Sodium Bisulfate

Livestock

Identification of Petitioned Substance

Chemical Names: Sodium bisulfate
IUPAC[1] name: Sodium hydrogen sulfate

Other Name:
Hydrogen sodium sulfate
Monosodium hydrogen sulfate
Sodium acid sulfate
Sulfuric acid sodium salt
Bisulfate of soda
Niter cake
Fanal

Trade Names: PLT® (Poultry Litter Treatment)

CAS Numbers: 7681-38-1 (anhydrous) and
13324-88-5 (monohydrate)

Other Codes:
Pesticide registration number 33907-3
EINECS[2] 231-665-7
EPA PC code 073201; 873201

[1] International Union of Pure and Applied Chemistry
[2] European chemical substances information system

Summary of Petitioned Use

The petitioned purpose for sodium bisulfate, in the form of the commercial product PLT® (currently there are no other commercial forms of sodium bisulfate designed to be used as a litter treatment), is to control ammonia in poultry houses for all species of domestic fowl in orders Galliformes (includes chickens, turkeys, quail, pheasant, etc.) and Anseriformes (waterfowl). It is intended as a topical litter and dirt pad treatment. It is not intended for use in feed, food or drinking water. It is being petitioned for addition to §205.603 as a poultry litter additive. According to the petitioner, litter amendments such as sodium bisulfate minimize ammonia volatilization, improving poultry health and maximizing the litter's agronomic, environmental, and financial value.

Characterization of Petitioned Substance

Composition of the Substance:

Sodium bisulfate is the sodium (Na^+) salt of the bisulfate anion (HSO_4^-) and has the molecular formula of $NaHSO_4$. It is a dry granular product that occurs as white crystals or granules. The anhydrous (no moisture) form is hygroscopic (absorbs moisture from the air). Sodium bisulfate is soluble in water, and its solutions are weakly acidic. The chemical structure of sodium bisulfate is shown in Figure 1 below.

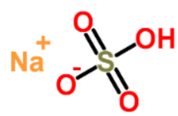

Figure 1. Chemical structure of sodium bisulfate (ChemSpider 2014)

Sodium bisulfate should not be confused with sodium bisulfite ($NaHSO_3$) or sodium sulfate (Na_2SO_4). Sodium sulfate occurs in nature in several minerals and is relatively common in alkaline lakes, ground water and sea water. In the European Union, sodium bisulfite is a food additive, with the EU designation of E222.

Source or Origin of the Substance:

Historically sodium bisulfate is a by-product from the manufacture of nitric acid from sodium nitrate and sulfuric acid. The by-product is referred to as niter cake.

Today there are two methods for producing sodium bisulfate. One involves mixing sodium hydroxide with sulfuric acid which will react to form sodium bisulfate and water as shown in the equation below. The result of this method, produced by JOST Chemical® (Jost Chemical 2014), results in a sodium bisulfate monohydrate which is used as a laboratory reagent.

$$NaOH + H_2SO_4 \rightarrow NaHSO_4 + H_2O$$

The petitioner states that they use another sodium bisulfate production method that involves reacting sodium chloride (salt) and sulfuric acid at elevated temperatures to produce sodium bisulfate and hydrogen chloride gas as shown in the equation below.

$$NaCl + H_2SO_4 \rightarrow NaHSO_4 + HCl$$

According to the petitioner, the liquid sodium bisulfate is then sprayed and cooled so that it forms solid beads. The hydrogen chloride gas produced is dissolved in water to produce hydrochloric acid, which may be sold as a by-product.

Properties of the Substance:

Sodium bisulfate is an odorless, dry granular white product. The chemical properties for the anhydrous form of sodium bisulfate are shown in Table 1. The properties of sodium sulfate, a common low-level impurity that can be found in sodium bisulfate, are also included for comparison. Sodium sulfate is also included for comparison, as it is often confused with sodium sulfite although they are distinctly different compounds.

Table 1. Chemical properties of sodium bisulfate (petitioned), sodium sulfate and sodium bisulfite (similar but chemically distinct substances that are often confused for sodium bisulfate but which have distinctly different properties). Sodium sulfate can be an impurity in the sodium bisulfate production.

PROPERTY	***SODIUM BISULFATE***[1]	***SODIUM SULFATE***[1]	***SODIUM BISULFITE***[2]
CAS	7681-38-1	7757-82-6	7631-90-5
Molecular weight	120.07	142.06	105.71
Density, g/cm^3	2.742	2.671	1.48
Melting point	315°F (157.2°C)	888°C	Decomposes
Specific gravity	2.435		
Solubility in water	50 g/100 mL at 0°C and 100 g/100 mL at 100°C	Soluble in about 3.6 parts H_2O	3.5 parts in cold H_20 & 2 parts in boiling H_2O
Flammability	Non-flammable	Non-flammable	

[1]Source: (EPA Chemical Properties Data 1998)
[2]Source: (PubChem 2014)

Sodium bisulfate in the commercial product PLT® is reported by the petitioners to be 93.2% pure, with 6.8% sodium sulfate (Na_2SO_4) as the only impurity said to be present. Sodium sulfate is the result of the reaction similar to that used to form sodium bisulfate, as shown below.

$$2\ NaCl + H_2SO_4 \rightarrow Na_2SO_4 + 2\ HCl$$

Specific Uses of the Substance:

Sodium bisulfate is used as a top dressing to poultry litter to control ammonia in poultry houses. It is widely used in the commercial poultry industry (Blake and Hess 2001). It is also used in the dairy industry to reduce bacterial counts in bedding and ammonia emissions, preventing environmental mastitis and calf respiratory stress (Sun, et al. 2008). Sodium bisulfate has been successfully used in commercial applications in a wide variety of animal housing types, including dry litter in broiler, turkey and layer facilities; deep bedding for horses (Sweeney, Scanlon, et al. 2000), swine and cattle; and free-stall and dry lot dairy housing systems. Specific application rates and application timings are necessary for reduction in environmental ammonia levels, as well as for reduction of food-borne pathogens and fly control purposes.

