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EXHIBIT 23

National Library of Medicine, Bentonite, CASRN: 1302-78-9, 5/16/2013

(23)

33 pages

BENTONITE

CASRN: 1302-78-9

For more information, search the NLM HSDB database.

Human Health Effects:

Toxicity Summary:
IDENTIFICATION: Bentonite is a rock formed of highly colloidal and plastic clays composed mainly of montmorillonite and produced in situ devitrification of volcanic ash. It may contain feldspar, cristobalite and crystaline quartz. Major uses of bentonite include binding foundry sand in molds, absorbing grease, oil and animal wastes; palletizing taconite iron ore and improving the properties of drilling muds. It is used as an ingredient in ceramics, water proofing and sealing in civil engineering projects such as landfill sites and nuclear waste repositories, serving as a filter, stabilizer or extender in adhesives, paints, cosmetics and medicines. It is used as a bonding agent in animal feed, carrier for pesticides, clarifying wine and vegetable oil and purifying waste water. HUMAN EXPOSURE: In the view of widespread distribution of bentonite in nature and its use in various consumer products, general population exposure to low concentrations is ubiquitous. Occupational exposure to bentonite dust from mining, processing and user industries is a factor. ANIMAL STUDIES: Single intratracheal injection into rodents of bentonite and montmorillonite with low quartz content caused dose and particle side dependent effects, as well as transient local inflammation, which included edema and increased lung weight. Single intratracheal exposures of rats to bentonite caused storage foci in the lungs. After intratracheal exposure of rats to this material with high quartz content, fibrosis is noted. Mice maintained on diets containing bentonite displayed slightly reduced growth rates. Mice treated with higher doses showed minimal growth and fatty livers and fibrosis of the liver and benign hepatomas. Bentonite increased the susceptibility of mice to pulmonary infection. In vitro studies of the effects of bentonite on a variety of mammalian cell types indicated a high degree of cytotoxicity. Limited studies did not demonstrate developmental toxicity in rats after oral exposure to bentonite. No adequate studies are available on the carcinogenicity of bentonite.
[[World Health Organization/International Programme on Chemical Safety; Environmental Heath Criteriia 231 Bentonite, Kaolin and Selected Clay Minerals pp. 1-5 (2005)]] **PEER REVIEWED**

Human Toxicity Excerpts:
/HUMAN EXPOSURE STUDIES/ Effects of bentonite in workers in processing plant...very high incidence of bronchial asthma (25%) in workers examined, and

attributed this to the irritant action of the bentonite dust on the bronchial epithelium.
[Browning, E. Toxicity of Industrial Metals. 2nd ed. New York: Appleton-Century-Crofts, 1969., p. 9] **PEER REVIEWED**

/SIGNS AND SYMPTOMS/ /Investigators/ reported radiological evidence, not supported by autopsy, of significant damage to lungs following exposures to bentonite or montmorillonite dust of 10-42 years.
[IPCS Environmental Health Criteria 231, Bentonite, Kaolin and selected clay minerals. Available from, as of April 5, 2013: [illegible]
PEER REVIEWED

/CASE REPORTS/ Five workers exposed to bentonite or Fuller's earth for periods ranging from less than 15 years to more than 40 years developed dyspnea, in some cases accompanied by cough and sputum, and pneumoconiosis. The general characteristics of the pneumoconiosis of the above five workers, as revealed on autopsy, included emphysema, lesions, numerous firm black patches and nodules 1- 20 mm in diameter, dilated air sacs, adhesions, isolated cavities filled with "black sludge," and other evidence of physical deterioration. ...The accumulated dust amounted to 128 mg/g of dry lung (analyzed by transmission electron microscopy). There was very little or no fibrosis of the type associated with silicosis. Microscopic examination of lung tissue revealed that the nodules were aggregates of fine brown pigment lying free in tissue spaces or contained in macrophages held in a fine reticulum.
[WHO; Environ Health Criteria 231: Bentonite, Kaolin, and Selected Clay Minerals (2005). Available from, as of April 3, 2013: [illegible] **PEER REVIEWED**

/CASE REPORTS/ /Investigators/ demonstrate that exposure to bentonite dust containing 5-11% silica can lead to silicosis. Exposure to this bentonite dust for 10 years with no other known exposure to silica dust led to advanced silicosis in three workers and to death, apparently from silicosis, in one of these three. All showed radiological evidence of silicosis, and the presence of silica in the lungs was confirmed by biopsy in one case.
[WHO; Environ Health Criteria 231: Bentonite, Kaolin, and Selected Clay Minerals (2005). Available from, as of April 3, 2013: [illegible] **PEER REVIEWED**

/CASE REPORTS/ ...A 20-year-old dental assistant who noted a foreign body in her right eye after using a drill to polish a patient's teeth with Prophypaste. Immediately she noticed decreased vision and photophobia. Several opaque deposits superficially embedded in her right cornea were removed within 2 h. There was no evidence of corneal perforation or iritis. A residual superficial corneal infiltrate was noted paracentrally. An anterior uveitis developed and was treated. One month after the injury, the cornea was edematous with a superficial, peripheral ringlike stromal infiltrate and a deep inferior stromal infiltrate. A retrocorneal abscess was present. There was no eyelid edema present. Culture results were negative. Anterior segment inflammation progression of the corneal edema, and an enlarged ring abscess in the corneal stroma continued. There was complete loss of red reflex and iris detail. The diagnosis was infectious endophthalmitis and anterior chamber and vitreous aspirations were performed. No organisms were seen but a few PMN leukocytes were present in the aspirations. These authors undertook the toxicity studies in rabbits presented in the ocular animal toxicity section under Bentonite. They concluded that the similarity of the findings in animals after injection of Bentonite with the findings in this case report suggested that Bentonite was the responsible agent in the dental assistant's symptoms.
[Cosmetic Ingredient Review; Final Report of the Cosmetic Ingredient Review Expert Panel; Final Report on the Safety Assessment of Aluminum Silicate, Calcium Silicate, Magnesium Aluminum Silicate, Magnesium Silicate, Magnesium Trisilicate, Sodium Magnesium Silicate, Zirconium Silicate, Attapulgite, Bentonite, Fuller's Earth, Hectorite, Kaolin, Lithium Magnesium Silicate, Lithium Magnesium Sodium Silicate, Montmorillonite, Pyrophyllite, and Zeolite; International Journal of Toxicology 22 (Suppl 1): 37-102 (2003)] **PEER REVIEWED**

/CASE REPORTS/ A 67-yr old man who had been employed in a bentonite milling plant in Wyoming for 10 yr underwent open lung biopsy to evaluate severe dyspnea with chest radiographic findings of circumscribed nodules. Chronic granulomatous inflammation consistent with silicosis was documented.
[Rom, W.N. (ed.). Environmental and Occupational Medicine. 2nd ed. Boston, MA: Little, Brown and Company, 1992., p. 481] **PEER REVIEWED**

/CASE REPORTS/ ...A 3-year-old girl presented with a chief complaint of vomiting, constipation, lethargy, and weakness over several days. On initial evaluation, the child was mildly dehydrated and had a serum potassium of 0.9 mmol/L. Electrocardiographic findings were also consistent with hypokalemia. Upon further questioning, the parents reported that they had been administering a home remedy, containing colloidal bentonite, both orally and rectally as treatment for persistent constipation. The child received intravenous antibiotics, a normal saline bolus, and multiple boluses of potassium chloride, resulting in eventual normalization of her electrolyte abnormalities. Ingestion of large quantities of clay substances, such as bentonite, can result in gastrointestinal binding of essential electrolytes and possible obstruction. Symptoms and laboratory values often resolve with replacement of electrolytes and cessation of bentonite intake. Although cases of oral ingestion of clay-like substances resulting in electrolyte abnormalities have been reported, there are no previously reported human cases of hypokalemia caused specifically by bentonite administration. This may be due to the unique rectal administration seen in this child, which has not previously been described.
[Bennett A, Stryjewski G; Pediatr Emerg Care 22 (7): 500-2 (2006)] **PEER REVIEWED** PubMed Abstract

/GENOTOXICITY/ To study the genotoxicity induced by organic bentonite particles in vitro. Human B lymphoblast cells (HMy2.CIR) were exposed to organic

bentonite particles at the doses of 0, 1.88, 3.75, 7.50 and 15.00 ug/mL for 24, 48 and 72 hr, calcium sulfate (30 ug/mL) and SiO2 (30 and 240 ug/mL) served as negative and positive controls, respectively. The genotoxicity of organic bentonite particles and soluble fraction was detected using comet assay and Cytokinesis-block micronucleus (CBMN) assay. The results of comet assay indicated that % tail DNA increased with the exposure doses and time in organic bentonite group, % tail DNA at the dose of 15.00 ug/mL for 24 hr, 48 hr and 72 hr in organic bentonite group were 3.20 +/- 0.19, 4.63 +/- 0.88 and 9.49 +/- 1.31 respectively which were significantly higher than those in calcium sulfate group (1.40 +/- 0.11, 1.37 +/- 0.22 and 0.90 +/- 0.16) and those in 30 ug/mL SiO2 group (1.83 +/- 0.21, 1.41 +/- 0.27 and 2.48 +/- 0.25) (P < 0.01). The results of CBMN assay showed that micronucleus frequencies (MNF) in organic bentonite group (except for 1.88 ug/mL for 24 hr) were significantly higher than those in 30 ug/mL calcium sulfate group (MNF for 24, 48 and 72 hr were 1.33% +/- 0.58%, 1.33% +/- 1.15% and 1.33% +/- 0.58%) and those in 30 ug/mL SiO2 group (2.00% +/-0.00%, 1.68% +/- 0.58% and 2.33% +/- 0.58%) (P < 0.01). The results of two assays demonstrated that the soluble fraction of organic bentonite did not induce the genotoxicity. The organic bentonite dusts can induce the genotoxicity in vitro, which may be from the particle fraction.
[Li XX et al; Zhonghua Lao Dong Wei Sheng Zhi Ye Bing Za Zhi. 28 (12): 914-7 (2010)] **PEER REVIEWED** PubMed Abstract

/GENOTOXICITY/ In the present study, we investigated the genotoxic potential of bentonite particles (diameter < 10 um) with an a-quartz content of up to 6% and different chemical modifications (alkaline, acidic, organic). Human lung fibroblasts (IMR90) were incubated for 36 hr, 48 hr, or 72 hr with bentonite particles in concentrations ranging from 1 to 15 ug/sq cm. Genotoxicity was assessed using the micronucleus (MN) assay and kinetochore analysis. The generation of reactive oxygen species (ROS) caused by bentonite particles via Fenton-like mechanisms was measured acellularly using electron spin resonance (ESR) technique and intracellularly by applying an iron chelator. The results show that bentonite-induced genotoxic effects in human lung fibroblasts are weak. The formation of micronuclei was only slightly increased after exposure of IMR90 cells to an acidic sample of bentonite dust with a quartz content of 4-5% for 36 hr (15 ug/sq cm), 48 hr (5 ug/sq cm), and 72 hr (1 ug/sq cm), to an alkaline sample with a quartz content of 5% for 48 hr and 72 hr (15 ug/sq cm), and to an acidic bentonite sample with 1% quartz for 72 hr (1 ug/sq cm). Native (untreated) and organic activated bentonite particles did not show genotoxic effects in most of the experiments. Also, bentonite particles with a quartz content < 1% were negative in the micronucleus assay. Generation of ROS measured by ESR was dependent on the content of transition metals in the sample but not on the quartz content or the chemical modification. Reduction of MN after addition of the iron chelator 2,2'-dipyridyl showed that ROS formation also occurs intracellularly. Altogether, /the authors/ conclude that the genotoxic potential of bentonite particles is generally low but can be altered by the content of quartz and available transition metals.
[Geh S et al; Inhal Toxicol.18 (6): 405-12 (2006)] **PEER REVIEWED** PubMed Abstract

/ALTERNATIVE and IN VITRO TESTS/ To assess the cytotoxicity of four clays containing an aluminum silicate-montmorillonite, bentonite, kaolinite and erionite-we used human umbilical vein endothelial, N1E-115 neuroblastoma, and ROC-1 oligodendroglial cells. Morphological examination, lactate dehydrogenase release and fatty acid release were used as indices of trauma. The clays were added in suspension to the cell cultures at concentrations of 0.1, 0.03 and 0.01 mg/mL of medium and the cells were incubated for 1, 6 and 24 hr. The clays did not lyse ROC-1 and N1E-115 cells and did not cause a dose-dependent increase in fatty acid levels at 24 hr. There were no significant increases in lactate dehydrogenase activity in N1E-115 neuroblastoma or ROC-1 oligodendroglial cells. In human umbilical vein endothelial cells, montmorillonite, kaolinite and bentonite caused a dose-dependent increase in fatty acids at 24 hr. All three clays caused cell lysis. /The authors/ postulate that the cytotoxicity of the clays containing an aluminum silicate towards endothelial cells may disrupt the blood-brain barrier in the affected areas, allowing the entry of the clay particle into the brain. Aluminum silicate clays caused a dose-dependent release of fatty acids in human umbilical vein endothelial cells. The clays also caused lysis of these cells. ROC-1 oligodendroglia and N1E-115 neuroblastoma cells were not lysed by the clays, suggesting that this is not a general phenomenon.
[Murphy EJ et al; Neuroscience 55 (2): 597-605 (1993)] **PEER REVIEWED** PubMed Abstract

