and Bollag, J.M., Microbial metabolism of pyridine, quinolone, acridine, and their derivatives under aerobic and anaerobic conditions, Microbiological Reviews, 60(3): 483-498 (1996).

[18] Naik, M.N. *et al*., Microbial Degradation and Phytotoxicity of Picloram and Other Substituted Pyridines, Soil Biology and Biochemistry, 4: 313-323 (1972), *see* p. 320; Sims, G.K. and Sommers, L.E., Biodegradation of Pyridine Derivatives in Soil Suspensions, 5:503-509 (1986).

[19] *See* Footnote 17, Kaiser, p. 488.

[20] *See* ChemID Plus Database entry for CAS Reg. No 499-83-2, *available at:* https://chem.nlm.nih.gov/chemidplus/name/dipicolinic%20acid.

the 14-day LC_{50} for birds was greater than 284 mg/kg body weight.[21] These values are all well above the EEC estimated in Item 6, above for terrestrial emission of HEDP.

Additionally, as noted above, the maximum estimated concentration of HEDP in sludge is necessarily less than 164 ppm when the solution is combined with the required sterile-water rinsate. HEDP shows no toxicity to terrestrial organisms at levels of up to 1,000 mg/kg in soil.[22] Thus, the very conservatively estimated *maximum* concentration in sludge is only 16% of the NOEC. The maximum concentration in soil will be lower due to dilution by the soil when the sludge is used as a soil amendment resulting in an even larger margin of safety with respect to this NOEC level. The proposed use of HEDP in the FCS mixture therefore is expected to present no terrestrial environmental toxicity concerns.

HEDP Aquatic Toxicity

Aquatic toxicity of HEDP has been summarized in the public literature, and is shown in the following table:[23]

Environmental Toxicity Data for HEDP

Species	Endpoint	mg/L
Short Term		
Lepomis macrochirus	96 hr LC_{50}	868
Oncorhynchus mykiss	96 hr LC_{50}	360
Cyprinodon variegatus	96 hr LC_{50}	2180
Ictalurus punctatus	96 hr LC_{50}	695
Leuciscus idus melonatus	48 hr LC_{50}	207 – 350
Daphnia magna	24 – 48 hr EC_{50}	165 – 500
Palaemonetes pugio	96 hr EC_{50}	1770
Crassostrea virginica	96 hr EC_{50}	89
Selenastrum capricornutum[a]	96 hr EC_{50}	3
Selenastrum capricornutum	96 hr NOEC	1.3
Algae[a]	96 hr NOEC	0.74
Chlorella vulgaris	48 hr NOEC	≥100
Pseudomonas putida	30 minute NOEC	1000
Long Term		
Oncorhynchus mykiss	14 day NOEC	60 – 180
Daphnia magna	28 day NOEC	10 – <12.5
Algae[a]	14 day NOEC	13

[a] The source for this endpoint is the HERA Phosphonates, 2004, Footnote 6, at Table 13.

Jaworska *et al.* showed that acute toxicity endpoints for HEDP ranged from 0.74 – 2,180 mg/L, while chronic NOECs were 60 – 180 mg/L for the 14 day NOEC for *Oncorhynchus*

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[21] *See* Footnote 6, HERA Report at Table 13.

[22] *Id.*

[23] *See* Footnote 10, Jaworska *et al.* (2002).

mykiss and the 28 day NOEC for the *Daphnia magna* ranged from 10 mg/l to <12.5 mg/l. Although a chronic NOEC of 0.1 mg/L for reproductive effects in *Daphnia magna* was reported, it is inconsistent with other toxicity data, and Jaworska *et al.* suggest that it is due to the depletion of micronutrients by HEDP instead of the intrinsic toxicity of HEDP.[24]

Because HEDP is a strong chelating agent, which can result in negative environmental effects, such as the complexing of essential nutrients, both an intrinsic NOEC ($NOEC_i$) and a NOEC that accounts for chelating effects (NOECc) are determined. As noted, it is probable that there will be excess nutrients present in industrial wastewater because eutrophication occurs widely in industrial wastewater coming from food processing facilities.[25]

We note that the 96 hour NOEC, 24-48 hour EC_{50}, and 96 hour EC_{50} values reported by Jarworska *et al*. for *Selenastrum capricornutum*, *Daphnia magna*, and *Crassostrea virginica*, respectively, were all likely due to chelation effects rather than intrinsic toxicity.[26] As such, these levels are not relevant in situations such as food processing plants, where excess nutrients are present. The HERA report on phosphonates includes a discussion of aquatic toxicity resulting from chelation of nutrients, rather than direct toxicity to aquatic organisms.[27] Chelation is not toxicologically relevant in the current evaluation because eutrophication, not nutrient depletion, has been demonstrated to be the controlling toxicological mode when evaluating wastewater discharges from food processing facilities. Jaworska *et al*. reports the lowest relevant endpoint for aquatic toxicity to be the 28-day NOEC for *Daphnia magna* (10 mg/L),[28] which is above the highest conservatively estimated EEC_{water} of 4.1 ppm for HEDP. It is important to again emphasize, however, that these estimated EEC values are entirely substitutional for the EEC values resulting from previously effective FCNs for the same use. Consequently, there will be no new environmental introductions when this FCN becomes effective.