Aside from PLT®, Jones Hamilton markets several other sodium bisulfate products: LS-PWT® is a poultry water treatment product. SAS® (Process Water Acidifier) acidifies processing water to maintain a pH ideal to maximize the antimicrobial properties of chlorine in poultry processing water and chill systems. AFG® (Animal Feed Grade) is an animal feed grade acidifier. In addition, ParlorPal® (general purpose acidulant) controls ammonia and reduces odors in dairy footbaths, cow bedding areas, calf pens and free stalls.

Floor-raised poultry are typically kept on litter that starts out as new bedding and becomes a mixture of decomposing manure, spilled feed, feathers and bedding throughout the life of the flock. For commercial broiler houses in the U.S., bedding is typically placed in the poultry house once per year and then reused repeatedly over several flocks (Moore, et al. 1995). This is known as built-up litter. Built-up litter is a major source of volatilizing ammonia, and litter management is a key factor affecting ammonia levels and emissions. Sodium bisulfate is typically added to poultry litter prior to the placement of chicks. The high temperatures during brooding (28-34°C or 82-93°F) enhance ammonia volatilization at a time when chicks are most susceptible to the health challenges associated with elevated ammonia levels (more than 25 ppm).

Sodium bisulfate application rates of 93-100 lbs. per 1,000 ft^2 controlled ammonia levels for up to 30 days relative to the untreated control (McWard and Taylor 2000). By this time the critical brooding period is over. Multiple applications at the manufacturer's recommended rate in two-week intervals reduced ammonia concentration by 56.6% and 21.8% at days 42 and 57, respectively (Purswell, et al. 2013). Growth rate and feed efficiency were not affected by repeated additions of the sodium bisulfate litter amendment with the birds present.

In addition to the control of ammonia levels in poultry houses, litter treatments have also been found to be effective in reducing litter microbial populations. This can be beneficial in controlling food-borne pathogens such as *Campylobacter* and *Salmonella* (Line 2002). Reducing the level of microbial contamination of litter is also important when the litter is removed and used as a fertilizer. Potential contamination of fresh fruits and vegetables grown on fields with applied animal manures is an increasing food safety concern (Hanning, Nutt and Ricke 2009).

The use of sodium bisulfate as a litter amendment reduces atmospheric ammonia content and reduces the frequency and populations of the human pathogen *Campylobacter*. A further benefit discovered includes significant reductions in the population of darkling beetles, a common poultry house pest (Terzich 1997).

For many years sodium bisulfate has been used as a pH reducer in a variety of agricultural, industrial, and food applications. The anti-bacterial properties of sodium bisulfate have been exploited in its application as a toilet bowl cleaner (EPA Reg #1913-24-AA) and as a preservative in EPA method #5035 "Closed-System Purge-and-Trap & Extraction for Volatile Organics in Soil and Water samples" to prevent microbial activity leading to release of volatile organic compounds (VOC)[3].

Different grades of sodium bisulfate are used in a wide variety of products where they function to lower pH.

1. Sodium bisulfate is used for pH reduction in swimming pools and spas.
2. Sodium bisulfate is a major component in dry acid bath formulations for metal cleaning.
3. Sodium bisulfate can act as an adjuvant, protecting agricultural spray chemicals against product loss due to alkaline hydrolysis in spray solutions. It cleans and adjusts pH.
4. Sodium bisulfate is used to reduce alkalinity in 'wash out' ponds formed by concrete truck clean out.
5. Sodium bisulfate is used in chemical grout. It acidifies a grout formulation to form a temporary seal while constructing underground tunnels.
6. Sodium bisulfate is the acidifier and cleaning ingredient in many compounds.
7. Sodium bisulfate neutralizes alkaline soils for construction projects.

Approved Legal Uses of the Substance:

PLT® is an EPA registered pesticide and carries EPA registration number 33907-3. Sodium bisulfate (U.S. EPA PC codes 073201, 873201) is EPA approved for pH adjustment and as a microbicide, fungicide and herbicide (Pesticide Action Network North America 2014).

While sodium bisulfate is not being petitioned for use in poultry feeds, it can safely be consumed by the chickens, although its benefits as a feed additive have not been consistently proven (Ruiz-Feria, et al. 2011). In 1997 sodium bisulfate was AAFCO (Association of American Feed Control Officials) approved as a general-use feed additive, including pet food. It is used as a urine acidifier in cat food to reduce kidney stones. In 1998 FDA listed sodium bisulfate as Generally Recognized as Safe (GRAS). The food-grade product meets the requirements set out in the Food Chemicals Codex (FCC). It is approved for food use in Canada, Mexico, and also in the European Union, Australia and New Zealand (E514ii). Food-grade sodium bisulfate is used as a food additive to leaven cake mixes, in meat and poultry processing, and to prevent browning of fresh-cut produce. It can also be used in beverages, dressings, sauces and fillings.

[3] Volatile Organic Compounds are substances that contain carbon and that evaporate (become a vapor) at room temperature. Some examples include benzene, hexane, toluene, and heptane.

Action of the Substance:

Sodium bisulfate reacts with ammonia, converting it to ammonium sulfate and thereby retaining nitrogen and increasing fertilizer value of the litter. Percent total phosphorus is reduced through dilution. Application rates vary from 0.32 – 1.95 kg per m^2 (65 – 400 lbs. per 1000 ft^2) depending on litter age and concentration of manure in the bedding.