/ALTERNATIVE and IN VITRO TESTS/ Considering the biological reactivity of pure quartz in lung cells, there is a strong interest to clarify the cellular effects of respirable siliceous dusts, like bentonites. In the present study, /the authors/ investigated the cellular uptake and the cytotoxic potential of bentonite particles (0< 10 um) with an alpha-quartz content of up to 6% and different chemical modifications (activation: alkaline, acidic, organic) in human lung fibroblasts (IMR90). Additionally, the ability of the particles to induce apoptosis in IMR90-cells and the hemolytic activity was tested. All bentonite samples were tested for endotoxins with the in vitro-Pyrogen test and were found to be negative. Cellular uptake of particles by IMR90-cells was studied by transmission electron microscopy (TEM). Cytotoxicity was analyzed in IMR90-cells by determination of viable cells using flow cytometry and by measuring of the cell respiratory activity. Induced apoptotic cells were detected by AnnexinV/Propidiumiodide-staining and gel electrophoresis. Our results demonstrate that activated bentonite particles are better taken up by IMR90-cells than untreated (native) bentonite particles. Also, activated bentonite particles with a quartz content of 5-6% were more cytotoxic than untreated bentonites or bentonites with a quartz content lower than 4%. The bentonite samples induced necrotic as well as apoptotic cell death. In general, bentonites showed a high membrane-damaging potential shown as hemolytic activity in human erythrocytes. We conclude that cellular effects of bentonite particles in human lung cells are enhanced after chemical treatment of the particles. The cytotoxic potential of the different bentonites is primarily characterized by a strong lysis of the cell

membrane.
[Geh S et al; Arch Toxicol. 80 (2): 98-106 (2006)] **PEER REVIEWED** [illegible]

/ALTERNATIVE and IN VITRO TESTS/ Cell suspensions were incubated with bentonite or montmorillonite for (where specified) 30 min to 24 hr, and the cells were tested for physical integrity or functional ability. Cell types included rat peritoneal macrophages, rabbit and rat alveolar macrophages, a macrophage-like cell line, other white cells, human and other erythrocytes, rodent neural cells, hamster tracheal epithelial cells, and human umbilical vein endothelial cells. The results usually indicated a high degree of cytotoxicity. Concentrations below 1.0 mg/mL of bentonite and montmorillonite particles less than 5 um in diameter caused lysis of human neutrophils, many types of erythrocytes, mouse embryo neuronal cells, and human umbilical vein endothelial cells. The velocity and degree of lysis of sheep erythrocytes were dose dependent. Using cow erythrocytes and montmorillonite, /investigators/ found that particles 0.2-2.0 um in diameter were most active and that particles greater than 2.0 um in diameter showed little or no haemolytic activity. The ability of low concentrations of these particles to lyse mammalian cells, although widespread, was not universal, since /investigators/ reported no lysis of neuroblastoma cells or oligodendroglial cells incubated in 0.1 mg montmorillonite or bentonite/mL for 18 or 24 hr.
[IPCS Environmental Health Criteria 231, Bentonite, Kaolin and selected clay minerals. Available from, as of April 5, 2013: [illegible] **PEER REVIEWED**

/OTHER TOXICITY INFORMATION/ The use of bentonite in various branches of industry, and first of all, in foundry workshops, grows rapidly. The literature data on health injuries bybentonite dust are rather contradictory: due primarily, to the changeable mineralogical composition of the raw material from different deposits. That requires a specific hygienic assessment of each deposit in exploitation. The authors studied the mineral composition, quantitative ratio of the mineral components and morphology of the particles from the respirable fraction of aerosol in the extraction of Bulgarian bentonite. The microscopic mineralogical analysis in phase contrast, established a basic mass of clay minerals, confirmed by the X-ray structural analysis. The free silicic oxide is presented by low-temperature crystobalite and quartz, more rarely opal and chalcedony. Its quantity does not surpass 1-2%. The experimental studies on experimental animals confirmed fibrosis, degree I and II, according to Belt and King. The clinical studies on the workers established the presence of reticular charges in the lungs, type S and L, according to ILO-UC classification. The hygienic characteristic of the Bulgarian bentonite provided grounds for its broad application as a substitute for more dangerous raw materials, quartz sand in the foundries, in particular. Regardless of its advantages, bentonite is not harmless. The adherence to MAC for dustiness and periodic control of the quartz content in the raw material and aerosol in the working environment, are compulsory.
[Mikha?lova-Docheva L et al; Probl Khig 11: 106-13 (1986)] **PEER REVIEWED** [illegible]

/OTHER TOXICITY INFORMATION/ In a sample of 32 workers exposed for varying periods to dust from processing, 14 showed radiological evidence of silicosis. These observations suggest that the beneficial effects /previously/ ascribed to bentonite in protecting rat lungs from silicosis may not be present in humans.
[WHO; Environ Health Criteria 231: Bentonite, Kaolin, and Selected Clay Minerals (2005). Available from, as of April 3, 2013: [illegible] **PEER REVIEWED**

Probable Routes of Human Exposure:
According to the 2006 TSCA Inventory Update Reporting data, the number of persons reasonably likely to be exposed in the industrial manufacturing, processing, and use of bentonite is 100 to 999; the data may be greatly underestimated(1).
[(1) US EPA; Inventory Update Reporting (IUR). Non-confidential 2006 IUR Records by Chemical, including Manufacturing, Processing and Use Information. Washington, DC: U.S. Environmental Protection Agency. Available from, as of Mar 25, 2013: [illegible] **PEER REVIEWED**

NIOSH (NOES Survey 1981-1983) has statistically estimated that 545,795 workers (36,750 of these were female) were potentially exposed to bentonite in the US. Statistically, an estimated 1,732, 6,525 and workers were potentially exposed to Blackhills bentonite, Wyoming bentonite in the US; (none of these were female). An estimated that 11,850 workers (11,045 of these were female) were potentially exposed to bentonite powder(1). Occupational exposure to bentonite may occur through inhalation of dust and dermal contact with this compound at workplaces where bentonite is produced or used. Use data indicate that the general population may be exposed to bentonite via ingestion of and dermal contact with consumer products containing bentonite(SRC).
[(1) NIOSH; NOES. National Occupational Exposure Survey conducted from 1981-1983. Estimated numbers of employees potentially exposed to specific agents by 2-digit standard industrial classification (SIC). Available from, as of Mar 25, 2013: [illegible] **PEER REVIEWED**

Occupational exposure to bentonite dust (total and respirable)(1).

Location/Date	No. Observ/No. Facil	Concn Range (mg/cu m)	Avg/Range (mg/cu m)

Fuller's Earth Plant, IL/1934	5/1	1-19	6
Bentonite Plants, WY/1950-1967	17/4	1-92	11-60
Older Iron Foundry, Germany/pre-1980	6/1	0.08-12.3	6.6
Modern Iron Foundry, Germany/pre-1980	5/1	0.56-7.9	4.8
Bentonite mines & plants, Bulgaria/pre-1981	220/?	1.6-1430.0	333
Non-ferrous foundry/pre-1987	13/1	0.20-27.9	6.65
Mines & plants, USA/1992-1998	251/16	0.00-6.97	0.06-2.18
Mines & plants, Turkey/1996-1999	24/11	2.6-11.2	
Foundries, Turkey/1990-1998	207/70	0.05-33.9	

[(1) IPCS; Environmental Health Criteria 231. Bentonite, Kaolin, and Selected Clay Minerals. Geneva, Switzerland: World Health Org, Internl Prog Chem Safety (2005)] **PEER REVIEWED**

...effects of bentonite in workers in processing plant.../showed/ some injurious effects...in lungs...
[Browning, E. Toxicity of Industrial Metals. 2nd ed. New York: Appleton-Century-Crofts, 1969., p. 9] **PEER REVIEWED**

Reported Fatal Dose:
1. 1= PRACTICALLY NONTOXIC: PROBABLE ORAL LETHAL DOSE (HUMAN) ABOVE 15 G/KG, MORE THAN 1 QT (2.2 LB) FOR 70 KG PERSON (150 LB).
[Gosselin, R.E., H.C. Hodge, R.P. Smith, and M.N. Gleason. Clinical Toxicology of Commercial Products. 4th ed. Baltimore: Williams and Wilkins, 1976., p. II-67] **PEER REVIEWED**

Emergency Medical Treatment:

Emergency Medical Treatment:

EMT Copyright Disclaimer:

The following Overview, *** BENTONITE ***, is relevant for this HSDB record chemical.

Life Support:

- This overview assumes that basic life support measures have been instituted.

Clinical Effects:

0.2.1 SUMMARY OF EXPOSURE
0.2.1.1 ACUTE EXPOSURE
A) Bentonite clay is physiologically inert. Upon ingestion, bentonite will swell into a homogenous mass up to 12 times the volume of the dry powder which may produce intestinal obstruction.
0.2.1.2 CHRONIC EXPOSURE
A) The powder may contain large amounts of free silica which can produce pneumoconiosis with chronic inhalation.
0.2.4 HEENT
0.2.4.1 ACUTE EXPOSURE
A) Direct eye exposure resulted in severe anterior segment uveitis and retrocorneal abscess in a dental assistant.
0.2.6 RESPIRATORY
0.2.6.1 ACUTE EXPOSURE
A) Chronic inhalation exposure to similar clays, such as Fuller's earth, has been shown to cause pneumoconiosis without pathological changes of silicosis. Symptoms usually appear after many years of exposure.
B) Bronchospasm was reported in up to 25 percent of bentonite-exposed workers in one processing plant.
0.2.8 GASTROINTESTINAL
0.2.8.1 ACUTE EXPOSURE
A) Bentonite has been used therapeutically as a bulk laxative, due to its ability to adsorb water and to swell into a homogenous mass. Ingestion without adequate liquids may result in intestinal obstruction.
0.2.12 FLUID-ELECTROLYTE
0.2.12.1 ACUTE EXPOSURE
A) Hypokalemia and microcytic iron-deficiency anemia has been described in patients chronically ingesting clay.
B) Hypokalemia was noted in a cat supposedly chronically

ingesting bentonite from cat litter, although this etiology has been disputed.

0.2.13 HEMATOLOGIC

0.2.13.1 ACUTE EXPOSURE

A) Microcytic iron-deficiency anemia may occur following chronic ingestion.

0.2.15 MUSCULOSKELETAL

0.2.15.1 ACUTE EXPOSURE

A) Chronic ingestion has been reported to cause myositis.

B) A cat supposedly chronically ingesting bentonite from cat litter developed lethargy and muscle weakness, although this etiology has been disputed.

0.2.20 REPRODUCTIVE HAZARDS

A) At the time of this review, no reproductive studies were found for bentonite in humans or experimental animals.

0.2.21 CARCINOGENICITY

0.2.21.1 IARC CATEGORY

A) IARC Carcinogenicity Ratings for CAS1302-78-9 (International Agency for Research on Cancer, 2015; IARC Working Group on the Evaluation of Carcinogenic Risks to Humans, 2010; IARC Working Group on the Evaluation of Carcinogenic Risks to Humans, 2010a; IARC Working Group on the Evaluation of Carcinogenic Risks to Humans, 2008; IARC Working Group on the Evaluation of Carcinogenic Risks to Humans, 2007; IARC Working Group on the Evaluation of Carcinogenic Risks to Humans, 2006; IARC, 2004):

1) Not Listed

0.2.22 GENOTOXICITY

A) At the time of this review, no genetic studies were found for bentonite.

Laboratory:

A) Laboratory measures are not usually useful. Monitor serum potassium levels in patients with significant exposure.

B) If respiratory tract irritation is present, monitor chest x-ray.

Treatment Overview:

0.4.2 ORAL EXPOSURE

A) DILUTION: If no respiratory compromise is present, administer milk or water as soon as possible after ingestion. Dilution may only be helpful if performed in the first seconds to minutes after ingestion. The ideal amount is unknown; no more than 8 ounces (240 mL) in adults and 4 ounces (120 mL) in children is recommended to minimize the risk of vomiting.

B) Encourage fluid intake. Monitor for evidence of constipation and intestinal obstruction.

0.4.3 INHALATION EXPOSURE

A) ACUTE - Acute effects have not been described. Refer to the document on TALC for more information.

0.4.4 EYE EXPOSURE

A) DECONTAMINATION: Remove contact lenses and irrigate exposed eyes with copious amounts of room temperature 0.9% saline or water for at least 15 minutes. If irritation, pain, swelling, lacrimation, or photophobia persist after 15 minutes of irrigation, the patient should be seen in a healthcare facility.

0.4.5 DERMAL EXPOSURE

A) OVERVIEW

1) DECONTAMINATION: Remove contaminated clothing and jewelry and place them in plastic bags. Wash exposed areas with soap and water for 10 to 15 minutes with gentle sponging to avoid skin breakdown. A physician may need to examine the area if irritation or pain persists (Burgess et al, 1999).

Range of Toxicity:

A) Acute poisoning is more related to water intake than to dose. In chronic exposure experimental animal studies, bentonite at 1% to 2% of the diet did not effect calcium or phosphorus metabolism, but larger amounts caused decreased growth, muscle weakness, and death with marked changes in both calcium and phosphorus metabolism.

[Rumack BH POISINDEX(R) Information System Micromedex, Inc., Englewood, CO, 2016; CCIS Volume 167, edition expires Feb, 2016. Hall AH & Rumack BH (Eds): TOMES(R) Information System Micromedex, Inc., Englewood, CO, 2016; CCIS Volume 167, edition expires Feb, 2016.] **PEER REVIEWED**

Antidote and Emergency Treatment:

If breathed in, move person into fresh air. If not breathing, give artificial respiration.