Dipicolinic Acid Environmental Toxicity

Very little experimental ecotoxicity data on dipicolinic acid were identified in the public literature. EPA's ECOTOX database identifies one study indicating a freshwater fish 96-hour LC_{50} of 322 mg/L for the fathead minnow. Nevertheless, the Environmental Protection Agency's Ecological Structure Activity Relationships (ECOSAR) Class Program predicts that

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[24] *Id.*

[25] *See* US EPA Office of Water, Fact Sheet EPA-822-F-01-010; Ecoregional Nutrient Criteria, Dec 2001, *available at* https://nepis.epa.gov/Exe/ZyPDF.cgi/P1009KCN.PDF?Dockey=P1009KCN.PDF.

[26] *See* Footnote 10, Jaworska *et al*. (2002).

[27] *See* Footnote 6, HERA Report at p. 25.

[28] *See* Footnote 10, Jaworska *et al*. (2002).

dipicolinic acid has low ecotoxicity based on its chemical structure.[29] The ECOSAR results for 2,6-pyridinedicarboxylic acid (*i.e.*, dipicolinic acid or "DPA") predict the following acute and chronic toxicity endpoints. The complete ECOSAR report for this analysis is attached to this EA.

ECOSAR Class	Organism	Endpoint	Concentration (mg/L)
Pyridine-alpha-acid	Fish	96 hr LC_{50}	324
	Green Algae	96 h EC_{50}	13.97
	Fish	Chronic Value	32.37
	Green Algae	Chronic Value	7.69

Based on these toxicity predictions, dipicolinic acid is not expected to result in any significant environmental effects at an estimated environmental concentration of 0.9 mg/L (0.9 ppm) resulting from the proposed use of the FCS.

9. **Use of Resources and Energy**:

The notified use of the FCS mixture will not require additional energy resources for the treatment and disposal of wastes as the FCS is expected to compete with, and to some degree replace, similar HEDP stabilized peroxyacetic acid antimicrobial agents already on the market. The manufacture of the antimicrobial agent will consume comparable amounts of energy and resources as similar products, and the raw materials used in the production of the mixture are commercially manufactured materials that are produced for use in a variety of chemical reactions and processes.

10. **Mitigation Measures**:

As discussed above, no significant adverse environmental impacts are expected to result from the use and disposal of the dilute FCS mixture. Therefore, the mixture is not reasonably expected to result in any new environmental issues that require mitigation measures of any kind.

11. **Alternatives to the Proposed Action**:

No potential adverse effects are identified herein which would necessitate alternative actions to that proposed in this Notification. If the proposed action is not approved, the result would be the continued use of the currently marketed antimicrobial agents that the subject FCS would replace. Such action would have no significant environmental impact. The addition of the antimicrobial agent to the options available to food processors is not expected to increase the use of peroxyacetic acid antimicrobial products.

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[29] This program is a sub-routine of the Estimation Program Interface (EPI) Suite – a structure-function predictive modeling suite developed and maintained by the U.S. EPA. Information on EPI Suite is *available at:* https://www.epa.gov/tsca-screeningtools/epi-suitetm-estimation-program-interface.

12. List of Preparers:

Catherine R. Nielsen, Counsel for Notifier, Keller and Heckman LLP, 1001 G Street, N.W., Suite 500 West, Washington, DC 20001. Ms. Nielsen has a J.D., with over thirty years of experience drafting food additive petitions and FCN submissions and environmental assessments.

Mark Hepp, Ph.D., Scientist, Keller and Heckman LLP, 1001 G Street, N.W., Suite 500 West, Washington, DC 20001. Dr. Hepp has a Ph.D. in Chemistry with many years of experience with FCN submissions and environmental assessments.

13. Certification:

The undersigned certifies that the information presented is true, accurate, and complete to the best of her knowledge.