A major issue with built up poultry litter is the loss of nitrogen as ammonia (NH_3) due to microbial mineralization of uric acid, which represents up to 80% of the total nitrogen in the litter. Elevated NH_3 can cause health problems to poultry, including irritation of the mucous membranes in the eyes and respiratory system, damage to the respiratory tract and increased susceptibility to respiratory disease (Kristensen and Wathes 2000). In addition, the loss of NH_3 into the atmosphere is environmentally damaging (Kelleher, et al. 2002) and reduces the nitrogen and overall value of the poultry litter as a fertilizer.

Litter is composed of a variety of organic compounds. Poultry use less than 30% of the nitrogen included in their feed. The remainder is excreted in manure and urine as uric acid (Cook, et al. 2011). Reducing the loss of nitrogen as ammonia is important for the health of the birds. Re-capturing this nitrogen is desired to maintain the fertilizer value of the litter and to increase the efficiency of the livestock/crop production system. Poultry excrete uric acid as the waste product from nitrogen metabolism. Uric acid and undigested proteins are the two main nitrogen components in poultry feces, representing 70% and 30% of total nitrogen respectively (Nahm 2003). The decomposition of uric acid requires the activity of numerous microbial enzymes which are active in moist conditions. The enzyme uricase begins the decomposition, and urease is directly responsible for the production of gaseous ammonia.

Poultry litter pH tends to be on the basic side, which encourages ammonia volatilization (Carlile 1984). When sodium bisulfate is applied to poultry litter, it dissociates into sodium (Na^+), hydrogen (H^+) and sulfate (SO_4^{-2}). The hydrogen reacts with the volatile ammonia (NH_3), converting it into ammonium (NH_4^+). The ammonium then reacts with the sulfate portion of sodium bisulfate, forming ammonium sulfate ($(NH_4)_2SO_4$) and preventing the release of the ammonia into the area. The newly formed ammonium sulfate does not aerosolize but is retained in the manure in its solid form, similar to ammonium sulfate in inorganic fertilizer. As the hydrogen ions react to form more stable compounds, the pH of the litter increases (Choi and Moore Jr. 2008).

$$2\ NaHSO_4 + 2\ NH_4OH \rightarrow (NH_4)_2SO_4 + Na_2SO_4 + 2\ H_2O$$

The petitioner states that ammonium sulfate remains bound in the litter as the pH increases. This statement was not substantiated by the literature. A two-year study comparing ammonia emissions from sodium bisulfate-treated and untreated broiler houses found that the total level of emissions from a house with treated built-up litter was the same as that of a house with untreated built-up litter, although the timing of the emissions were different. The pattern of ammonia emission from the house with the treated built-up litter suggests that the ammonia held in the acid-treated litter at the beginning of the flock was released in the latter part of the flock's grow-out period (Wheeler, Casey, et al. 2008). Similar results were obtained in pen studies (Tasistro, Ritz and Kissel 2007). Additional sodium bisulfate application is therefore required for ongoing ammonia control throughout the life of the flock. While sodium bisulfate can be applied to the litter with birds in the poultry house (Purswell, et al. 2013), it is not common in the industry.

Combinations of the Substance:

For the petitioned use, sodium bisulfate is not used in combination with other substances. PLT® is the only brand name product developed as a litter additive and it does not use any inert ingredients, stabilizers, preservatives, carriers, anti-caking agents or other materials.

Sodium bisulfate must not be mixed with liquid chlorine bleach (hypochlorites), ammonia cleansers or similar products, or alcohols. Sodium bisulfate is hygroscopic so must be kept in a tightly closed container (ScienceLab.com MSDS 2014).

Status

Historic Use:

Sodium bisulfate is not currently permitted in organic livestock production as a poultry litter treatment.

Sodium bisulfate is a dry, granular acid salt that has also been used for many years as a pH reducer in a variety of agricultural, industrial and food applications. Since the 1970s sodium bisulfate has been used as a poultry litter amendment to reduce atmospheric ammonia and improve flock health. The pH-reducing and antimicrobial properties of sodium bisulfate have led to its use for ammonia binding and bacterial reduction in poultry, dairy, and equine manure and bedding materials.

Sodium bisulfate has also been used in 34 EPA registered products, mostly toilet bowl cleaners. It has been categorized as a mineral acid by the EPA (EPA 1993). In general, mineral acids dissociate and release hydrogen ions (H^+), resulting in a reduction of pH. How low the pH goes, and for how long, depends on the amount of neutralizing ions present, the buffering capacity of the medium to which it is applied, and the amount of dilution.

The antibacterial properties of sodium bisulfate have been exploited in its application as a sanitizer (EPA registration #1913-24-AA) and as a preservative (EPA method #5035) to prevent microbial activity leading to volatile organic compounds (VOCs). The production of ammonia (NH_3), VOCs and greenhouse gases (GHGs) by animal manures has received increased scrutiny by both state and federal regulatory agencies, and by the public at large. These gases are produced by microbial activity on the nitrogen and carbon compounds that are not utilized by the animals but instead are excreted in the feces and/or urine.

Organic Foods Production Act, USDA Final Rule:

Sodium bisulfate does not currently appear in OFPA nor the USDA Final Rule for poultry litter treatments.

International

Canada - Canadian General Standards Board Permitted Substances List
http://www.tpsgc-pwgsc.gc.ca/ongc-cgsb/programme-program/normes-standards/internet/bio-org/documents/032-0311-2008-eng.pdf
Sodium bisulfate does not appear in Table 5.3 of the Permitted Substances List and, therefore, is not permitted for this use in Canada.

CODEX Alimentarius Commission, Guidelines for the Production, Processing, Labelling and Marketing of Organically Produced Foods (GL 32-1999)
http://www.fao.org/organicag/doc/glorganicfinal.pdf
Sodium bisulfate is not listed in Annex 2 for Permitted Substances for the Production of Organic Foods.