[Sigma-Aldrich Material Safety Data Sheet for Nanoclay, hydrophilic bentonite. Available from, as of April 3, 2013: http://www.sigma-aldrich.com/catalog/product/aldrich/682659?lang=en&region=US **PEER REVIEWED**

Animal Toxicity Studies:

Toxicity Summary:

IDENTIFICATION: Bentonite is a rock formed of highly colloidal and plastic clays composed mainly of montmorillonite and produced in situ devitrification of volcanic

ash. It may contain feldspar, cristobalite and crystaline quartz. Major uses of bentonite include binding foundry sand in molds, absorbing grease, oil and animal wastes; palletizing taconite iron ore and improving the properties of drilling muds. It is used as an ingredient in ceramics. water proofing and sealing in civil engineering projects such as landfill sites and nuclear waste repositories, serving as a filter, stabilizer or extender in adhesives, paints, cosmetics and medicines. It is used as a bonding agent in animal feed, carrier for pesticides, clarifying wine and vegetable oil and purifying waste water. HUMAN EXPOSURE: In the view of widespread distribution of bentonite in nature and its use in various consumer products, general population exposure to low concentrations is ubiquitous. Occupational exposure to bentonite dust from mining, processing and user industries is a factor. ANIMAL STUDIES: Single intratracheal injection into rodents of bentonite and montmorillonite with low quartz content caused dose and particle side dependent effects, as well as transient local inflammation, which included edema and increased lung weight. Single intratracheal exposures of rats to bentonite caused storage foci in the lungs. After intratracheal exposure of rats to this material with high quartz content, fibrosis is noted. Mice maintained on diets containing bentonite displayed slightly reduced growth rates. Mice treated with higher doses showed minimal growth and fatty livers and fibrosis of the liver and benign hepatomas. Bentonite increased the susceptibility of mice to pulmonary infection. In vitro studies of the effects of bentonite on a variety of mammalian cell types indicated a high degree of cytotoxicity. Limited studies did not demonstrate developmental toxicity in rats after oral exposure to bentonite. No adequate studies are available on the carcinogenicity of bentonite.
[[World Health Organization/International Programme on Chemical Safety; Environmental Heath Criteriia 231 Bentonite, Kaolin and Selected Clay Minerals pp. 1-5 (2005)]] **PEER REVIEWED**

Non-Human Toxicity Excerpts:
/LABORATORY ANIMALS: Acute Exposure/ Ten (5M:5F) albino rats, 200 - 254 g, each received a single oral dose of the test article at a concentration of 5 grams per kilogram bodyweight. Animals were observed for pharmacologic activity and drug toxicity 1, 3, 6, and 24 hours after treatment, and daily thereafter for a total of 14 days. Non-survivors and animals surviving the 14 day observation period were subjected to gross necropsy, with all findings noted. The test article was used as a 25 % gravimetric corn oil suspension. Dose Level:5 mg/kg Mortality: 0 % This test article is not toxic orally to rats under conditions of this test.
[European Chemicals Bureau; IUCLID Dataset for Bentonite(1302-78-9), p.30 (2000 CD-ROM edition). Available from, as of April 2, 201[illegible]: [illegible] **PEER REVIEWED**

/LABORATORY ANIMALS: Acute Exposure/ Ten (5M:5F) albino rats, 210 - 298 g, were exposed to the test article at an atmospheric concentration of 200 milligrams per liter for 1 hour. Animals were observed for pharmacotoxic effects and mortality 1, 3, 6, and 24 hours after treatment, and daily thereafter for a total of 14 days. Non-survivors and animals sacrificed at the end of the 14 day observation period were subjected to gross necropsy, with all findings noted. The test article was used as received. Dose Level: 200 mg/L Mortality: 0 % The test article is not toxic to rats by inhalation under conditions of this test.
[European Chemicals Bureau; IUCLID Dataset for Bentonite(1302-78-9), p.31 (2000 CD-ROM edition). Available from, as of April 2, 201[illegible]: [illegible] **PEER REVIEWED**

/LABORATORY ANIMALS: Acute Exposure/ Six (3M:3F) New Zealand white rabbits, 2.31- 3.19 kilograms, each received a single dermal application of the test article at a dose level of 2 grams per kilogram bodyweight. The skin of three (3J animals (2M:1F) was abraded; the remaining animals' skin remained intact. The test sites were occluded for 24 hours, at which time the occlusive wrap and any remaining test article were removed. Animals were observed for pharmacologic activity 1, 3, 6, and 24 hours after treatment, and daily thereafter for a total of 14 days. Non-survivors and animals surviving the 14 day observation period were subjected to gross necropsy, with all findings noted. The test article was moistened with saline. Dose Level: 2 g/kg. Mortality: 0 % This test article is not toxic dermally to rabbits under conditions of this test.
[European Chemicals Bureau; IUCLID Dataset for Bentonite(1302-78-9), p.32 (2000 CD-ROM edition). Available from, as of April 2, 201[illegible]: [illegible] **PEER REVIEWED**

/LABORATORY ANIMALS: Acute Exposure/ Six (6) New Zealand white rabbits each received a single dermal application of 0.5 gram of the test article on two test sites, one abraded and one intact. The test sites were occluded for 24 hours, and were observed individually for erythema, edema, and other effects 24 and 72 hours after application. Mean scores from the 24 and 72 hour readings were averaged to determine the primary irritation index. The test article was moistened with water prior to use. Primary Irritation Index: 0.25. The test article is not a primary dermal irritant to rabbits under conditions of this test.
[European Chemicals Bureau; IUCLID Dataset for Bentonite(1302-78-9), p.35 (2000 CD-ROM edition). Available from, as of April 2, 201[illegible]: http://ecb.jrc.ec.europa.eu/esis/ **PEER REVIEWED**

/LABORATORY ANIMALS: Acute Exposure/ Six (6) New Zealand white rabbits, free from visible ocular defects, each received a single intraocular application of 0.1 gram of the test article in one eye. The contralateral eye, remaining untreated, served as a control. The eyes of all animals remained unwashed for 24 hours. Observations of corneal opacity, iritis, conjunctivitis, and other effects, were recorded 24, 48, and 72 hours after treatment, and at 4 and 7 days if irritation persisted. The test article was used as received. The test article is a mild ocular irritant to rabbits under conditions of this test.

[European Chemicals Bureau; IUCLID Dataset for Bentonite (1302-78-9), p.36 (2000 CD-ROM edition). Available from, as of April 2, 2013: [illegible] **PEER REVIEWED**

/LABORATORY ANIMALS: Acute Exposure/ /Investigators/ gave subplantar injections of 0.05 mL of a 5% solution of Bentonite to male Wistar rats. The rats either received both hind paw injections at an interval of 24 hr or their left paw was injected with Bentonite and their right paw injected with 0.05 mL of a 10% solution of Kaolin. The injection was of Kaolin. Subcutaneous Bentonite granulomas were produced on the left side, both dorsally and ventrally. Simultaneously Kaolin granulomas were produced on the right side analogous to the Bentonite injection. Sodium salicylate and prednisone suppressed the Bentonite edema during the first 24 hr. The presence of mononuclear cells was confirmed.
[Cosmetic Ingredient Review; Final Report of the Cosmetic Ingredient Review Expert Panel; Final Report on the Safety Assessment of Aluminum Silicate, Calcium Silicate, Magnesium Aluminum Silicate, Magnesium Silicate, Magnesium Trisilicate, Sodium Magnesium Silicate, Zirconium Silicate, Attapulgite, Bentonite, Fuller's Earth, Hectorite, Kaolin, Lithium Magnesium Silicate, Lithium Magnesium Sodium Silicate, Montmorillonite, Pyrophyllite, and Zeolite; International Journal of Toxicology 22 (Suppl 1): 37-102 (2003)] **PEER REVIEWED**

/LABORATORY ANIMALS: Acute Exposure/ /Investigators/ administered a single dose of 40 mg of Bentonite suspended in 1 mL of physiological saline containing 40,000 IU of crystalline penicillin intratracheally to male CFY rats. The Bentonite's composition consisted of 73% Montmorillonite, 18% cristobalite, 3% quartz, 3% feldspar, and 3% other minerals. Particle sizes were <2 um. The control group received 1 mL of physiological saline containing 40,000 IU of crystalline penicillin. Animals were killed 12, 24, 48, or 72 hr or 90 days after exposure. Body and lung weight of the rats were measured. The right lung was fixed and sectioned for microscopic examination. The lipids and phospholipids were analyzed in the left lung. The body weights of the rats were moderately decreased and the lung weight increased 72 hr after Bentonite exposure. After 90 days, the lung weight was only slightly greater than that of the control animals. Upon microscopic examination at 12 hr, Bentonite exposure had resulted in a nonspecific inflammation of mostly neutrophils with perivascular edema, alveolitis, and incipient bronchopneumonia. A small number of macrophages and lymphocytes were detected. Dust particles were observed in the leukocytes and macrophages or extracellularly in the alveoli. After the 24th hr, bronchopneumonia was present after coalescence of the inflammatory foci; the pneumonia then became necrotizing and desquamative. Necrotic neutrophilic leukocytes and eosinophil leukocytes were observed. The reticular network collapsed between the 48th and 72nd hr. Exposure after 90 days included dust storage foci filled with large foamy cells with pale cytoplasm. Closely packed cells with dark cytoplasm and nuclei were located at the periphery. After 12 and 24 hr, the amount of lipids and phospholipids in the lungs was not altered. However, between 48 and 72 hr, the lipid and phospholipid content increase but distribution remained the same. After 90 days the value was the same as seen at 72 hr.
[Cosmetic Ingredient Review; Final Report of the Cosmetic Ingredient Review Expert Panel; Final Report on the Safety Assessment of Aluminum Silicate, Calcium Silicate, Magnesium Aluminum Silicate, Magnesium Silicate, Magnesium Trisilicate, Sodium Magnesium Silicate, Zirconium Silicate, Attapulgite, Bentonite, Fuller's Earth, Hectorite, Kaolin, Lithium Magnesium Silicate, Lithium Magnesium Sodium Silicate, Montmorillonite, Pyrophyllite, and Zeolite; International Journal of Toxicology 22 (Suppl 1): 37-102 (2003)] **PEER REVIEWED**

/LABORATORY ANIMALS: Acute Exposure/ Preparations of Prophypaste, Bentonite, tragacanth, trypsin, and sterile water were injected either intralamellarly or directly into the anterior chamber of six adult New Zealand rabbits at concentrations ranging from 1 to 5 mg/mL. No significant reactions were recorded with sterile water, Prophypaste, tragacanth, or combinations of tragacanth and Bentonite. Bentonite caused severe iritis after injection into the anterior chamber, but no corneal or retrocorneal reaction was noted grossly or microscopically. In five of the eyes where Bentonite was injected intralamellarly, widespread corneal infiltrates and retrocorneal membranes were observed within 2 to 5 days. The sixth eye had no reaction, only 0.1 mL of 0.25 mg/mL was injected. Anterior chamber taps of the eyes showed viscous mucopurulent material. Microscopic sections showed pseodoeosinophils, retrocorneal membranes, and fibrovascular membranes in the anterior segment. Polarized light revealed highly birefringent particles were found at the injections sites, but not in the retrocorneal masses.
[Cosmetic Ingredient Review; Final Report of the Cosmetic Ingredient Review Expert Panel; Final Report on the Safety Assessment of Aluminum Silicate, Calcium Silicate, Magnesium Aluminum Silicate, Magnesium Silicate, Magnesium Trisilicate, Sodium Magnesium Silicate, Zirconium Silicate, Attapulgite, Bentonite, Fuller's Earth, Hectorite, Kaolin, Lithium Magnesium Silicate, Lithium Magnesium Sodium Silicate, Montmorillonite, Pyrophyllite, and Zeolite; International Journal of Toxicology 22 (Suppl 1): 37-102 (2003)] **PEER REVIEWED**

/LABORATORY ANIMALS: Acute Exposure/ Intratracheal injection of moderate amounts (0.16-0.27 g/kg of body weight) of finely powdered (where specified, mean diameter <5 um) bentonite into rodents evoked responses indicative of cytotoxic effects, as well as rapid and/or long-lasting irritation of or damage to the lungs. Gross effects on the lungs of rats administered 0.19 g/kg of body weight included inflammation and edema within 12 hr, bronchopneumonia by day 1, and a doubling of wet weight by day 3, followed by a gradual decline to a value still significantly above the initial weight by day 90. The histology of the inflammation included large numbers of neutrophil leukocytes plus some macrophages and lymphocytes at 12 hr, mainly eosinophil and necrobiotic leukocytes by day 1, and collapse of the reticular network by day 3. Some bentonite particles were held within the macrophages and leukocytes at day 3. Changes in gross morphology and histology were accompanied by changes in the chemistry of lung lavage fluid. These included elevated levels of phospholipid and acid phosphatase by day 3. The increase in phospholipid was not, however, accompanied by any change in the relative abundance of phospholipid fractions. Phospholipid was still somewhat elevated 3 months after exposure. ... Hydroxyproline was slightly elevated 3 months after exposure.

