Hydrogen Chloride

Crops

Identification of Petitioned Substance

Chemical Names:
Hydrogen chloride

CAS Numbers:
7647-01-0

Other Name:
Anhydrous hydrochloric acid, muriatic acid, chlorane, chlorohydric acid,

Other Codes:
IUPAC: chlorane
InChIKey: VEXZGXHMUGYJMC-UHFFFAOYSA-N
PubChem: CID 313

Summary of Petitioned Use

Following a petition submitted in 2002 (USDA, 2002), the NOSB voted April 29, 2004 recommending addition of hydrogen chloride to the National List (NOSB, 2002). The final rule was published September 11, 2006 (Day, 2006; Electronic Code of Federal Regulations, 2013) as follows:

> § 205.601 Synthetic substance allowed for use in organic crop production.
>
> In accordance with restrictions specified in this section, the following synthetic substances may be used in organic crop production: *Provided,* that, use of such substances do not contribute to contamination of crops, soil, or water. Substances allowed by this section, except disinfectants and sanitizers in paragraph (a) and those substances in paragraphs (c), (j), (k), and (l) of this section, may only be used when the provisions set forth in §205.206(a) through (d) prove insufficient to prevent or control the target pest.
>
> (n) Seed preparations. Hydrogen chloride (CAS 7647-01-0) for delinting cotton seed for planting.

The NOSB reviewed and recommended hydrogen chloride for renewal at its November, 2009 meeting (NOSB, 2009). As required by the Organic Foods Production Act, the National Organic Standards Board has the responsibility to review each substance on the National List within five years of its adoption to determine whether the substance should be renewed or removed from the National List.[1] A previous technical report for hydrogen chloride was completed in August, 2003 and is available on the internet (NOP, 2003). For the 2016 sunset review, the NOSB requested an updated limited scope technical evaluation report for hydrogen chloride covering new developments in cottonseed delinting technology and engineering. To support their decision-making the document has been limited to the following sections:

- Identification of the Petitioned Substance
- Summary of Petitioned (Current) Use
- Evaluation Question #11
- Evaluation Question #12

The current listing for hydrogen chloride is scheduled to sunset on 9/12/2016.[2]

[1] OFPA, Section 2118(e).
[2] The current list of sunset dates is available on the NOP website at NOP 5611 – National List Sunset Dates.

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

Evaluation Question #11: 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)).

The cotton seed is an ovoid, somewhat pointed, dark brown structure. Prior to ginning and delinting, the epidermis of the seed has two types of fibers or lint: long lint fibers and short linters (or fuzz fibers—Oostehuis and Jernstedt, 1999). The long lint fibers are removed during ginning. Cotton ginning is the process of separating long cotton fibers from the cottonseeds (May and Lege, 1999). Short fibers (linters) remaining on the seed after ginning are removed by delinting. The number of linters remaining on cottonseed after ginning is dependent upon both the type of gin used and the variety of cotton (Kanawade and Kashyap, 1981). Respectively, there are 3900-5300 fuzzy, 5300-7000 mechanically delinted and 10,500-12,300 acid delinted cottonseeds per kilogram. Table 1 provides a list of materials/practices that are used in practice to prepare cottonseed for planting.

Although fuzzy seed can be planted, there are several important benefits gained from delinting. Delinted seed can be readily cleaned and gravity-graded to enhance vigor and remove low density high moisture seeds. The singulation and flowability of delinted seed is also improved compared to fuzzy seed which clump in precision planters. There are two approaches to delinting: acid and mechanical.

Acid delinting is the primary method of delinting in the United States. Acid delinting sterilizes the surface of the seed and improves seed health (Gregory et al., 1999). As a result, it is effective in preventing *Xanthomonas campestris* infection and the fungal disease, anthracnose.

Acid delinting is only effective with strong acids. Sensitivity of cottonseed to damage from acid delinting is dependent upon variety, time of exposure and concentration of the acid. Acid damage can affect germination, vigor and fiber quality (Ibrahim et al., 2006; Hopper and Hinton, 1979; Kausal et al., 2005, 2007; Khah and Passam, 1994; Kausak et al., 2007; Prashant et al., 2011). Sulfuric acid is the most common strong acid used both in the United States and internationally. Sulfuric acid is not allowed for delinting under the NOP, but is allowed for use as a stabilizer for soil amendments containing liquid fish products (§ 7 *cfr* 205.601; NOSB, 1995, 2006; USDA, 2003; 2005; 2006; 2012). Sulfuric acid is favored for cottonseed delinting in humid climates and is readily applicable to small lots of cottonseed (Biradarpatil, 2008). There are two general approaches, one using concentrated wet acid and another using diluted acid. Both are relatively low in cost and useful regardless of humidity and seed moisture content. The concentrated acid method has been in use for many years. Fuzzy cottonseed (>40 kg) is placed in a large vessel with a proportionate amount of concentrated sulfuric acid. The vessel is rotated at a slow speed (30-35 rpm) for 6-15 minutes. This treatment burns off the linters. The acid is removed from the vessel, and cottonseeds are subsequently washed with water, neutralized with lime and dried. Safety considerations are important since concentrated sulfuric acid is very corrosive (Bahl, 1981).