European Economic Community (EEC) Council Regulation, EC No. 834/2007
http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32007R0834&from=EN
Article 14 does not have a provision for production aids such as litter amendments. As such, sodium bisulfate is not approved for this use in Europe.

European Economic Community (EEC) Council Regulation, EC No. 889/2008
http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32008R0889&from=EN
Chapter 2, article 11 allows for litter 'enrichment' with approved mineral products. Sodium bisulfate is not listed and as such is not allowed for use in organic livestock production in Europe.

Japan Agricultural Standard (JAS) for Organic Production
http://www.maff.go.jp/e/jas/specific/pdf/836_2012-2.pdf

The Japanese Agricultural Standard for Organic Livestock Products (Notification no. 1608 of the Ministry of Agriculture, Forestry and Fisheries of October 27, 2005; partially revised in 2012) does not have a provision for litter amendments. As such, sodium bisulfate is not approved for this use in Japan.

International Federation of Organic Agriculture Movements (IFOAM) NORMS for Organic Production and Processing
http://www.ifoam.org/sites/default/files/ifoam_norms_version_july_2014.pdf
Sodium bisulfate is not listed in Appendix 5 for substances approved for pest and disease control and disinfection in livestock housing and equipment. There are no provisions for litter amendments. As such, sodium bisulfate is not approved for this use in organic production under IFOAM standards.

Evaluation Questions for Substances to be used in Organic Crop or Livestock Production

Evaluation Question #1: Indicate which category in OFPA that the substance falls under: (A) Does the substance contain an active ingredient in any of the following categories: copper and sulfur compounds, toxins derived from bacteria; pheromones, soaps, horticultural oils, fish emulsions, treated seed, vitamins and minerals; livestock parasiticides and medicines and production aids including netting, tree wraps and seals, insect traps, sticky barriers, row covers, and equipment cleansers? (B) Is the substance a synthetic inert ingredient that is not classified by the EPA as inerts of toxicological concern (i.e., EPA List 4 inerts) (7 U.S.C. § 6517(c)(1)(B)(ii))? Is the synthetic substance an inert ingredient which is not on EPA List 4, but is exempt from a requirement of a tolerance, per 40 CFR part 180?

Sodium bisulfate is a synthetic substance in that it is manufactured using a chemical process where sodium hydroxide interacts with sulfuric acid.

A) Sodium bisulfate contains sulfur (S) in the form of bisulfate (HSO_4^-). It is not a toxin produced from bacteria. Sodium bisulfate is not a pheromone, horticultural oil, fish emulsion, treated seed, vitamin or mineral. Although not a soap, sodium bisulfate is a key ingredient in several cleansers. Sodium bisulfate is not a livestock parasiticide or medicine. It is not a physical production aid such as netting, insect trap, sticky barrier, etc. It does function as a production aid in that it is a litter amendment to control ammonia levels in the poultry house.
B) Sodium bisulfate is an inert ingredient which is not listed on EPA List 4 (7 U.S.C. §6517(c)(1)(B)(ii)), but is exempt from a requirement of a tolerance per 40 CFR part 180. An EPA final rule published in the Federal Register (Federal Register 2014) established an exemption from the requirement of a tolerance of residues of sodium bisulfate when used as an inert ingredient in antimicrobial formulations on food contact surfaces. This exemption applies to its use in public eating places, dairy processing equipment and food processing equipment and utensils at no more than 2,000 ppm in final formulation. The regulation was effective June 6, 2014.

Evaluation Question #2: Describe the most prevalent processes used to manufacture or formulate the petitioned substance. Further, describe any chemical change that may occur during manufacture or formulation of the petitioned substance when this substance is extracted from naturally occurring plant, animal, or mineral sources (7 U.S.C. § 6502 (21)).

There are two methods for producing sodium bisulfate. One method involves mixing sodium hydroxide with sulfuric acid, which will react to form sodium bisulfate and water. The result of this method, produced by JOST chemical (Jost Chemical 2014) is a sodium bisulfate monohydrate which is used as a laboratory reagent.

$$NaOH + H_2SO_4 \rightarrow NaHSO_4 + H_2O$$

The petitioner states that they use the second method, which involves reacting sodium chloride (salt) with sulfuric acid at elevated temperatures to produce sodium bisulfate and hydrogen chloride.

$$NaCl + H_2SO_4 \rightarrow NaHSO_4 + HCl$$

Per the petition, sodium chloride and sulfuric acid are mixed together in a reaction vessel at 600°F. Molten sodium bisulfate and hydrogen chloride gas are produced from this reaction. The molten sodium bisulfate is transferred to the spray chamber where it is sprayed and cooled to form solid beads. The beaded sodium bisulfate is then screened for size and transferred to bulk storage bins or packaged off into containers. The hydrogen chloride gas produced in the reaction is absorbed in water to produce hydrochloric acid, which is sold as a co-product of the manufacturing process. There are no left over reactants requiring disposal. According to the petitioner, quality control measures used in the manufacturing of sodium bisulfate ensure that all the starting materials are contained in the final products so that no waste is generated.

Evaluation Question #3: Discuss whether the petitioned substance is formulated or manufactured by a chemical process, or created by naturally occurring biological processes (7 U.S.C. § 6502 (21)).

Sodium bisulfate is manufactured by the chemical process described in the previous question. It is not created by naturally occurring biological processes or extracted from any naturally occurring plant, animal or mineral source.

Evaluation Question #4: Describe the persistence or concentration of the petitioned substance and/or its by-products in the environment (7 U.S.C. § 6518 (m) (2)).