[WHO; Environ Health Criteria 231: Bentonite, Kaolin, and Selected Clay Minerals (2005). Available from, as of April 3, 2013: [illegible] **PEER REVIEWED**

/LABORATORY ANIMALS: Acute Exposure/ The effects of smaller intratracheal doses of bentonite on rats are uncertain. /One study/ reported that 0.027 g/kg of body weight had no effect on protein or lactate dehydrogenase (LDH) in lavage from the lung 15-60 days after dosage, whereas /a second study/, also using lavage from the lungs, noted a variety of effects indicating irritation and damage immediately following doses of 0.012 and 0.0012 g/kg of body weight. These effects included large and rapid increases in soluble protein, LDH, and polymorphonuclear leukocytes, with peaks at day 1 or day 2 followed by a decline to somewhat above baseline by day 7. Alveolar macrophages were increased by day 7. The findings in these two studies need not be contradictory, since the observations of /the second study/ permit the possibility that elevated values for LDH and protein were present following dosage in the /first/ experiment, but declined back to baseline prior to their first sample on day 15. The changes in gross morphology, white cell abundances, and biochemistry described above appear to form a generally coherent picture. Swelling and edema stem from changes at the cellular level. /Investigators/ found increased LDH and protein in the lavage-sensitive indicators of lung damage that preceded visible mechanical damage and impairment of gas exchange. Increased LDH was ascribed to damage to cell membranes and leakage from lung cells, whereas increased protein was ascribed to increased vascular permeability. The latter conclusion is supported by /previous/ analyses, which reported serum albumin as the major constituent of the recovered protein. The increases in polymorphonuclear leukocytes may be triggered by phagocytosis of bentonite particles by alveolar macrophages.
[WHO; Environ Health Criteria 231: Bentonite, Kaolin, and Selected Clay Minerals (2005). Available from, as of April 3, 2013: [illegible] **PEER REVIEWED**

/LABORATORY ANIMALS: Acute Exposure/ Single intratracheal exposures of rats to bentonite produced storage foci in the lungs 3-12 months later; even 12 months after exposure, fibrosis had not progressed beyond Belt-King grade 1. Macroscopically, the foci were visible in fixed material as greyish-white masses up to the size of a "pin prick or a poppy seed" - i.e., approximately 1 mm. The structure of these storage foci was described in detail using slides stained with hematoxylin-eosin, Van Gieson's solution, and Foot's silver impregnation. /Investigators/ reported that "The foci contained large cells with foamy protoplasm, and [with] nuclei often located at the edge of the cells. In the foam cells no lipids could be demonstrated by Sudan staining. PAS [para-aminosalicylic acid] reaction was intensely positive, showing that substances of carbohydrate nature are accumulated in the foci. In polarized light a great mass of intracellularly located doubly refractive fine grainy substance was to be seen. This characteristic alteration was to be observed in the lungs of the animals killed the 40th day after the application of the dust, and the microscopic findings in the tissues had not changed essentially up to the end of the experiment [365 days]. In the foci, sometimes a poorly developed reticular network of loose structure occurred too, but collagen fibers did not develop. The silver impregnated preparations showed in the area of the foci the precipitation of a greyish-black homogeneous substance between the fibers."
[WHO; Environ Health Criteria 231: Bentonite, Kaolin, and Selected Clay Minerals (2005). Available from, as of April 3, 2013: [illegible] **PEER REVIEWED**

/LABORATORY ANIMALS: Acute Exposure/ In addition to directly damaging the lung, bentonite had a potential, even at low doses, for increasing susceptibility to pulmonary infection. /Investigators/ followed single intratracheal injections of 5, 0.5, or 0.05 mg/kg of body weight into mice with aerosolized Group C Streptococcus sp. The lowest dose did not significantly elevate mortality from Streptococcus infection over controls, whereas the highest dose produced 85% excess mortality and the intermediate dose 43% excess mortality over controls. Earlier studies demonstrated a close correlation between the effects on susceptibility to infection following dosing by sustained inhalation and by administering the same amount of test substance in a single intratracheal injection.
[WHO; Environ Health Criteria 231: Bentonite, Kaolin, and Selected Clay Minerals (2005). Available from, as of April 3, 2013: http://www.inchem.org/pages/ehc.html **PEER REVIEWED**

/LABORATORY ANIMALS: Acute Exposure/ In most experiments, bentonite also displayed local toxic effects after intra- or subdermal injection. Subdermal injection of 10 mg/kg of body weight as 5% bentonite gel into the plantar of rats produced pronounced edema within an hour. The swelling continued to enlarge for a week and then slowly regressed, but it was still evident 6 weeks after injection. The edema was accompanied by marked increases in macrophages and polymorphonuclear leukocytes, which peaked at 30 hr. The leukocytes declined back to the baseline after 4 weeks, whereas the macrophages were still elevated at 6 weeks.
[WHO; Environ Health Criteria 231: Bentonite, Kaolin, and Selected Clay Minerals (2005). Available from, as of April 3, 2013: http://www.inchem.org/pages/ehc.html **PEER REVIEWED**

/LABORATORY ANIMALS: Acute Exposure/ The granulomatous inflammation resulting from a moderate intradermal injection of relatively coarse (diameter 79-90 um) bentonite into the skin of guinea-pigs was /investigated/ both visually and with light and electron microscopy. The injection induced a chronic inflammatory response with ulceration and maximum induration at 7-10 days. By day 2, there was vascular dilation and some infiltration of monocytes and polymorphonuclear leukocytes. The macrophage infiltration rapidly increased in density and by the termination of observations, day 30, had become mainly multinuclear cells, had phagocytized most of the bentonite particles, and had evolved into a loose, disorganized mass. This mass was walled off from adjoining tissues by active fibrosis, which also subdivided the cells into clumps.
[WHO; Environ Health Criteria 231: Bentonite, Kaolin, and Selected Clay Minerals (2005). Available from, as of April 3, 2013: http://www.inchem.org/pages/ehc.html **PEER REVIEWED**

/LABORATORY ANIMALS: Acute Exposure/ Bentonite, a silicate, induces a classical non-immunological foreign body reaction when injected intradermally into guinea pigs. The cellular response consists of a mass of macrophages and large macrophage polykaryons, surrounded and infiltrated by an extensive fibrous reaction. The bentonite granuloma shows no signs of intercellular organization of the reacting cells. Study of its ultrastructure suggests a low turnover lesion with a stable, long-lived cell population. The bentonite granuloma is contrasted with the tuberculous, immunologically mediated epithelioid cell granuloma produced in sensitized guinea pigs.
[Browett PJet al; J Pathol 130 (1): 57-64 (1980)] **PEER REVIEWED** [illegible]

/LABORATORY ANIMALS: Subchronic or Prechronic Exposure/ During 33-day addn to fodder of chickens at 2 & 6% & during 90-day introduction into concentrations 1, 3 & 5%, activated bentonite did not provoke any changes in behavior, overall state & in the clinical biochemical & electrolytic composition of blood, but caused growth suppression.
[DRUMEV D ET AL; VET MED NAUKI 17 (3): 84 (1980)] **PEER REVIEWED**

/LABORATORY ANIMALS: Chronic Exposure or Carcinogenicity/ There are limited data on the effects of multiple exposures of experimental animals to montmorillonite or bentonite. Mice maintained on diets containing 10% or 25% bentonite but otherwise adequate to support normal growth displayed slightly reduced growth rates, whereas mice maintained on a similar diet with 50% bentonite showed minimal growth and developed fatty livers and eventually fibrosis of the liver and benign hepatomas.
[WHO; Environ Health Criteria 231: Bentonite, Kaolin, and Selected Clay Minerals (2005). Available from, as of April 3, 2013: [illegible] **PEER REVIEWED**

/ALTERNATIVE and IN VITRO TESTS/ In vitro studies of the effects of bentonite on a variety of mammalian cell types usually indicated a high degree of cytotoxicity. Concentrations below 1.0 mg/mL of bentonite and montmorillonite particles less than 5 um in diameter caused membrane damage and even cell lysis, as well as functional changes in several types of cells. The velocity and degree of lysis of sheep erythrocytes were dose dependent.
[WHO; Environ Health Criteria 231: Bentonite, Kaolin, and Selected Clay Minerals (2005). Available from, as of April 3, 2013: [illegible] **PEER REVIEWED**

/ALTERNATIVE and IN VITRO TESTS/ Cell suspensions were incubated with bentonite or montmorillonite for (where specified) 30 min to 24 hr, and the cells were tested for physical integrity or functional ability. Cell types included rat peritoneal macrophages, rabbit and rat alveolar macrophages, a macrophage-like cell line, other white cells, human and other erythrocytes, rodent neural cells, hamster tracheal epithelial cells, and human umbilical vein endothelial cells. The results usually indicated a high degree of cytotoxicity. Concentrations below 1.0 mg/mL of bentonite and montmorillonite particles less than 5 um in diameter caused lysis of human neutrophils, many types of erythrocytes, mouse embryo neuronal cells, and human umbilical vein endothelial cells. The velocity and degree of lysis of sheep erythrocytes were dose dependent. Using cow erythrocytes and montmorillonite, /investigators/ found that particles 0.2-2.0 um in diameter were most active and that particles greater than 2.0 um in diameter showed little or no haemolytic activity. The ability of low concentrations of these particles to lyse mammalian cells, although widespread, was not universal, since /investigators/ reported no lysis of neuroblastoma cells or oligodendroglial cells incubated in 0.1 mg montmorillonite or bentonite/mL for 18 or 24 hr.
[IPCS Environmental Health Criteria 231, Bentonite, Kaolin and selected clay minerals. Available from, as of April 5, 2013: [illegible]
PEER REVIEWED

/VETERINARY CASE REPORTS/ A 2 1/2-y-old spayed female cat was presented for lethargy and weakness. The cat was hypokalemic (3.1 m Eq K/L) and severely anemic (60% PVC, 1.3 g hemoglobin/dL). The cat was known to ingest bentonite-containing cat litter. It recovered with treatment of iv fluids, electrolytes and whole blood transfusion and was discharged. Two months later the cat was presented again with signs similar to those seen previously. This occurred 1 mo after the owner resumed the use of bentonite-containing cat litter. The signs were remarkably similar to those reported in humans from the chronic ingestion of bentonite clays. Bentonite toxicosis is suggested by the coexistence of hypokalemia hypochromic anemia in cats presented with lethargy and muscle weakness.
[Hornfeldt CS et al; Vet Hum Toxicol 38 (5): 365-6 (1996)] **PEER REVIEWED** [illegible]

Non-Human Toxicity Values:
LD50 Rat intravenous 35 mg/kg
[Lewis, R.J. Sr. (ed) Sax's Dangerous Properties of Industrial Materials. 11th Edition. Wiley-Interscience, Wiley & Sons, Inc. Hoboken, NJ. 2004., p. 351] **PEER REVIEWED**

Ecotoxicity Values:
LC50; Species: Oncorhynchus mykiss (Rainbow Trout) weight 1 (0.3-2.9) g; Conditions: freshwater, static, 10.5 deg C, pH 8.2, hardness 340 mg/L $CaCO_3$;

Concentration: 19000000 ug/L for 96 hr /formulation/
[Sprague JB, Logan WJ; Environ Pollut 19 (4): 269-281 (1979) as cited in the ECOTOX database. Available from, as of February 11, 2013: [illegible]
PEER REVIEWED

Metabolism/Pharmacokinetics:

Mechanism of Action:
The mechanism by which bentonite increases susceptibility is unknown. /Investigators/ however, postulated that enzyme inhibition by bentonite may be a factor, based on their in vitro observation that a low concentration of bentonite can totally suppress the activity of human leukocyte elastase, an enzyme important in the destruction of microorganisms phagocytized by neutrophils.
[WHO; Environ Health Criteria 231: Bentonite, Kaolin, and Selected Clay Minerals (2005). Available from, as of April 3, 2013: [illegible] **PEER REVIEWED**

Interactions:
Numerous studies have established that aflatoxin is a potent developmental toxin in animals. Previous research has demonstrated that a phyllosilicate clay, hydrated sodium calcium aluminosilicate (HSCAS or Novasil), tightly binds and immobilizes aflatoxins in the gastrointestinal tract of animals and markedly reduces the bioavailability and toxicity of aflatoxin. Our objective in this study was to utilize the pregnant rat as an in vivo model to compare the potential of hydrated sodium calcium aluminosilicate and bentonite to prevent the developmental toxicity of aflatoxin. Aluminosilicates (HSCAS) and bentonite were added to the diet at a level of 0.5% (w/w) and fed to the pregnant rat throughout pregnancy (ie days 0-20). Test animals were fed an aflatoxin -contaminated diet (2.5 mg kg(-1) diet) with or without sorbents during gestation days 6-15. Evaluations of toxicity were performed on day 20. These included maternal (mortality, body weights, feed intake and litter weights), developmental (embryonic resorptions and fetal body weights) and biochemical (ALT, AST and AP) evaluations. Sorbents alone were not toxic and aflatoxin alone resulted in significant maternal and developmental toxicity. Animals treated with phyllosilicate (plus aflatoxin) were comparable to controls following evaluations for resorptions, live fetuses and fetal body weights, as well as biochemical parameters. While bentonite plus aflatoxin resulted in significant reduction in fetal body weight, none of the fetuses from hydrated sodium calcium aluminosilicate or bentonite plus aflatoxin-treated groups had any gross, internal soft tissue or major skeletal malformations.
[Abdel-Wahhab MA et al; J Appl Toxicol 19 (3): 199-204 (1999)] **PEER REVIEWED** PubMed Abstract

Molasses, sodium bentonite (montmorillonite clay) and zeolite (crushed clinoptilolite rock) were examined as supplement ingredients to improve the safety margin of urea supplementation in a series of seven experiments. These experiments were designed to provide an understanding of the relationship between urea intake and the influence of the above ingredients on rumen pH and total ammonia concentrations. Rumen fistulated Merino ewes of 35-40 kg live weight were administered various amounts of urea with and without supplement mixes. Rumen parameters were measured at 0, 0.5, 1.0, 1.5, 2.5, 5.0 and 24 h after treatment administration. Acetic acid and sucrose were also tested together with molasses for comparative effects on rumen parameters. In the last experiment, blood pH and total plasma ammonia were also determined. Free ammonia values of rumen liquor were calculated for experiments 2 to 7. In four experiments, molasses at 50, 100 and/or 150 g mixed with urea significantly reduced the normal rapid rise in ruminal pH, total and free ammonia values compared with urea (10 g) only treatments. In two experiments, associated presence or absence of clinical toxicity at various quantities of urea (8 to 25 g) with and without active ingredients confirmed the positive effect of molasses in preventing toxicity at : 0.44 g urea/kg liveweight. The addition of molasses reduced the increase in ruminal pH by up to 0.5 pH units and absolute values were consistently below pH 7.0. Sucrose (100 g) and acetic acid (800 ml of 1 M) had the same and greater effect, respectively, compared with molasses (150 g) when added with urea (10 g) on ruminal pH and total and free ammonia changes over five hours post treatment. The partly hydrated urea/bentonite mix (approx 1:1 bentonite:water ratio) was associated with a delay in the increases in ruminal pH and free ammonia concentrations. Bentonite mixes, in either fully hydrated or fully dehydrated states, and zeolite mixes resulted in no significant effects. With reference to previous reports, the results support the positive role of a stable acid pH in the rumen for ensuring safe urea supplementation.
[Stephenson R GA et al; Aust J Agric Res 43 (2): 301-14 (1992)] **PEER REVIEWED**

...Ingestion of large quantities of clay substances, such as bentonite, can result in gastrointestinal binding of essential electrolytes and possible obstruction. ...
[Bennett A, Stryjewski G; Pediatr Emerg Care 22 (7): 500-2 (2006)] **PEER REVIEWED** PubMed Abstract