Date: May 12, 2020

[redacted]

Catherine R. Nielsen
Counsel for Notifier

14. List of References:

1. Environmental Protection Agency, Reregistration Eligibility Decision: Peroxy Compounds (December 1993).
2. U.S. High Production Volume (HPV) Chemical Challenge Program: Assessment Plan for Acetic Acid and Salts Category; American Chemistry Council, June 28, 2001.
3. Human and Environmental Risk Assessment (HERA) on ingredients of Household Cleaning Products, Sodium Sulfate (January 2006).
4. The Organization for Economic Cooperation and Development (OECD) SIDS Voluntary Testing Programme for International High Production Volume Chemicals (OECD SIDS), Sulfuric Acid, 2001; *available at* https://hpvchemicals.oecd.org/UI/handler.axd?id=248f397d-64b3-4e14-8be9-473974e8dfdb.
5. HERA – Human & Environment Risk Assessment on Ingredients of European Household Cleaning Products: Phosphonates (June 9, 2004), *available at* www.heraproject.com – Phosphonates.
6. Rapaport, Robert A., 1988 Prediction of consumer product chemical concentrations as a function of publicly owned treatment works, treatment type, and riverine dilution. Environmental Toxicology and Chemistry 7(2), 107-115.

7. U.S. Environmental Protection Agency (EPA), Technical Development Document for the Final Effluent Limitations Guidelines and Standards for the Meat and Poultry Products Point Source Category (40 C.F.R. 432), EPA-821R-04011, September 8, 2004, p. 6-7.
8. Jaworska, J.; Van Genderen-Takken, H.; Hanstveit, A.; van de Plassche, E.; Feijtel, T. Environmental risk assessment of phosphonates, used in domestic laundry and cleaning agents in the Netherlands. *Chemosphere* **2002,** *47*, 655-665.
9. Amador, J.A. and Tatlor, B.P., Coupled metabolic and photolytic pathway for degradation of pyridinecarboxylic acids, especially 2,6-pyridinedicarboxylic acid, Applied and Environmental Microbiology, 56(5): 1352-1356 (1990).
10. Seyfried B. and Schnink, B. Fermentive degradation of 2,6-pyridinedicarboxylic acid (Pyridine-2,6- dicarboxylic acid) by a defined coculture of strictly anaerobic bacteria, Biodegradation, 1(1), 1-7 (1990).
11. Kaiser, J.P., Feng, Y., and Bollag, J.M., Microbial metabolism of pyridine, quinolone, acridine, and their derivatives under aerobic and anaerobic conditions, Microbiological Reviews, 60(3): 483-498 (1996).
12. Naik, M.N. *et al*., Microbial Degradation and Phytotoxicity of Picloram and Other Substituted Pyridines, Soil Biology and Biochemistry, 4: 313-323 (1972).
13. Sims, G.K. and Sommers, L.E., Biodegradation of Pyridine Derivatives in Soil Suspensions, 5:503-509 (1986).
14. Department of Agriculture (USDA), Fertilizer Use and Price: Table 5 – U.S. consumption of selected phosphate and potash fertilizers, 1960-2011 (2003), accessed March 11, 2016, *available at* http://www.ers.usda.gov/data-products/fertilizer-use-and-price.aspx.
15. EPA Office of Water, Fact Sheet EPA-822-F-01-010; Ecoregional Nutrient Criteria, (December 2001), *available at* https://nepis.epa.gov/Exe/ZyPDF.cgi/P1009KCN.PDF?Dockey=P1009KCN.PDF.

15. Attachments

1. Environmental Protection Agency (EPA) ECOSAR Analysis Report on 2,6-Pyridinedicarboxylic Acid.

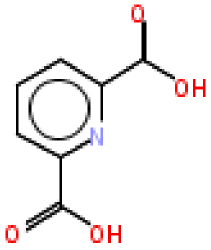
ECOSAR Analysis Report on 2,6-Pyridinedicarboxylic Acid

Organic Module Report

Results of Organic Module Evaluation

CAS	Name	SMILES
499832	2,6-Pyridinedicarboxylic acid	O=C(O)c(nc(cc1)C(=O)O)c1

Structure



Details	
Mol Wt	167.12
Selected LogKow	0.57
Selected Water Solubility (mg/L)	5000
Selected Melting Point (°C)	249
Estimated LogKow	0.57
Estimated Water Solubility (mg/L)	4829.06
Measured LogKow	None
Measured Water Solubility (mg/L)	5000
Measured Melting Point (°C)	249

Class Results:	

Pyridine alpha-acid

Organism	Duration	End Point	Concentration (mg/L)	Max Log Kow	Flags
Fish	96h	LC50	323.61	5	
Green Algae	96h	EC50	13.97	6.4	

Class Results:	

Organism	Duration	End Point	Concentration (mg/L)	Max Log Kow	Flags
Fish		ChV	32.37	8	• The toxicity value was estimated through application of acute-to-chronic ratios per methods outlined in the ECOSAR Methodology Document
Green Algae		ChV	7.69	8	