Sodium bisulfate is hygroscopic in that it attracts water. Sodium bisulfate dissociates completely in water into sodium (Na^+), hydrogen (H^+) and sulfate (SO_4^{-2}). As a mineral acid, sodium bisulfate is not expected to contaminate ground water or soil or to accumulate in the food chain (EPA 1993).

Without the addition of the sodium bisulfate, the nitrogen present in the litter would be lost as volatile ammonia. Sodium bisulfate captures this nitrogen, increasing the nitrogen content of the litter (Choi and Moore Jr. 2008). Sodium bisulfate-treated chicken litter also provides a nitrogen source in a form that plants can use immediately (ammonium sulfate). Ammonium sulfate is available to plants as a nitrogen source. In the soil the ammonium ion is released and forms a small amount of acid, lowering the soil pH while contributing nitrogen for plant growth. In commercial fertilizers, nitrogen is supplied in the form of ammonium nitrate. The nitrogen content of ammonium sulfate is lower – 21% nitrogen and 24% sulfur, compared to ammonium nitrate (NH_4NO_3) with 34% nitrogen.

Bacterial levels in poultry litter have been shown to decrease as pH decreases. The use of PLT® has been shown to reduce survivability of *E. coli* and *Salmonella* in broiler house litter (Pope and Cherry 2000). As such, sodium bisulfate may be a beneficial component for pathogen reduction, and could play a role in an on-farm HACCP (Hazard Analysis and Critical Control Points) program, although further research is needed (Pope and Cherry 2000).

PLT® is reported to be 93.2% pure, with 6.8% sodium sulfate as an impurity. Sodium sulfate is also produced in the reaction of sodium bisulfate and ammonia, but has not been shown to be a concern for the welfare of the flock or the environment,. In fact, sodium sulfate can be used as a source of sodium without chloride in poultry diets (Jankowski, et al. 2011).

Evaluation Question #5: Describe the toxicity and mode of action of the substance and of its breakdown products and any contaminants. Describe the persistence and areas of concentration in the environment of the substance and its breakdown products (7 U.S.C. § 6518 (m) (2)).

See response to question 4 and 6 for information about the breakdown products and their toxicity. The mode of action of sodium bisulfate with ammonia is unrelated to the type of litter used. The only effect of litter type is the amount of moisture and thus the amount of ammonia produced. For example, sand, grass and newspaper litters volatilize greater amounts of ammonia than wood shavings (Garces, Chilundo and Jairoce 2013). Bedding materials help absorb moisture, limiting the production of ammonia gas and growth of harmful pathogens. Historically, pine shavings have been used as poultry bedding and are the standard to which other materials are compared. There are some regional variations in bedding material, with peanut hulls sometimes used in Georgia and Florida, or rice hulls in Arkansas and Mississippi. Other bedding materials studied include, but are not limited to, pine bark, chipped pine, mortar sand, ground hardware pallets, chopped straw, ground door filler, and cotton-gin trash (Bilgili, et al. 2009). While bedding material in poultry houses must be absorbent, it must also dry quickly. Paper products absorb moisture well but do not dry out appropriately. This can lead to caking, especially around the waterers, which can cause increased ammonia production, footpad lesions and breast blisters (Bilgili, et al. 2009).

<u>Evaluation Question #6:</u> Describe any environmental contamination that could result from the petitioned substance's manufacture, use, misuse, or disposal (7 U.S.C. § 6518 (m) (3)).

The hydrogen chloride gas produced in the production of sodium bisulfate is absorbed in water to produce hydrochloric acid which can be sold as a co-product. There are no other materials requiring disposal. Quality control measures used in the manufacturing of sodium bisulfate ensure that all the starting materials are converted to final products so that no waste is generated.

EPA's Envirofacts Master Chemical Integrator (EMCI) (EMCI 2009) references the Environmental Defense Fund's Chemical Score Card for sodium bisulfate (Chemical Scorecard 2011). The chemical scorecard summarizes information about the health effects, hazard rankings, industrial and consumer product uses, environmental releases, risk assessment values and regulatory coverage for different products. They use a three ranking system looking at human health, ecological health and integrated environmental rankings. They rank products from least hazardous to most hazardous in a scale from 0-100. Worker exposure hazard score for sodium bisulfate was 18. The environmental hazard value score was 15, and the total hazard value score was 12. Sodium bisulfate has a safe ranking for EPA's Design for the Environment (DfE) program (DfE 2014).

In general, mineral acids such as ammonium sulfate (by product of sodium bisulfate treated litter) will dissociate and release hydrogen ions in the environment thus decreasing the pH. The extent and duration of this decrease in pH will depend on the amount of neutralizing ions present, the buffering capacity of the medium, and the amount of dilution possibilities. However, ammonium sulfate only exerts a small decrease in pH. For example, the application of an ammonium sulfate fertilizer 21-0-0 at 10 lbs per 1000 square feet changes the soil pH from 7.5 to 7.4 (Mason 2008). There was no literature to suggest that repeated applications of sodium bisulfate treated litter would lead to decreases in soil or water pH. .

Sodium bisulfate is harmful if swallowed in large amounts (ScienceLab.com MSDS 2014). Symptoms of swallowing more than one tablespoon of sodium bisulfate include burning pain in the mouth, diarrhea, vomiting and severe low blood pressure. If sodium bisulfate touches human skin, symptoms may include blisters, burns and painful red skin. If sodium bisulfate gets in eyes there may be decreased vision, eye pain, eye redness and tearing (ScienceLab.com MSDS 2014).

Sodium bisulfate is incompatible with strong bases, strong oxidizing agents, sodium carbonate and sodium hypochlorite. It should not be mixed with chlorine bleach or ammonia cleansers.