/Investigators/ gave subplantar injections of 0.05 mL of a 5% solution of Bentonite to male Wistar rats. The rats either received both hind paw injections at an

interval of 24 hr or their left paw was injected with Bentonite and their right paw injected with 0.05 mL of a 10% solution of Kaolin. The injection was of Kaolin. Subcutaneous Bentonite granulomas were produced on the left side, both dorsally and ventrally. Simultaneously Kaolin granulomas were produced on the right side analogous to the Bentonite injection. Sodium salicylate and prednisone suppressed the Bentonite edema during the first 24 hr. The presence of mononuclear cells was confirmed.
[Cosmetic Ingredient Review; Final Report of the Cosmetic Ingredient Review Expert Panel; Final Report on the Safety Assessment of Aluminum Silicate, Calcium Silicate, Magnesium Aluminum Silicate, Magnesium Silicate, Magnesium Trisilicate, Sodium Magnesium Silicate, Zirconium Silicate, Attapulgite, Bentonite, Fuller's Earth, Hectorite, Kaolin, Lithium Magnesium Silicate, Lithium Magnesium Sodium Silicate, Montmorillonite, Pyrophyllite, and Zeolite; International Journal of Toxicology 22 (Suppl 1): 37-102 (2003)] **PEER REVIEWED**

/Investigators/ administered a single dose of 40 mg of Bentonite suspended in 1 mL of physiological saline containing 40,000 IU of crystalline penicillin intratracheally to male CFY rats. The Bentonite's composition consisted of 73% Montmorillonite, 18% cristobalite, 3% quartz, 3% feldspar, and 3% other minerals. Particle sizes were <2 um. The control group received 1 mL of physiological saline containing 40,000 IU of crystalline penicillin. Animals were killed 12, 24, 48, or 72 hr or 90 days after exposure. Body and lung weight of the rats were measured. The right lung was fixed and sectioned for microscopic examination. The lipids and phospholipids were analyzed in the left lung. The body weights of the rats were moderately decreased and the lung weight increased 72 hr after Bentonite exposure. After 90 days, the lung weight was only slightly greater than that of the control animals. Upon microscopic examination at 12 hr, Bentonite exposure had resulted in a nonspecific inflammation of mostly neutrophils with perivascular edema, alveolitis, and incipient bronchopneumonia. A small number of macrophages and lymphocytes were detected. Dust particles were observed in the leukocytes and macrophages or extracellularly in the alveoli. After the 24th hr, bronchopneumonia was present after coalescence of the inflammatory foci; the pneumonia then became necrotizing and desquamative. Necrotic neutrophilic leukocytes and eosinophil leukocytes were observed. The reticular network collapsed between the 48th and 72nd hr. Exposure after 90 days included dust storage foci filled with large foamy cells with pale cytoplasm. Closely packed cells with dark cytoplasm and nuclei were located at the periphery. After 12 and 24 hr, the amount of lipids and phospholipids in the lungs was not altered. However, between 48 and 72 hr, the lipid and phospholipid content increase but distribution remained the same. After 90 days the value was the same as seen at 72 hr.
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Pharmacology:

Therapeutic Uses:

Ther (VET): The efficacy of locally produced bentonite was evaluated with respect to ameliorating the adverse effects of aflatoxins (AF) in piglets fed AF contaminated diets. Forty eight piglets were randomly assigned to one of four treatments: 1) 0 g of bentonite and 0 ug AF/kg feed (control); 2) 4 g of bentonite plus 200 ug AF/kg feed (AF + Bento 4); 3) 5 g of bentonite plus 200 ug AF/kg feed (AF + Bento 5) and 4) 0 g of bentonite plus 200 ug AF/kg feed (AFA). Piglets in the AFA treatment had lower overall average daily weight gain (ADG), feed conversion efficiency, albumin (ALB) and total protein (TP) compared to the control diet, while mean serum leukocyte and enzyme activities (glutamic-oxalacetic transaminase (GOT), glutamic-pyruvic transaminase (GPT), gamma glutamyltransferase (GGT), alkaline phosphatase (ALP) and lactic dehydrogenase (LDH)) were significant increased. The inclusion of bentonite at 0.4% or 0.5% in the AF contaminated diet restored the lower performance, feed efficiency and abnormal blood profiles of the piglets given AF and no differences between 0.4 and 0.5% inclusion of bentonite. The findings in the present study provide critically needed confirmation that bentonite has the ability to reduce the adverse effects of AF.
[Thieu NQ et al; Trop Anim Health Prod 40 (8): 649-56 (2008)] **PEER REVIEWED** PubMed Abstract

Ther (VET): Bentonite was compared with activated charcoal as therapy for lantana poisoning in calves dosed 5 d previously with leaf material of the common pink-edged red taxon of Lantana camara. Both therapies were given by stomach tube as a single dose at 5 g/kg. Five of 5 calves in each of the groups given bentonite and activated charcoal recovered while 5 of 6 calves in the control group died. Calves given bentonite took 3 d longer on average to recover fully than those given activated charcoal but the effects of the 2 therapies on plasma total bilirubin concentrations were statistically indistinguishable. Bentonite was judged to have promise as a cheap alternative to activated charcoal for therapy of lantana poisoning of cattle.
[McKenzie RA; Aust Vet J 68 (4); 146-8 (1991)] **PEER REVIEWED**

Immediate administration of an absorbent after ingestion is likely to improve the outcome of a paraquat ingestion. Bentonite (75% suspension) & fuller's earth

(30% suspension) in an adult dose of 100 to 150 g each, are thought to be the most effective. /Paraquat and Diquat Herbicides/
[Rom, W.N. (ed.). Environmental and Occupational Medicine. 2nd ed. Boston, MA: Little, Brown and Company, 1992., p. 996] **PEER REVIEWED**

Interactions:

Numerous studies have established that aflatoxin is a potent developmental toxin in animals. Previous research has demonstrated that a phyllosilicate clay, hydrated sodium calcium aluminosilicate (HSCAS or Novasil), tightly binds and immobilizes aflatoxins in the gastrointestinal tract of animals and markedly reduces the bioavailability and toxicity of aflatoxin. Our objective in this study was to utilize the pregnant rat as an in vivo model to compare the potential of hydrated sodium calcium aluminosilicate and bentonite to prevent the developmental toxicity of aflatoxin. Aluminosilicates (HSCAS) and bentonite were added to the diet at a level of 0.5% (w/w) and fed to the pregnant rat throughout pregnancy (ie days 0-20). Test animals were fed an aflatoxin-contaminated diet (2.5 mg kg(-1) diet) with or without sorbents during gestation days 6-15. Evaluations of toxicity were performed on day 20. These included maternal (mortality, body weights, feed intake and litter weights), developmental (embryonic resorptions and fetal body weights) and biochemical (ALT, AST and AP) evaluations. Sorbents alone were not toxic and aflatoxin alone resulted in significant maternal and developmental toxicity. Animals treated with phyllosilicate (plus aflatoxin) were comparable to controls following evaluations for resorptions, live fetuses and fetal body weights, as well as biochemical parameters. While bentonite plus aflatoxin resulted in significant reduction in fetal body weight, none of the fetuses from hydrated sodium calcium aluminosilicate or bentonite plus aflatoxin-treated groups had any gross, internal soft tissue or major skeletal malformations.
[Abdel-Wahhab MA et al; J Appl Toxicol 19 (3): 199-204 (1999)] **PEER REVIEWED** PubMed Abstract

Molasses, sodium bentonite (montmorillonite clay) and zeolite (crushed clinoptilolite rock) were examined as supplement ingredients to improve the safety margin of urea supplementation in a series of seven experiments. These experiments were designed to provide an understanding of the relationship between urea intake and the influence of the above ingredients on rumen pH and total ammonia concentrations. Rumen fistulated Merino ewes of 35-40 kg live weight were administered various amounts of urea with and without supplement mixes. Rumen parameters were measured at 0, 0.5, 1.0, 1.5, 2.5, 5.0 and 24 h after treatment administration. Acetic acid and sucrose were also tested together with molasses for comparative effects on rumen parameters. In the last experiment, blood pH and total plasma ammonia were also determined. Free ammonia values of rumen liquor were calculated for experiments 2 to 7. In four experiments, molasses at 50, 100 and/or 150 g mixed with urea significantly reduced the normal rapid rise in ruminal pH, total and free ammonia values compared with urea (10 g) only treatments. In two experiments, associated presence or absence of clinical toxicity at various quantities of urea (8 to 25 g) with and without active ingredients confirmed the positive effect of molasses in preventing toxicity at : 0.44 g urea/kg liveweight. The addition of molasses reduced the increase in ruminal pH by up to 0.5 pH units and absolute values were consistently below pH 7.0. Sucrose (100 g) and acetic acid (800 ml of 1 M) had the same and greater effect, respectively, compared with molasses (150 g) when added with urea (10 g) on ruminal pH and total and free ammonia changes over five hours post treatment. The partly hydrated urea/bentonite mix (approx 1:1 bentonite:water ratio) was associated with a delay in the increases in ruminal pH and free ammonia concentrations. Bentonite mixes, in either fully hydrated or fully dehydrated states, and zeolite mixes resulted in no significant effects. With reference to previous reports, the results support the positive role of a stable acid pH in the rumen for ensuring safe urea supplementation.
[Stephenson R GA et al; Aust J Agric Res 43 (2): 301-14 (1992)] **PEER REVIEWED**

...Ingestion of large quantities of clay substances, such as bentonite, can result in gastrointestinal binding of essential electrolytes and possible obstruction. ...
[Bennett A, Stryjewski G; Pediatr Emerg Care 22 (7): 500-2 (2006)] **PEER REVIEWED** PubMed Abstract

/Investigators/ gave subplantar injections of 0.05 mL of a 5% solution of Bentonite to male Wistar rats. The rats either received both hind paw injections at an interval of 24 hr or their left paw was injected with Bentonite and their right paw injected with 0.05 mL of a 10% solution of Kaolin. The injection was of Kaolin. Subcutaneous Bentonite granulomas were produced on the left side, both dorsally and ventrally. Simultaneously Kaolin granulomas were produced on the right side analogous to the Bentonite injection. Sodium salicylate and prednisone suppressed the Bentonite edema during the first 24 hr. The presence of mononuclear cells was confirmed.
[Cosmetic Ingredient Review; Final Report of the Cosmetic Ingredient Review Expert Panel; Final Report on the Safety Assessment of Aluminum Silicate, Calcium Silicate, Magnesium Aluminum Silicate, Magnesium Silicate, Magnesium Trisilicate, Sodium Magnesium Silicate, Zirconium Silicate, Attapulgite, Bentonite, Fuller's Earth, Hectorite, Kaolin, Lithium Magnesium Silicate, Lithium Magnesium Sodium Silicate, Montmorillonite, Pyrophyllite, and Zeolite; International Journal of Toxicology 22 (Suppl 1): 37-102 (2003)] **PEER REVIEWED**

/Investigators/ administered a single dose of 40 mg of Bentonite suspended in 1 mL of physiological saline containing 40,000 IU of crystalline penicillin intratracheally to male CFY rats. The Bentonite's composition consisted of 73% Montmorillonite, 18% cristobalite, 3% quartz, 3% feldspar, and 3% other minerals. Particle sizes were <2 um. The control group received 1 mL of physiological saline containing 40,000 IU of crystalline penicillin. Animals were killed 12, 24, 48, or 72

hr or 90 days after exposure. Body and lung weight of the rats were measured. The right lung was fixed and sectioned for microscopic examination. The lipids and phospholipids were analyzed in the left lung. The body weights of the rats were moderately decreased and the lung weight increased 72 hr after Bentonite exposure. After 90 days, the lung weight was only slightly greater than that of the control animals. Upon microscopic examination at 12 hr, Bentonite exposure had resulted in a nonspecific inflammation of mostly neutrophils with perivascular edema, alveolitis, and incipient bronchopneumonia. A small number of macrophages and lymphocytes were detected. Dust particles were observed in the leukocytes and macrophages or extracellularly in the alveoli. After the 24th hr, bronchopneumonia was present after coalescence of the inflammatory foci; the pneumonia then became necrotizing and desquamative. Necrotic neutrophilic leukocytes and eosinophil leukocytes were observed. The reticular network collapsed between the 48th and 72nd hr. Exposure after 90 days included dust storage foci filled with large foamy cells with pale cytoplasm. Closely packed cells with dark cytoplasm and nuclei were located at the periphery. After 12 and 24 hr, the amount of lipids and phospholipids in the lungs was not altered. However, between 48 and 72 hr, the lipid and phospholipid content increase but distribution remained the same. After 90 days the value was the same as seen at 72 hr.
[Cosmetic Ingredient Review; Final Report of the Cosmetic Ingredient Review Expert Panel; Final Report on the Safety Assessment of Aluminum Silicate, Calcium Silicate, Magnesium Aluminum Silicate, Magnesium Silicate, Magnesium Trisilicate, Sodium Magnesium Silicate, Zirconium Silicate, Attapulgite, Bentonite, Fuller's Earth, Hectorite, Kaolin, Lithium Magnesium Silicate, Lithium Magnesium Sodium Silicate, Montmorillonite, Pyrophyllite, and Zeolite; International Journal of Toxicology 22 (Suppl 1): 37-102 (2003)] **PEER REVIEWED**

Reported Fatal Dose:
1. 1= PRACTICALLY NONTOXIC: PROBABLE ORAL LETHAL DOSE (HUMAN) ABOVE 15 G/KG, MORE THAN 1 QT (2.2 LB) FOR 70 KG PERSON (150 LB).
[Gosselin, R.E., H.C. Hodge, R.P. Smith, and M.N. Gleason. Clinical Toxicology of Commercial Products. 4th ed. Baltimore: Williams and Wilkins, 1976., p. II-67] **PEER REVIEWED**

Environmental Fate & Exposure:

Environmental Fate/Exposure Summary:
Bentonite's production and use in domestic products, cat litter, construction materials, ceramics, pharmaceuticals, beer and wine production and cosmetics may result in its release to the environment through various waste streams. Its use in drilling muds, in agricultural practice as a carrier and an animal feed binder will result in its direct release to the environment. Bentonite is a colloidal native hydrated aluminum silicate (clay) found in midwest of USA and in Canada. Occupational exposure to bentonite may occur through inhalation of dust and dermal contact with this compound at workplaces where bentonite is produced or used. Use data indicate that the general population may be exposed to bentonite via ingestion of and dermal contact with consumer products containing bentonite. (SRC)
PEER REVIEWED

Probable Routes of Human Exposure:
According to the 2006 TSCA Inventory Update Reporting data, the number of persons reasonably likely to be exposed in the industrial manufacturing, processing, and use of bentonite is 100 to 999; the data may be greatly underestimated(1).
[(1) US EPA; Inventory Update Reporting (IUR). Non-confidential 2006 IUR Records by Chemical, including Manufacturing, Processing and Use Information. Washington, DC: U.S. Environmental Protection Agency. Available from, as of Mar 25, 2013: [illegible] **PEER REVIEWED**

NIOSH (NOES Survey 1981-1983) has statistically estimated that 545,795 workers (36,750 of these were female) were potentially exposed to bentonite in the US. Statistically, an estimated 1,732, 6,525 and workers were potentially exposed to Blackhills bentonite, Wyoming bentonite in the US; (none of these were female). An estimated that 11,850 workers (11,045 of these were female) were potentially exposed to bentonite powder(1). Occupational exposure to bentonite may occur through inhalation of dust and dermal contact with this compound at workplaces where bentonite is produced or used. Use data indicate that the general population may be exposed to bentonite via ingestion of and dermal contact with consumer products containing bentonite(SRC).
[(1) NIOSH; NOES. National Occupational Exposure Survey conducted from 1981-1983. Estimated numbers of employees potentially exposed to specific agents by 2-digit standard industrial classification (SIC). Available from, as of Mar 25, 2013: [illegible] **PEER REVIEWED**

Occupational exposure to bentonite dust (total and respirable)(1).