A simple form of dilute sulfuric acid delinter for cottonseed can be constructed from three plastic tanks (delinting tank, washing tank and sieve), a stand and an agitator. Technical grade sulfuric acid for such a device can be successfully used at concentrations between 55-65%. Treatment with acid lasts about six minutes. After acid treatment, delinted seeds are washed and treated with lime to neutralize the acid, although sodium carbonate may also be used (Javellonar et al., 1998). While the former method has faced environmental issues the latter has gained acceptance. Although, commonly used for conventional crops, sulfuric acid is not allowed for use in delinting cottonseed under USDA organic regulations.

The gas-acid or dry acid delinting method utilizing hydrogen chloride (anhydrous hydrochloric acid) is a common method in the arid region of West Texas. In this process, cotton linters are converted into a powder (Ardashev, 1933). Gas-acid delinting uses less acid, and is generally less expensive than the wet acid process. However, excessive corrosion of equipment and higher seed moisture content has limited the use of gas-acid delinting in humid regions. If the neutralization process is mismanaged, seed can be severely damaged. Hydrogen chloride is in a gaseous state and has a high affinity for water. Its movement into cracks in the seed coat and the embryo is facilitated by increasing seed moisture content. The potential

for severe damage to cottonseed and reduced germination is likely if seed moisture is greater than 10% (Gregory et al., 1999).

The gas-acid delinting procedure consists of exposing fuzzy seed in an air tight chamber to a controlled amount of hydrogen chloride gas. Duration of exposure can be up to 30 minutes. After the gas is removed, the seeds are gently brushed to remove the brittle linters (Hopper and Hinton, 1979). Residual brushed material can be further processed to methylcellulose (Ardashev et al., 1933). After brushing, cottonseeds are neutralized with lime or calcium carbonate. Under USDA regulations, hydrated lime is allowed in organic crop production as a plant disease control (§7 CFR 205.601) and calcium carbonate is a nonsynthetic substance also allowed in or on processed products labelled as organic (§7 CFR 205.605). Recently, a gas-acid delinting plant was developed in India that is resistant to corrosion, has a pre-drying step so that cottonseed moisture is low prior to treatment, uses ammonia to neutralize the acid and has a pollution scrubber attached that removes potential air pollution risks and dilutes released acid (Maharashtra Seeds, 2013; Bureau of Indian Standards; 2009 a, b; 2010 a, b; 2013 a, b, c, d, e).

Acid delinting remains an effective method for delinting. It has been so effective, that there has not been a strong economic incentive to develop alternative methods. Rather, improvements for acid delinting have consisted of building environmentally friendly processing plants, improving safety measures and developing acid resistant equipment. The hazards and environmental restrictions associated with acid delinting are still important issues.

Small farmers in the tropics of Africa have developed a range of natural alternative methods for improving fuzzy cottonseed for planting. For example, Senegalese farmers use the juice of the Baobab tree (*Adamsonia digitata*) mixed with manure to produce a fermented product that appears to burn linters from the seed. Indian farmers use a combination of termite clay and dung to coat seed, which incorporates a natural fungicide and improves singulation and flowability (Elzakker and Caldas, 1999).

Fuzzy cottonseed is viable and can readily be planted; however, its tendency to clump has restricted applicability of standardized commercially produced precision planters in production. Coating fuzzy seed improves both singulation and flowability. A patented process called EasiFlo™ , developed by Cotton, Inc. is used widely in the animal feed industry. EasiFlo™ is a gelatinized corn starch based coating that permits machine handling of cottonseed. Machine handling of fuzzy cottonseed led to further development of starch based coatings for use in cottonseed for planting. To facilitate coating fuzzy cottonseed for planting, a specialized patented gin stand was developed capable of removing additional linters and the entangled fibers that remain after saw-based ginning. Cottonseeds for treatment are also conditioned to a moisture level of 5% and subsequently re-dried in order to matte down the remaining linters. After conditioning, coating mixtures of gelatinized starch (not certified organic in this study) and talc respectively at 1-2% and 1% by weight are applied uniformly to the seeds. Coated seeds are then permitted to dry.

Cottonseed density is indicative of the germination rate, vigor, stand quality, early flowering and early fruiting. It is believed that medium and high density seed perform better in cotton stand production. Coated seed can be sorted by fractionating air aspiration to separate low from medium and high density seed. A study at Texas Tech University, run over the course of two years, compared field establishment percent, field emergence rate, lint yield and a number of seed laboratory analyses for cottonseed quality between fuzzy seed coated as described and acid delinted seed. This study concluded that there was not a significant difference between coated and acid delinted seed for precision planting (Olivier, 2005). Furthermore, it was shown that the germination rate of coated cottonseeds is improved over acid delinted cottonseed when soil temperatures are below 20^{o}C (McMichael et al., 2004). Although not yet developed as a high throughput system, coated seed has the potential to provide an effective alternative to the acid delinting process for organic seed production. In another study, several types of coatings including starch, clay and livestock manure were compared with acid delinting. Among the treatments, seeds coated with starch, a combination of starch and livestock manure, clay or a combination of livestock manure and clay had the highest and fastest germination when compared to chemically delinted seeds. Germination and vigor of seeds with these coatings improved with time until three months in storage (Calamaan et al., 1996).The starch dextrin was previously petitioned as a seed coating for addition to the National List, but it was not recommended by the NOSB (NOSB, 2007; 2008).