The levels at which sodium bisulfate is added to poultry litter in broiler houses has been shown to have no statistically significant effect on the incidence of foot pad lesions (Nagaraj, Wilson and Saenmahayak, et al. 2007). Multiple additions of the product PLT during broiler grow out effectively controlled ammonia volatilization from litter with no reduction in foot pad quality (Purswell, et al. 2013).

<u>Evaluation Question #7:</u> Describe any known chemical interactions between the petitioned substance and other substances used in organic crop or livestock production or handling. Describe any environmental or human health effects from these chemical interactions (7 U.S.C. § 6518 (m) (1)).

Sodium bisulfate should not be mixed with chlorine bleach or ammonia cleansers. In addition, sodium bisulfate should not be mixed with sodium carbonate or sodium hypochlorite, which are both approved substances for use in organic production. Sodium carbonate is a §205.605 (a) nonsynthetic allowed substance, and may be used as a natural cleaning product on organic operations. Sodium hypochlorite is on §205.601 as a synthetic allowed as an algaecide, disinfectant and sanitizer. Sodium hypochlorite is also on §205.603 as a synthetic allowed for disinfecting and sanitizing facilities and equipment. Sodium sulfate should not, therefore, be used when sodium hypochlorite has been used for disinfecting and sanitizing poultry facilities.

<u>Evaluation Question #8:</u> Describe any effects of the petitioned substance on biological or chemical interactions in the agro-ecosystem, including physiological effects on soil organisms (including the salt index and solubility of the soil), crops, and livestock (7 U.S.C. § 6518 (m) (5)).

According to the EPA website (EPA 2014), toxicity tests of sodium bisulfate with mosquitos, green algae and water fleas showed that it is not acutely toxic. The research, however, is very old (Anderson 1946, Dowden and Bennett 1965). More recent data could not be located. Sodium bisulfate is used as a means of chemically preserving soil samples to prevent the microbiological degradation of volatile organic compounds (Hewitt 1995).

Soil pH is an important chemical property because it affects the availability of essential plant nutrients (Lucas and Davis 1961). Most of the common crops have a wide range of pH adaptation. As an example, alfalfa, corn and small grains grow well in soil pHs ranging from 5.7 to 8.1. No research could be found on the maximum level of sodium bisulfate that could be added to soil before it would have an adverse effect on soil chemistry. No research showing effects of fertilizing with PLT-treated litter on soil ecosystem could be found, indicating a need for research in this area. The use of PLT-treated litter in the Delmarva Peninsula, a region with heavy broiler production, has not been shown to have negative effects on the soil when applied at levels applicable to the nutrient requirement of the crop being grown (Guo, N. Tongtavee and Labreveux 2009).

The biggest environmental concern with respect to animal manures, including poultry litter, is currently phosphorus runoff (Moore Jr., et al. 1995). Phosphorus is normally the limiting nutrient for eutrophication, which has been identified as an important water problem in United States surface waters. Manure typically has a low nitrogen-to-phosphorus ratio and, if manure is applied to meet the nitrogen requirement of the crops being fertilized, there is a buildup of phosphorus in agricultural soils. Much of this soil phosphorus is lost in runoff from pastures fertilized with manure. As a result, much of the manure must be applied based on crop phosphorus requirement, limiting the potential of poultry manure as an organic fertilizer. Increasing the nitrogen content of the manure, by preventing volatilization, improves its value as an organic fertilizer, thereby reducing phosphorus buildup (Moore Jr., et al. 1995).

To control ammonia levels in animal houses, including poultry houses, sodium bisulfate is added to the bedding or litter. In a study looking at the effect of sodium bisulfate on skin and hooves of horses, it was concluded that sodium bisulfate was safe for use in horse barns (Sweeney, Habecker and Russell 2000). In the study, sodium bisulfate was applied to clipped intact skin after a single and repetitive application. Sodium bisulfate was also applied to the sole of both front hooves and covered with wet gauze. Contact with moistened sodium bisulfate had no effect on pony skin. There were no gross changes, but contact with sodium bisulfate for 6 hours on 10 consecutive days did cause mild to moderate microscopic changes. However, the duration of contact in the study was in excess of that expected under typical husbandry conditions.

The addition of PLT® to poultry litter in broiler houses had no statistically significant effect on the incidence of pododermatitis[4] (Nagaraj, Wilson and Saenmahayak, et al. 2007).

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[4] Footpad dermatitis is a condition caused by necrotic lesions on the plantar surface of footpads of poultry raised on litter material with high moisture levels or ammonia levels, leading to secondary bacterial infection and complications leading to lameness.

<u>Evaluation Question #9:</u> Discuss and summarize findings on whether the use of the petitioned substance may be harmful to the environment (7 U.S.C. § 6517 (c) (1) (A) (i) and 7 U.S.C. § 6517 (c) (2) (A) (i)).

As previously discussed, sodium bisulfate has not been reported to be harmful to the environment.

Sodium bisulfate is used in a variety of commercial applications. It is used in home and institutional pools and spas to maintain the water pH between 7.2 and 7.6. Sodium bisulfate is often used as an adjuvant for agricultural spray chemicals to protect against alkaline hydrolysis which can result in product loss. Sodium bisulfate is used as a de-scaler for boilers, cooling towers and water lines by altering water pH. Sodium bisulfate reduces alkalinity in 'washout' ponds formed when concrete trucks are cleaned out. Sodium bisulfate is often the acidifier in cleaning products. These are only a few of the industries making use of sodium bisulfate on a regular basis. No reports of ecosystem contamination from the use of sodium bisulfate in any of these industries have been located.

<u>Evaluation Question #10:</u> Describe and summarize any reported effects upon human health from use of the petitioned substance (7 U.S.C. § 6517 (c) (1) (A) (i), 7 U.S.C. § 6517 (c) (2) (A) (i)) and 7 U.S.C. § 6518 (m) (4)).