Location/Date	No. Observ/No.	Concn Range (mg/cu	Avg/Range (mg/cu

	Facil	m)	m)
Fuller's Earth Plant, IL/1934	5/1	1-19	6
Bentonite Plants, WY/1950-1967	17/4	1-92	11-60
Older Iron Foundry, Germany/pre-1980	6/1	0.08-12.3	6.6
Modern Iron Foundry, Germany/pre-1980	5/1	0.56-7.9	4.8
Bentonite mines & plants, Bulgaria/pre-1981	220/?	1.6-1430.0	333
Non-ferrous foundry/pre-1987	13/1	0.20-27.9	6.65
Mines & plants, USA/1992-1998	251/16	0.00-6.97	0.06-2.18
Mines & plants, Turkey/1996-1999	24/11	2.6-11.2	
Foundries, Turkey/1990-1998	207/70	0.05-33.9	

[(1) IPCS; Environmental Health Criteria 231. Bentonite, Kaolin, and Selected Clay Minerals. Geneva, Switzerland: World Health Org, Internl Prog Chem Safety (2005)] **PEER REVIEWED**

...effects of bentonite in workers in processing plant.../showed/ some injurious effects...in lungs...
[Browning, E. Toxicity of Industrial Metals. 2nd ed. New York: Appleton-Century-Crofts, 1969., p. 9] **PEER REVIEWED**

Natural Pollution Sources:
Clay of montmorillonite type, derived primarily from alteration of volcanic ash. Two distinct types of bentonite are (1) Wyoming and South Dakota deposits referred to as sodium montmorillonite having high gelling, swelling, and viscosity properties and (2) Mississippi bentonite referred to as calcium montmorillonite with little or no swelling capacity. /PRC: See CAS/RN 61029-13-8 & 1318-93-0/
[Meister, R.T., Sine, C. (eds) Crop Protection Handbook Volume 92, Willoughby, OH, 2006., p. D 44] **PEER REVIEWED**

Colloidal native hydrated aluminum silicate (clay) found in midwest of USA and in Canada. Consists principally of montmorillonite, Al2O3.4SiO2.H2O.
[O'Neil, M.J. (ed.). The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals. Whitehouse Station, NJ: Merck and Co., Inc., 2006., p. 175] **PEER REVIEWED**

Wyoming; Mississippi; Texas; Canada; Italy; the former U.S.S.R.
[Lewis, R.J. Sr.; Hawley's Condensed Chemical Dictionary 15th Edition. John Wiley & Sons, Inc. New York, NY 2007., p. 132] **PEER REVIEWED**

The largest and highest quality sodium bentonite deposits in the world are located in South Dakota, Wyoming, and Montana ... The Clay Spur bentonite bed extends west from Belle Fourche, SD, and then north into Alberta, Canada.
[Murray HH; Ullmann's Encyclopedia of Industrial Chemistry. 7th ed. (1999-2012). New York, NY: John Wiley & Sons; Clays. Online Posting Date: 15 Dec 2006] **PEER REVIEWED**

Southern or subbentonites occur in Texas and Mississippi.
[Murray HH; Ullmann's Encyclopedia of Industrial Chemistry. 7th ed. (1999-2012). New York, NY: John Wiley & Sons; Clays. Online Posting Date: 15 Dec 2006] **PEER REVIEWED**

Texas calcium bentonites are found in a belt paralleling the present gulf coast in Cretaceous and Tertiary sediments.
[Murray HH; Ullmann's Encyclopedia of Industrial Chemistry. 7th ed. (1999-2012). New York, NY: John Wiley & Sons; Clays. Online Posting Date: 15 Dec 2006] **PEER REVIEWED**

Other calcium bentonites are produced in the United States in Arizona, Alabama, and Nevada.

[Murray HH; Ullmann's Encyclopedia of Industrial Chemistry. 7th ed. (1999-2012). New York, NY: John Wiley & Sons; Clays. Online Posting Date: 15 Dec 2006] **PEER REVIEWED**

Bentonite deposits are also found in England, Germany, Argentina, Greece, Italy, Hungary, Italy, India, Japan, and the Republic of Georgia.
[Murray HH; Ullmann's Encyclopedia of Industrial Chemistry. 7th ed. (1999-2012). New York, NY: John Wiley & Sons; Clays. Online Posting Date: 15 Dec 2006] **PEER REVIEWED**

Artificial Pollution Sources:
Bentonite's production and use in domestic products, cat litter, construction materials, ceramics, pharmaceuticals, beer and wine production and cosmetics(1) may result in its release to the environment through various waste streams(SRC). Its use in drilling muds, in agricultural practice as a carrier and an animal feed binder(1) will result in its direct release to the environment(SRC).
[(1) Murray HH; Kirk-Othmer Encyclopedia of Chemical Technology. (1999-2012). New York, NY: John Wiley & Sons; Clays, Uses. Online Posting Date: 20 Dec 2002] **PEER REVIEWED**

Environmental Biodegradation:
Biodegradation of bentonite appears to be minimal, if it occurs at all(1).
[(1) IPCS; Environmental Health Criteria 231. Bentonite, Kaolin, and Selected Clay Minerals. Geneva, Switzerland: World Health Org, Internl Prog Chem Safety (2005)] **PEER REVIEWED**

Environmental Abiotic Degradation:
Abiotic degradation of bentonite proceeds on a geological time scale(1).
[(1) IPCS; Environmental Health Criteria 231. Bentonite, Kaolin, and Selected Clay Minerals. Geneva, Switzerland: World Health Org, Internl Prog Chem Safety (2005)] **PEER REVIEWED**

Environmental Standards & Regulations:

FIFRA Requirements:
Residues of bentonite are exempted from the requirement of a tolerance when used in accordance with good agricultural practice as inert (or occasionally active) ingredients in pesticide formulations applied to growing crops or to raw agricultural commodities after harvest. Use: solid diluent, carrier.
[40 CFR 180.910 (USEPA); U.S. National Archives and Records Administration's Electronic Code of Federal Regulations. Available from, as of March 28, 2013: [illegible] **PEER REVIEWED**

FDA Requirements:
Bentonite is an indirect food additive for use only as a component of adhesives.
[21 CFR 175.105 (USEPA); U.S. National Archives and Records Administration's Electronic Code of Federal Regulations. Available from, as of March 27, 2013: [illegible] **PEER REVIEWED**

Substance added directly to human food affirmed as generally recognized as safe (GRAS).
[21 CFR 184.1155 (USFDA); U.S. National Archives and Records Administration's Electronic Code of Federal Regulations. Available from, as of March 28, 2013: [illegible] **PEER REVIEWED**

Bentonite used as a general purpose food additive in animal drugs, feeds, and related products is generally recognized as safe when used in accordance with good manufacturing or feeding practice.
[21 CFR 582.1155 (USFDA); U.S. National Archives and Records Administration's Electronic Code of Federal Regulations. Available from, as of March 28, 2013: http://www.ecfr.gov/cgi-bin/ECFR?page=browse **PEER REVIEWED**

Allowable Tolerances:

Residues of bentonite are exempted from the requirement of a tolerance when used in accordance with good agricultural practice as inert (or occasionally active) ingredients in pesticide formulations applied to growing crops or to raw agricultural commodities after harvest. Use: solid diluent, carrier.
[40 CFR 180.910 (USEPA); U.S. National Archives and Records Administration's Electronic Code of Federal Regulations. Available from, as of March 28, 2013: [illegible]] **PEER REVIEWED**

Chemical/Physical Properties:

Molecular Formula:

UVCB
PEER REVIEWED

Molecular Weight:

.. a rock or clay base industrial material and is, therefore, a mixture of minerals. No molecular formula can be given.
[IPCS; Environmental Health Criteria 231. Bentonite, Kaolin, and Selected Clay Minerals. Geneva, Switzerland: World Health Org, Intl Prog Chem Safety (2005)] **PEER REVIEWED**

Color/Form:

A clay containing appreciable amounts of the clay mineral montmorillonite; light yellow or green, cream, pink, gray to black solid
[Lewis, R.J. Sr. (ed) Sax's Dangerous Properties of Industrial Materials. 11th Edition. Wiley-Interscience, Wiley & Sons, Inc. Hoboken, NJ. 2004., p. V2: 351] **PEER REVIEWED**

The color in the massive condition varies from yellowish-white to almost black. The powder is cream colored to pale brown.
[O'Neil, M.J. (ed.). The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals. Whitehouse Station, NJ: Merck and Co., Inc., 2006., p. 175] **PEER REVIEWED**

Light to cream-colored impalpable powder
[Lewis, R.J. Sr.; Hawley's Condensed Chemical Dictionary 15th Edition. John Wiley & Sons, Inc. New York, NY 2007., p. 132] **PEER REVIEWED**

The Clay Spur benonite usually ranges from 0.5 to 2 meters thick ... generally light yellowish green on the outcrop, becoming bluish green away from the outcrop.
[Murray HH; Ullmann's Encyclopedia of Industrial Chemistry. 7th ed. (1999-2012). New York, NY: John Wiley & Sons; Clays. Online Posting Date: 15 Dec 2006] **PEER REVIEWED**

Southern or subbentonites are waxy and vary from blue when fresh to yellow when weathered.
[Murray HH; Ullmann's Encyclopedia of Industrial Chemistry. 7th ed. (1999-2012). New York, NY: John Wiley & Sons; Clays. Online Posting Date: 15 Dec 2006] **PEER REVIEWED**

Tertiary bentonite ranges from white to gray to yellow
[Murray HH; Ullmann's Encyclopedia of Industrial Chemistry. 7th ed. (1999-2012). New York, NY: John Wiley & Sons; Clays. Online Posting Date: 15 Dec 2006] **PEER REVIEWED**

Texas calcium bentonites range from 0.5 to 3 meters thick and varies from yellow to green to dark brown.
[Murray HH; Ullmann's Encyclopedia of Industrial Chemistry. 7th ed. (1999-2012). New York, NY: John Wiley & Sons; Clays. Online Posting Date: 15 Dec 2006] **PEER REVIEWED**

Cheto Arizona bentonite is white to light gray.
[Murray HH; Ullmann's Encyclopedia of Industrial Chemistry. 7th ed. (1999-2012). New York, NY: John Wiley & Sons; Clays. Online Posting Date: 15 Dec 2006] **PEER REVIEWED**

Odor:

Odorless
[Osol, A. and J.E. Hoover, et al. (eds.). Remington's Pharmaceutical Sciences. 15th ed. Easton, Pennsylvania: Mack Publishing Co., 1975., p. 334] **PEER REVIEWED**

Taste:

Tasteless
[Osol, A. and J.E. Hoover, et al. (eds.). Remington's Pharmaceutical Sciences. 15th ed. Easton, Pennsylvania: Mack Publishing Co., 1975., p. 334] **PEER REVIEWED**

pH:
In the presence of water, it forms translucent suspension with pH of around 9
[Osol, A. and J.E. Hoover, et al. (eds.). Remington's Pharmaceutical Sciences. 15th ed. Easton, Pennsylvania: Mack Publishing Co., 1975., p. 334] **PEER REVIEWED**

Solubilities:
Insoluble in water and common organic solvents
[Lewis, R.J. Sr. (ed) Sax's Dangerous Properties of Industrial Materials. 11th Edition. Wiley-Interscience, Wiley & Sons, Inc. Hoboken, NJ. 2004., p. V2: 351] **PEER REVIEWED**

Other Chemical/Physical Properties:
Resists high temperatures & may be sterilized by heat
[Browning, E. Toxicity of Industrial Metals. 2nd ed. New York: Appleton-Century-Crofts, 1969., p. 3] **PEER REVIEWED**

Lamellar aluminum silicate, each lattice layer is sheet of hydrated alumina sandwiched between 2 silica sheets
[Osol, A. and J.E. Hoover, et al. (eds.). Remington's Pharmaceutical Sciences. 15th ed. Easton, Pennsylvania: Mack Publishing Co., 1975., p. 309] **PEER REVIEWED**

Very fine powder free from grit, nearly white but may be pale buff or cream color; insoluble in water or acids; odorless with slightly earthy taste; it does not swell in organic solvents /Bentonite USP/
[Osol, A. and J.E. Hoover, et al. (eds.). Remington's Pharmaceutical Sciences. 15th ed. Easton, Pennsylvania: Mack Publishing Co., 1975., p. 1243] **PEER REVIEWED**