Vegetable starch is not the only type of coating used for cottonseed. Chitosan when treated with sodium hydroxide forms a gel potentially applicable to coating cottonseed (Zeng and Shi, 2009). Water potential

and imbibition for these coatings have been studied and evaluated in the development of effective coatings that maintain shape and form but permit seed to germinate on time with the appropriate vigor (Grellier et al., 1999). No significant differences in yield were found between clay based cottonseed coatings and acid delinted cottonseed. (Zeybek et al., 2010). Not only was the clay based coating enabling for mechanical planting, it also provided fungal protection for the encoated seeds.

Table 1 Methods for preparing cottonseed for planting

Method	Applications	Approved for USDA Organic?
No treatment	Seed is planted manually. Not suitable for large farms	Yes
Concentrated Sulfuric Acid Delinting	Used commercially to permit metered planting	No
Dilute Sulfuric Acid Delinting	Used commercially to permit metered planting	No
Acid-Gas Delinting using Hydrogen Chloride	Used commercially to permit metered planting	Yes, allowed synthetic substance.
Power Roller Gin Relinting	Used in conjunction with coating	Yes
New Sawless Mechanical Delinter	No chemical treatment or coating is necessary. Not currently commercialized.	Yes
Baobab Tree Extract Delinting	Small scale, localized use.	Yes, nonsynthetic
Mud and Dung Coating	Small scale, localized use.	Yes, nonsynthetic
Starch Based Coating	In development for large scale use.	Only if starch is nonsynthetic. Dextrin was previously petitioned as a synthetic seed coating and was not recommended by NOSB.
Clay Based Coating	In development for large scale use.	Yes, if nonsynthetic
Chitosan	In use for rice, other seeds to follow	No.

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

Following ginning, short fibers called linters remain attached to cottonseed. These fibers reduce singulation and flowability. Reduced flowability hinders cleaning and accurate metering of seed in planting operations (Kattes et al., 1993). This short staple inter-felted fiber accounts for approximately ten percent of the weight of the seeds. Furthermore, delinting cottonseed increases its coverage area two to three fold over pubescent seed (Ardashev, 1933). Various mechanical methods have been used to singulate the seed and improve flowability. Most of the methods involve partial or complete removal of the linters and tags (Delouche, 1987).

Flame delinting has been used in the past, but is no longer well accepted. Cottonseed is coated with kerosene, heated and flamed. A specific apparatus is necessary for this process. The resulting seed is similar to acid delinted seed although it is much harder to control seed quality during this process (Hiwasse et al, 1981). Kerosene is not an allowed seed treatment for organic crop production.

Fuzzy cottonseeds released during the ginning process are irregular. Mechanical delinting or re-ginning can potentially improve homogeneity and reduce the irregularity of fuzzy seed. Classically fuzzy cottonseed has been mixed with mud and manure for manual planting. However, the high throughput nature of modern cotton farming makes it difficult to handle the irregular seed after re-ginning because the remaining fibers still cause clumping. Early attempts to remove more of the linters mechanically using a saw type gin produced damaged seed that does not germinate well. An improved power roller gin that uses paddles has been described as effectively removing long linters remaining on ginned seed cotton (Laird et al, 2000). This gin not only recovers 2-2.5% more lint from seed cotton, it provides fuzzy seed that can easily be coated with clay or starch based seed coating for machine handling.

Recently reported is the testing of a new mechanical cottonseed delinter built by the USDA Agricultural Research Service, Southern Plains Area, Cropping Systems Research Lab, 1604 East FM 1294, Lubbock, TX 79403. The new delinter is intended to replace chemical delinting commonly used in the industry today. The new delinter uses a novel process that does not include saws and has produced nearly naked seed during initial testing. Currently, various abrasive materials are being evaluated and a bench-scale model is being built for cotton breeders. The work was confirmed by the project's research leader, but published information is not yet available (Holt, 2013).

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Bureau of Indian Standards (2013b) IS 15859: Cotton seed delinting machinery – Buffing Machine with Air Jet and Nylon Brush.

Bureau of Indian Standards (2013c) IS 15860: Cotton seed delinting machinery – Ammonia Cotton Seed Neutralizer Machine with Ammonia Vaporizer.

Bureau of Indian Standards (2013d) IS 15861: Cotton seed delinting machinery – Pollution Control System with Scrubber, Cyclone, Chimney, Hoods and Ducting.

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