Sodium bisulfate is typically spread mechanically on litter prior to bird placement. It must be hand applied when birds are in the house. Sodium bisulfate is considered hazardous by the OSHA Hazard Communication Standard (29 CFR 1910.1200) in that it causes serious eye irritation, may cause respiratory irritation, and may be harmful if swallowed. When handling sodium bisulfate, it is important to use personal protective equipment. Breathing in dust must be avoided. It is important to wash thoroughly after handling sodium bisulfate. The material is hygroscopic and will readily absorb moisture.

<u>Evaluation Question #11:</u> Describe all natural (non-synthetic) substances or products which may be used in place of a petitioned substance (7 U.S.C. § 6517 (c) (1) (A) (ii)). Provide a list of allowed substances that may be used in place of the petitioned substance (7 U.S.C. § 6518 (m) (6)).

A new type of litter amendment has become available which is based on dried *Yucca schidigera* whole plant. This is Eco-Gest YS® (Nova Microbial Technologies 2014), however it is unknown if it has been approved for use on an organic farm by any certifier or material review organization. Yucca extract products have already been employed as a feed additive for the control of manure odors in organic production (Prince Yuccaplus and Bioliquid 3000®).

There is also a group of litter additives that can be applied to built-up litter to speed the release of ammonia, which is then flushed out of the poultry house before the chicks are placed. This would include such products as agricultural lime ($CaCO_3$), the least effective, and burnt lime (CaO), the most effective, with the effectiveness of hydrated lime ($Ca(OH)_2$) falling in between. This method for controlling ammonia levels in the poultry house shifts the flux in gaseous nitrogen to outside the poultry facility, which can have associated negative impacts on the surrounding environment (Kelleher, et al. 2002).

Another group of litter amendments that have been used to control ammonia in poultry litter are clay-based products that adsorb[5] odors and reduce ammonia release by absorbing moisture. This would include zeolite (natural clay material). Zeolite from Clean Age Minerals, Inc. (Clean Age Minerals 2014) has been approved by the third party material review organization, OMRI (it is "OMRI Listed"). Additional OMRI Listed products include Barn Fresh Plus and Activated Barn Fresh (Absorbent Products 2012), which are combinations of diatomaceous earth and calcium montmorillonite[6] with added citric acid. These products are possible alternatives for sodium bisulfate for control of ammonia.

[5] Adsorb refers to binding to the surface rather than being absorbed.
[6] A type of clay

Poultry excrete uric acid as a waste product from nitrogen metabolism. Uric acid and undigested proteins are the two main nitrogen components in poultry feces, representing 70% and 30% of total nitrogen, respectively (Nahm 2003). The decomposition of uric acid requires the activity of numerous microbial enzymes found within the bacteria that occur naturally in the poultry litter. Microbial uricase begins the decomposition of uric acid, while microbial urease is directly responsible for the production of gaseous ammonia (NH_3). Litter amendments typically aim at interfering with the action of these enzymes.

Another group of litter amendments act by inhibiting microbial growth and enzyme production through competitive exclusion and enzyme inhibition. This would include some of the more recently developed products such as Oxydol Poultry (Agranco Corporation 2014), but this product is not OMRI Listed, and the status of its compliance with the USDA organic regulations is unknown.

The petitioner referred to the use of dried neem leaves for the reduction of ammonia levels. Research on neem leaves was conducted in Bangladesh (Shishir, Murshed and Al-Mamun 2013) where other litter amendments are not available. Neem (*Azadirachta indica*) is a large evergreen fast-growing perennial tree native to Bangladesh and South Asian countries, and neem leaves are not available in large quantities in the U.S.

<u>Evaluation Question #12:</u> Describe any alternative practices that would make the use of the petitioned substance unnecessary (7 U.S.C. § 6518 (m) (6)).

Sodium bisulfate is used as a litter amendment to control ammonia levels in poultry houses. There are management practices which can also play a role in ammonia control, each with different pros and cons. These would include adequate ventilation, appropriate litter material selection, using new litter with each flock, managing litter moisture content, and reducing litter nitrogen content through bird density and diet formulation.

Option 1. Increased ventilation rates

The amount of gas and dust emissions from poultry houses does not vary much during the year; however, concentrations are quite seasonal, with high levels occurring in the winter during times of low air exchange, and with low levels in the summer when more ventilation is provided. While increased ventilation will improve the conditions within the poultry house, this does not address the environmental concerns related to ammonia production (McCrory and Hobbs 2001). Once emitted into the atmosphere, NH_3 can rapidly convert to NH_4^+ aerosol, which forms fine particulate matter (PM2.5) that can be deposited into the smallest airways in the lungs. Additionally, NH_4^+ can contribute to haze. Ammonia or NH_4^+ deposition (dry or with rainfall) may contribute to soil acidification and algal growth in water bodies.

Various methods have been developed to address the emissions from poultry houses. Physical treatments include biofilters and scrubbers, as well as moisture and ventilation control. Such systems require the use of air outlets similar to those used in mechanically ventilated poultry houses.

Option 2. Litter material selection and management

Bedding materials serve three important functions. The first is moisture management. In order for bacterial enzymes to convert nitrogen-containing compounds into ammonia, water is required. The chemical reactions cannot occur in the absence of moisture. The bedding material absorbs excess moisture from poultry manure and the water system. The bedding material also promotes drying by increasing the surface area of the poultry house floor.

The second important factor is the role of bedding in diluting the fecal material. The bedding reduces contact between the birds and the manure produced. Lastly, the bedding material insulates hatchlings from the cooling effects of the ground, and provides a protective cushion between the birds and the floor. An effective bedding material must be absorbent, lightweight, inexpensive and non-toxic. Ideal bedding materials have high moisture absorption and release qualities (dry out) to minimize litter caking[7]. In addition, the bedding material must be compatible as a fertilizer or soil amendment after it has served its purpose in the poultry house.