Feels greasy and soap-like ... has a high cation exchange capacity
[IPCS; Environmental Health Criteria 231. Bentonite, Kaolin, and Selected Clay Minerals. Geneva, Switzerland: World Health Org, Internl Prog Chem Safety (2005)] **PEER REVIEWED**

Interstitial water held in the clay mineral lattice is an additional major factor controlling the plastic, bonding, compaction suspension and other properties of montmorillonite-group clay minerals
[IPCS; Environmental Health Criteria 231. Bentonite, Kaolin, and Selected Clay Minerals. Geneva, Switzerland: World Health Org, Internl Prog Chem Safety (2005)] **PEER REVIEWED**

The property of forming gels is very much increased by addition of small amt of alkaline substances such as magnesium oxide.
[O'Neil, M.J. (ed.). The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals. Whitehouse Station, NJ: Merck and Co., Inc., 2006., p. 175] **PEER REVIEWED**

It has the property of forming highly viscous suspensions or gels with not less than ten times its weight of water.
[O'Neil, M.J. (ed.). The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals. Whitehouse Station, NJ: Merck and Co., Inc., 2006., p. 175] **PEER REVIEWED**

Forms colloidal suspension in water with strongly thixotropic properties. There are two varieties: (1) sodium bentonite (Wyoming or western), has high swelling capacity in water, and (2) calcium bentonite (southern), with negligible swelling capacity.
[Lewis, R.J. Sr.; Hawley's Condensed Chemical Dictionary 15th Edition. John Wiley & Sons, Inc. New York, NY 2007., p. 132] **PEER REVIEWED**

The high-swelling Wyoming or sodium bentonites contain ca 30% moisture when delivered to the plant. The Southern or calcium bentonites have ca 25% moisture. The processed bentonite generally contains only 7-8% moisture, although because bentonite is hygroscopic, it may contain considerably more moisture when used.
[Gerhartz, W. (exec ed.). Ullmann's Encyclopedia of Industrial Chemistry. 5th ed.Vol A1: Deerfield Beach, FL: VCH Publishers, 1985 to Present., p. VA7: 124 (1986)] **PEER REVIEWED**

Bentonites in which sodium montmorillonites are the major mineral constituent have a high swelling capacity.
[Murray HH; Ullmann's Encyclopedia of Industrial Chemistry. 7th ed. (1999-2012). New York, NY: John Wiley & Sons; Clays. Online Posting Date: 15 Dec 2006] **PEER REVIEWED**

Bentonites in which calcium montmorillonites are the major mineral constituent commonly have a low swelling capacity. The clays are commonly referred to as Southern or subbentonites.

[Murray HH; Ullmann's Encyclopedia of Industrial Chemistry. 7th ed. (1999-2012). New York, NY: John Wiley & Sons; Clays. Online Posting Date: 15 Dec 2006] **PEER REVIEWED**

Chemical Safety & Handling:

Fire Potential:

Not combustible.
[International Program on Chemical Safety/Commission of the European Union; International Chemical Safety Card on Bentonite (1302-78-9) (May 6, 2010). Available from, as of April 1, 2013: [illegible] **PEER REVIEWED**

Fire Fighting Procedures:

Use water spray, alcohol-resistant foam, dry chemical or carbon dioxide.
[Sigma-Aldrich Material Safety Data Sheet for Nanoclay, hydrophilic bentonite. Available from, as of April 3, 2013: [illegible] **PEER REVIEWED**

In case of fire in the surroundings; all extinguishing agents allowed.
[International Program on Chemical Safety/Commission of the European Union; International Chemical Safety Card on Bentonite (1302-78-9) (May 6, 2010). Available from, as of April 1, 2013: [illegible] **PEER REVIEWED**

Hazardous Reactivities & Incompatibilities:

Bentonite particles are negatively charged and flocculation occurs when electrolytes or positively charged suspensions are added. Bentonite is thus said to be incompatible with strong electrolytes...
[Rowe, R.C., Sheskey, P.J., Quinn, M.E.; (Eds.), Handbook of Pharmaceutical Excipients 6th edition Pharmaceutical Press, London, England 2009, p. 54] **PEER REVIEWED**

Incompatibilities: acids and acid salts decrease the water-absorbing power and thus cause a breakdown of the magma.
[Troy, D.B. (Ed); Remmington The Science and Practice of Pharmacy. 21 st Edition. Lippincott Williams & Williams, Philadelphia, PA 2005, p. 1073] **PEER REVIEWED**

Hazardous Decomposition:

Hazardous decomposition products formed under fire conditions. - Aluminum oxide, silicon oxides
[Sigma-Aldrich Material Safety Data Sheet for Nanoclay, hydrophilic bentonite. Available from, as of April 3, 2013: [illegible] **PEER REVIEWED**

Protective Equipment & Clothing:

Wear self-contained breathing apparatus for fire-fighting if necessary.
[Sigma-Aldrich Material Safety Data Sheet for Nanoclay, hydrophilic bentonite. Available from, as of April 3, 2013: [illegible] **PEER REVIEWED**

Provide appropriate exhaust ventilation at places where dust is formed.
[Sigma-Aldrich Material Safety Data Sheet for Nanoclay, hydrophilic bentonite. Available from, as of April 3, 2013: [illegible] **PEER REVIEWED**

Avoid inhalation of dust. Use local exhaust or breathing protection.
[International Program on Chemical Safety/Commission of the European Union; International Chemical Safety Card on Bentonite (1302-78-9) (May 6, 2010). Available from, as of April 1, 2013: http://www.inchem.org/pages/icsc.html **PEER REVIEWED**

Protective gloves. Wear safety goggles or eye protection in combination with breathing protection.
[International Program on Chemical Safety/Commission of the European Union; International Chemical Safety Card on Bentonite (1302-78-9) (May 6, 2010). Available from, as of April

1, 2013: [illegible] **PEER REVIEWED**

Stability/Shelf Life:

Suspensions are most stable at a pH above 7.
[Troy, D.B. (Ed); Remmington The Science and Practice of Pharmacy. 21 st Edition. Lippincott Williams & Williams, Philadelphia, PA 2005, p. 1073] **PEER REVIEWED**

Storage Conditions:

Keep container tightly closed in a dry and well-ventilated place.
[Sigma-Aldrich Material Safety Data Sheet for Nanoclay, hydrophilic bentonite. Available from, as of April 3, 2013: [illegible] **PEER REVIEWED**

Bentonite should be stored in an airtight contaner in a cool, dry place.
[Rowe, R.C., Sheskey, P.J., Quinn, M.E.; (Eds.), Handbook of Pharmaceutical Excipients 6th edition Pharmaceutical Press, London, England 2009, p. 54] **PEER REVIEWED**

Bentonite is hygroscopic, and sorption of atmospheric water should be avoided.
[Rowe, R.C., Sheskey, P.J., Quinn, M.E.; (Eds.), Handbook of Pharmaceutical Excipients 6th edition Pharmaceutical Press, London, England 2009, p. 54] **PEER REVIEWED**

Cleanup Methods:

Sweep up and shovel. Keep in suitable, closed containers for disposal.
[Sigma-Aldrich Material Safety Data Sheet for Nanoclay, hydrophilic bentonite. Available from, as of April 3, 2013: [illegible] **PEER REVIEWED**

Personal protection: particulate filter respirator adapted to the airborne concentration of the substance. Sweep spilled substance into covered containers. If appropriate, moisten first to prevent dusting. Wash away remainder with plenty of water.
[International Program on Chemical Safety/Commission of the European Union; International Chemical Safety Card on Bentonite (1302-78-9) (May 6, 2010). Available from, as of April 1, 2013: [illegible] **PEER REVIEWED**

Disposal Methods:

SRP: At the time of review, criteria for land treatment or burial (sanitary landfill) disposal practices are subject to significant revision. Prior to implementing land disposal of waste residue (including waste sludge), consult with environmental regulatory agencies for guidance on acceptable disposal practices.
PEER REVIEWED

Occupational Exposure Standards:

Manufacturing/Use Information:

Uses:

As of Fuller's earth; as emulsifier for oils; as a base for plasters. Pharmaceutical aid (suspending agent).
[O'Neil, M.J. (ed.). The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals. Whitehouse Station, NJ: Merck and Co., Inc., 2006., p. 175] **PEER REVIEWED**

Granular carrier; powder suspension agent
[Farm Chemicals Handbook 2000. Willoughby, Ohio: Meister 2000., p. C 50] **PEER REVIEWED**

Drilling mud; foundry binders; iron ore pelletizing; cat litter; sealants; animal feed binders; paint; agricultural carriers; nanoclays; industrial oil absorbants; bleaching clays; catalysts; detergents; ceramics; cosmetics; dessicants; crayons; medical formulations; beer and wine clarification; suspension aids; de-inking on paper; tape joint compounds; emulsion stabilizers; slurry trench excavation; adhesives; pharmaceuticals; organoclays /Smectites/
[Murray HH; Kirk-Othmer Encyclopedia of Chemical Technology. (1999-2012). New York, NY: John Wiley & Sons; Clays, Uses. Online Posting Date: 20 Dec 2002] **PEER REVIEWED**

Oil-well drilling fluids; cement slurries for oil-well casings; bonding agent in foundry sands and pelletizing of iron ores; sealant for canal walls; thickener in lubricating greases and fireproofing compositions; cosmetics; decolorizing agent; filler in ceramics, refractories, paper coatings; asphalt modifier; polishes and abrasives; food additive; catalyst support
[Lewis, R.J. Sr.; Hawley's Condensed Chemical Dictionary 15th Edition. John Wiley & Sons, Inc. New York, NY 2007., p. 132] **PEER REVIEWED**

Drying agent in fertilizer impregnations /Flo-Fre/
[Lewis, R.J. Sr.; Hawley's Condensed Chemical Dictionary 15th Edition. John Wiley & Sons, Inc. New York, NY 2007., p. 570] **PEER REVIEWED**

Bentonite functions as an absorbent, bulking agent, emulsion stabilizer, opacifying agent, suspending agent-nonsurfactant, and viscosity-increasing agent-aqueous in cosmetic formulations.
[Cosmetic Ingredient Review; Final Report of the Cosmetic Ingredient Review Expert Panel; Final Report on the Safety Assessment of Aluminum Silicate, Calcium Silicate, Magnesium Aluminum Silicate, Magnesium Silicate, Magnesium Trisilicate, Sodium Magnesium Silicate, Zirconium Silicate, Attapulgite, Bentonite, Fuller's Earth, Hectorite, Kaolin, Lithium Magnesium Silicate, Lithium Magnesium Sodium Silicate, Montmorillonite, Pyrophyllite, and Zeolite; International Journal of Toxicology 22 (Suppl 1): 37-102 (2003)] **PEER REVIEWED**

Bentonite is listed as being used in foundry sand bonding, bleaching clay in oil refining and decolorizers, filtering agents, water impedance, animal feed, pharmaceuticals, paint, plasticity increasers, and iron-ore pelletizing. Another source reported Bentonite as being used as an adsorbent, emulsion stabilizer, and suspending agent. Bentonite is categorized by the National Formulary as a suspending and/or viscosity-increasing agent.
[Cosmetic Ingredient Review; Final Report of the Cosmetic Ingredient Review Expert Panel; Final Report on the Safety Assessment of Aluminum Silicate, Calcium Silicate, Magnesium Aluminum Silicate, Magnesium Silicate, Magnesium Trisilicate, Sodium Magnesium Silicate, Zirconium Silicate, Attapulgite, Bentonite, Fuller's Earth, Hectorite, Kaolin, Lithium Magnesium Silicate, Lithium Magnesium Sodium Silicate, Montmorillonite, Pyrophyllite, and Zeolite; International Journal of Toxicology 22 (Suppl 1): 37-102 (2003)] **PEER REVIEWED**

The leading uses of nonswelling bentonite were in foundry sand and water treatment and filtering.
[USGS; Minerals Yearbook 2010 Database on Clay and Shale. Available from, as of Mar 23, 2013: [illegible] **PEER REVIEWED**

For smaller markets, swelling bentonite accounted for more than 95% of the bentonite sold for adhesives; animal feed; clarifying and decolorizing animal, mineral, and vegetable oils and greases; cosmetics, medical, and pharmaceutical; fertilizers; miscellaneous ceramics; miscellaneous fillers and extenders; oil and grease absorbents; paint; and plastics. Swelling bentonite accounted for less than 50% of sales for water treatment and filtering. Nonswelling bentonite accounted for most sales for chemical manufacturing and fertilizer and pesticide carriers.
[USGS; Minerals Yearbook 2010 Database on Clay and Shale. Available from, as of Mar 23, 2013: [illegible] **PEER REVIEWED**

One of 17-clay-like ingredients that are based on silicates ... used in a wide variety of product types, including bath products, makeup and skin care products ... acts as an absorbent, bulking agent, emulsion stabilizer, opacifying agent, suspending agent - nonsurfactant and viscosity increasing agent (aqueous)
[Personal Care Products Council; CosmeticsINFO.org. Washington, DC. Available from, as of Mar 27, 2013: [illegible] **PEER REVIEWED**

MEDICATION (See also: Therapeutic Uses)
PEER REVIEWED

MEDICATION (VET) (See also: Therapeutic Uses)
PEER REVIEWED

Manufacturers:
Bentonite - Producer and Manufacture Data (2012)

Company	Site	City State Zip	Manufacture	Import
Lanxess Corp	Rhein Chemie Corp Plant, 145 Parker Court	Chardon OH 44024-1112		
Penzoil Quaker State dba Shell Oil	Penzoil-Quaker State Co, 700 Milam	Houston TX 77002-2806		X
Hallmark	Crayola LLC Bethlehem Plt, 2475 Brodhead Rd	Bethlehem PA 18020-8906		X
Corning Inc	Cormtech In 500 International Dr	Durham NC 27712-8911		X
NGK North America	NGK Ceramics USA Inc, 119 Mazeppa Rd	Moorseville NC 28115		
Proctor & Gamble Co	Proctor & Gamble Co, 1 Proctor And Gamble Plaza	Cincinnati OH 45202-3392		
Agrium Advanced Technologies Inc	Agrium Advanced Technologies (US) Inc, 2405 Vassar Rd	Reese MI 48757-9340		X
Wyoben Inc	Wyo-Ben Sage Creek	Lovell WY 82431		
Wyoben Inc	Wyo-Ben, Inc Stucco Plant	Greybull, WY 82426		
Wyoben Inc	Wyo-Ben Lucerne Plant	Thermopolis WY 82443		