Pine shavings are the most commonly used material in the U.S., and typically the standard to which other potential bedding materials are compared. Other commonly used materials, depending on location, include peanut hulls and rice hulls. Straw is sometimes used as animal bedding, but it is not as effective in moisture control, making it a poor choice for poultry bedding (Benabdeljelil and Ayachi 1996). Straw also has a tendency to mold. Sawdust has also been used, but it has an inherent risk of ingestion by poultry, leading to digestive problems. Some have had limited success with crushed corn cobs.

European research looking at wheat straw as a litter material reported lower ammonia emissions than with wood shavings, but this reduction was due to caking of the litter material which has adverse effects on chicken health (Tasistro, Ritz and Kissel 2007). Broiler weight gain was significantly lower when wheat straw was used, which could have been caused by the greater caking observed with wheat straw.

Option 3. Single use litter

Floor-raised poultry are typically kept on litter that starts out as new bedding and becomes a mixture of decomposing manure, spilled feed, feathers and bedding throughout the life of the flock. For commercial broiler houses in the U.S., bedding is typically placed in the poultry house once per year and then reused repeatedly over several flocks. This is known as built-up litter. Built-up litter is a major source of volatilizing ammonia, and litter management is a key factor affecting ammonia levels and emissions. New bedding for each flock is more common in other countries, particular Europe, Australia, and Brazil. Even in these countries, however, sustainability of the poultry industry is leading more towards the re-use of litter as effective bedding material is becoming scarce, and the prices are high (Walkden-Brown, et al. 2013). As a result, bedding availability, quality and cost are important considerations (Walkden-Brown, et al. 2013). With increased costs, producers may be tempted to use less bedding material. Litter ammonia levels have been shown to be higher with less bedding material (Al Homidan and Petchey 1997).

As previously indicated, bedding materials serve three important functions. The first is moisture management. The second is diluting the fecal material. The third is acting as insulation to keep the birds from getting chilled by the cold ground. The built-up litter provides this insulation so that only a top dressing of fresh bedding is required with each flock. When using fresh bedding with each flock, more bedding is required to provide this insulation. As a result, using new litter with each flock results in a higher volume of used litter requiring disposal.

In comparing ammonia emissions from broiler barns using new bedding, sodium bisulfate treated built-up litter, or untreated built-up litter, it was found that the use of new bedding for every flock led to consistently lower ammonia emissions at day 21 of the 42-day grow out period (Wheeler, Casey, et al. 2008). Built-up litter without sodium bisulfate treatment had the highest emissions, followed by the treated built-up litter.

Option 4. Environmental moisture control

The bacteria involved in the breakdown of uric acid and undigested proteins in poultry manure require moisture. The environment inside a poultry house is a reflection of the overall production efficiency operation. House design and environmental control, ventilation, feeder and drinker management, flock health, stocking density, litter quality and husbandry are important factors.

Several factors can affect the moisture content of the excreta, and thereby the litter. Genetic changes in broiler chickens over the last 20 years has resulted in dramatic increases in body weight gain and feed efficiency. These have been accompanied by significant increases in water consumption as well (Williams,

[7] When litter begins to retain moisture it clumps together, which is referred to as caking.

Tabler and Watkins 2013). Some factors are related to management and housing, including the amount and type of bedding material, temperature, ventilation, heating, drinking system and bird density. Disease status will also have an effect.

Dietary factors may also affect water consumption and excretion, and thus manure moisture content. High-protein diets formulated to meet methionine requirements without the use of synthetic amino acids result in excessive dietary protein that must be catabolized by the birds and excreted via the kidneys in the form of uric acid. This implies higher water consumption to facilitate the increased excretion. On average, a 1% increase in dietary protein level increases water consumption by 3% (Larbier and Leclercq 1992). The detrimental effect of dietary protein level on water consumption can be confounded by the choice of protein source. Soybean meal has been shown to result in greater water intake than equal amounts of animal protein (Wheeler and James Jr. 1950). Soybean meal, the main protein source in poultry diets, contains other components that can be responsible for a higher water excretion, such as fiber with high water retention capacity, fermentable sugars and potassium (Francesch and Brufau 2004). Broilers fed all vegetable diets based on corn and soybean meal have similar growth performance as long as feed formulation corrects for the reduced nutrient availability in such diets. However, these types of feeds lead to a greater amount of excreta due to higher water intake and a higher proportion of indigestible components (Vieira and Lima 2005)

The use of cereals rich in soluble non-starch polysaccharides (NSP) such as rye, barley, triticale and some wheat varieties has been associated with litter problems related to an increase in the amount of excreta, or to the excreta stickiness and wateriness. The use of feed enzymes in poultry diets has been successful in countering the adverse effects of the NSPs from such cereal grains (Francesch and Brufau 2004).

Option 5. Reduction in the nitrogen excreted in poultry waste

A reduction in ambient nitrogen can be achieved by reducing the level of nitrogen in poultry waste. This can be achieved by lowering the amount of crude protein in the diet with the use of synthetic amino acids such as methionine. The reduction is achieved by reducing the non-essential amino acid pool and supplying a more 'ideal' amino acid profile in the diet. Crude protein diets for meat chickens can be reduced from 22.5% to 16.6% fecal nitrogen concentrations (Waldroup 2000). The research with turkeys, ducks and layers on the reduction of crude protein to reduce the nitrogen content of poultry waste is not as extensive as that with broilers, but it shows similar trends (Nahm 2003).

The level of nitrogen in the litter is also affected by the number of birds placed in the house, the level of litter used, and the amount of time the flock spends outside of the house.

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