[US EPA; Chemical Data Reporting (CDR). Non-confidential 2012 Chemical Data Reporting information on chemical production and use in the United Sates. Available from, as of Mar 25, 2013: [illegible] **PEER REVIEWED**

Bentonite - Producer and Manufacture Data (2006)

Company	Site	City State Zip	Manufacture	Import
Reckitt Benckiser Inc	Reckitt Benckiser - Parsippany	Parsippany NJ 07054	No	Yes
Sud Chemie A.G. Munchen	Sud Chemie N.A. - Corporate Headquarters	Louisville KY 40210	No	Yes
The Proctor & Gamble Co.	Proctor & Gamble Co - Cincinnati	Cincinnati OH 45202	No	Yes

[US EPA; Inventory Update Reporting (IUR). Non-confidential 2006 IUR Records by Chemical, including Manufacturing, Processing and Use Information. Washington, DC: U.S. Environmental Protection Agency. Available from, as of Mar 25, 2013: http://cfpub.epa.gov/iursearch/index.cfm **PEER REVIEWED**

The leading producer companies were, in alphabetical order: American Colloid Co.; BASF SE; Bentonite Performance Minerals LLC; Black Hills Bentonite Co.; Nestle S.A. (fuller's earth); Oil-Dri Corp. of America (fuller's earth)
[USGS; Minerals Yearbook 2010 Database on Clay and Shale. Available from, as of Mar 23, 2013: [illegible] **PEER

REVIEWED**

The 10 leading producer States were, in decreasing order of tonnage: Georgia, Wyoming, Texas, Alabama, Missouri, North Carolina, Ohio, Tennessee, Virginia, and Mississippi.
[USGS; Minerals Yearbook 2010 Database on Clay and Shale. Available from, as of Mar 23, 2013: [illegible] **PEER REVIEWED**

Methods of Manufacturing:
Bentonite beneficiation and processing involves relatively simple milling techniques that involve crushing or shredding, drying, and grinding and screening to suitable sizes.
[Gerhartz, W. (exec ed.). Ullmann's Encyclopedia of Industrial Chemistry. 5th ed.Vol A1: Deerfield Beach, FL: VCH Publishers, 1985 to Present., p. VA7: 124 (1986)] **PEER REVIEWED**

Virtually all bentonite is strip-mined.
[Murray HH; Ullmann's Encyclopedia of Industrial Chemistry. 7th ed. (1999-2012). New York, NY: John Wiley & Sons; Clays. Online Posting Date: 15 Dec 2006] **PEER REVIEWED**

General Manufacturing Information:
Bentonite is a rock formed of highly colloidal and plastic clays composed mainly of montmorillonite, a clay mineral of the smectite group, and is produced by in situ devitrification of volcanic ash. In addition to montmorillonite, bentonite may contain feldspar, cristobalite, and crystalline quartz. The special properties of bentonite are an ability to form thixotrophic gels with water, an ability to absorb large quantities of water, and a high cation exchange capacity. The properties of bentonite are derived from the crystal structure of the smectite group, which is an octahedral alumina sheet between two tetrahedral silica sheets. Variations in interstitial water and exchangeable cations in the interlayer space affect the properties of bentonite and thus the commercial uses of the different types of bentonite. By extension, the term bentonite is applied commercially to any clay with similar properties. Fuller's earth is often a bentonite.
[WHO; Environ Health Criteria 231: Bentonite, Kaolin, and Selected Clay Minerals (2005). Available from, as of April 3, 2013: [illegible] **PEER REVIEWED**

Bentonites in which sodium montmorillonites are the major mineral constituent commonly have a high swelling capacity. The largest and highest quality sodium bentonite deposits in the world are located in South Dakota, Wyoming, and Montana. These clays are commonly called Western or Wyoming bentonites.
[Murray HH; Ullmann's Encyclopedia of Industrial Chemistry 7th ed. (1999-2013). NY, NY: John Wiley & Sons; Clays. Online Posting Date: December 15, 2006] **PEER REVIEWED**

Bentonites in which calcium montmorillonites are the major mineral constituent commonly have a low swelling capacity. These clays are generally referred to as Southern or subbentonites. Large deposits of these calcium bentonites occur in Texas and Mississippi.
[Murray HH; Ullmann's Encyclopedia of Industrial Chemistry 7th ed. (1999-2013). NY, NY: John Wiley & Sons; Clays. Online Posting Date: December 15, 2006] **PEER REVIEWED**

Smectite is the name for a group of sodium, calcium, magnesium, iron, lithium aluminum silicates, which include the individual minerals sodium montmorillonite, calcium montmorillonite, nontronite, saponite, and hectorite. The rock in which these smectite minerals are usually dominant is bentonite. The name bentonite was first suggested in 1898 ... and is the term commonly used to describe the industrial mineral. The term bentonite was defined /and/ ... restricted it to a clay material altered from a glassy igneous material, usually a tuff or volcanic ash. /It has been/ suggested that bentonite /is/ any clay composed dominantly of a smectite clay mineral and whose physical properties are dictated by this clay mineral. ...There are many clays designated as bentonite that did not originate by the alteration of volcanic ash or tuff. Therefore, the term bentonite usually does not include the mode of origin.
[Murray HH; Ullmann's Encyclopedia of Industrial Chemistry. 7th ed. (1999-2012). New York, NY: John Wiley & Sons; Clays. Online Posting Date: 15 Dec 2006] **PEER REVIEWED**

Accepted in Europe as a food additive in certain applications. Included in the FDA Inactive Ingredients Database (oral capsules, tablets and suspensions, Topical suspensions, controlled release transdermal films and vaginal suppositories).
[Rowe, R.C., Sheskey, P.J., Quinn, M.E.; (Eds.), Handbook of Pharmaceutical Excipients 6th edition Pharmaceutical Press, London, England 2009, p. 55] **PEER REVIEWED**

Volclay, a sodium form capable of absorbing five times its wt in water & swelling to 12-15 times its original vol, is used at up to 2% of feed ration (40 lb/ton) for cattle & sheep.
[Rossoff, I.S. Handbook of Veterinary Drugs. New York: Springer Publishing Company, 1974., p. 40] **PEER REVIEWED**

In 1998, 19 companies produced bentonite from approximately 60 quarries in 11 States.
[USGS; Minerals Yearbook 1998uDatabase on Clay and Shale. Available from, as of August 25, 2000: [illegible] **PEER REVIEWED**

The highest quality swelling clay is the yellowish green bentonite, which has been weathered and oxidized.
[Murray HH; Ullmann's Encyclopedia of Industrial Chemistry. 7th ed. (1999-2012). New York, NY: John Wiley & Sons; Clays. Online Posting Date: 15 Dec 2006] **PEER REVIEWED**

The major nonclay minerals present in the Clay Spur bentonite are quartz, opal-CT, feldspar, mica, and some zeolite.
[Murray HH; Ullmann's Encyclopedia of Industrial Chemistry. 7th ed. (1999-2012). New York, NY: John Wiley & Sons; Clays. Online Posting Date: 15 Dec 2006] **PEER REVIEWED**

In southern or subbentonites, quartz, feldspar and micas are the major nonclay minerals present.
[Murray HH; Ullmann's Encyclopedia of Industrial Chemistry. 7th ed. (1999-2012). New York, NY: John Wiley & Sons; Clays. Online Posting Date: 15 Dec 2006] **PEER REVIEWED**

Quartz and micas are the major nonclay minerals in Tertiary bentonite.
[Murray HH; Ullmann's Encyclopedia of Industrial Chemistry. 7th ed. (1999-2012). New York, NY: John Wiley & Sons; Clays. Online Posting Date: 15 Dec 2006] **PEER REVIEWED**

Cheto Arizona bentonite contains a small amount of kaolinite with quartz, micas, and feldspars as common non-clay impurities.
[Murray HH; Ullmann's Encyclopedia of Industrial Chemistry. 7th ed. (1999-2012). New York, NY: John Wiley & Sons; Clays. Online Posting Date: 15 Dec 2006] **PEER REVIEWED**

In the English literature, bentonites are referred to as fuller's earth. The term fuller's earth refers to any natural material that has the capacity to decolorize oil to an extent that is of commercial value.
[Murray HH; Ullmann's Encyclopedia of Industrial Chemistry. 7th ed. (1999-2012). New York, NY: John Wiley & Sons; Clays. Online Posting Date: 15 Dec 2006] **PEER REVIEWED**

Bentonite (a Natural Hydrated Aluminium Silicate) is listed in the Cosmetics Directive of the European Union (Annex IV, Part I) as CI 77004, and may be used in all cosmetics and personal care products. When used as a color in cosmetic products in the European Union, this ingredient must be called CI 77004.
[Personal Care Products Council; CosmeticsINFO.org. Washington, DC. Available from, as of Mar 27, 2013: [illegible] **PEER REVIEWED**

The Food and Drug Administration (FDA) has reviewed the safety of ... bentonite and determined that /it is/ Generally Recognized as Safe (GRAS) for use as /a/ direct food additive
[Personal Care Products Council; CosmeticsINFO.org. Washington, DC. Available from, as of Mar 27, 2013: [illegible] **PEER REVIEWED**

High-swelling sodium bentonite ... is preferred for drilling muds, pelletizing iron ore, and sealing and waterproofing ... low-swelling calcium bentonite is preferred for filtering, clarifying, and absorbing and serving as a filler, stabilizer, extender, carrier, bonding agent, or catalyst. Both types are used in foundry sand.
[IPCS; Environmental Health Criteria 231. Bentonite, Kaolin, and Selected Clay Minerals. Geneva, Switzerland: World Health Org, Interml Prog Chem Safety (2005)] **PEER REVIEWED**

Nanoclays are nanoparticles of layered mineral silicates. Depending on chemical composition and nanoparticle morphology, nanoclays are organized into several classes such as montmorillonite, bentonite, kaolinite, hectorite, and halloysite. Organically-modified nanoclays (organoclays) are an attractive class of hybrid organic-inorganic nanomaterials with potential uses in polymer nanocomposites, as rheological modifiers, gas absorbents and drug delivery carriers. /Nanoclays/
[Sigma-Aldrich, Nano Minerals: Nanoclays. Available from, as of April 3, 2013: [illegible] **PEER REVIEWED**

Formulations/Preparations:
Hollander & McClanahan base is/ a hydrophilic base containing bentonite... /it contains/ petrolatum 32 g, bentonite 13 g, sodium lauryl sulfate 0.5 g, water 54 g, methylparaben 0.1 g /Bentonite USP/
[Osol, A. and J.E. Hoover, et al. (eds.). Remington's Pharmaceutical Sciences. 15th ed. Easton, Pennsylvania: Mack Publishing Co., 1975., p. 1537] **PEER REVIEWED**

Bentonite USP: magma USP (5%) /contains/ bentonite 5 g /&/ purified water, to make 100 mL. Ointment /contains/ bentonite 15 g, propylene glycol 15 mL, /&/ petrolatum, to make 100 g. /Bentonite USP/
[American Hospital Formulary Service. Volumes I and II. Washington, DC: American Society of Hospital Pharmacists, to 1984., p. 84:24.12] **PEER REVIEWED**

Addition of a humectant (glycerin, sorbitol, etc) in amounts up to 10% will retard ... /drying/ action /of bentonite & water ointments/. /Bentonite USP/
[Osol, A. and J.E. Hoover, et al. (eds.). Remington's Pharmaceutical Sciences. 15th ed. Easton, Pennsylvania: Mack Publishing Co., 1975., p. 1537] **PEER REVIEWED**

Depending on sequence of mixing it is possible to prepare both oil/water and water/oil emulsions. When oil/water emulsion is desired, bentonite is first dispersed in water and allowed to hydrate so as to form a magma. The oil-phase phase is then added gradually with constant trituration. Because the aqueous phase is always in excess, the oil/water emulsion type is favored. To prepare water/oil emulsion, bentonite is first dispersed in oil; water is then added gradually.
[Troy, D.B. (Ed); Remmington The Science and Practice of Pharmacy. 21 st Edition. Lippincott Williams & Williams, Philadelphia, PA 2005, p. 331] **PEER REVIEWED**

"Flo-Fre" - trademark for flowability aid for soybean meal and other feeds
[Lewis, R.J. Sr.; Hawley's Condensed Chemical Dictionary 15th Edition. John Wiley & Sons, Inc. New York, NY 2007., p. 570] **PEER REVIEWED**

There are two varieties: (1) sodium bentonite (Wyoming or western), which has high swelling capacity in water; and (2) calcium bentonite (southern), with negligible swelling capacity.
[Lewis, R.J. Sr.; Hawley's Condensed Chemical Dictionary 15th Edition. John Wiley & Sons, Inc. New York, NY 2007., p. 132] **PEER REVIEWED**

Impurities:

Cheto Arizona bentonite contains a small amount of kaolinite with quartz, micas, and feldspars as common non-clay impurities.
[Murray HH; Ullmann's Encyclopedia of Industrial Chemistry. 7th ed. (1999-2012). New York, NY: John Wiley & Sons; Clays. Online Posting Date: 15 Dec 2006] **PEER REVIEWED**

The principle constituent is Montmorillonite. However, other minerals such as illite, kaolinite, and nonargillaceous detrital minerals can be present. Most Bentonites appear relatively pure and other mineral contributions rarely exceed 10%. Cristobalite is often present. Montmorillonite compositions frequently vary either in its lattice structure or in the exchangeable ions present.
[Cosmetic Ingredient Review; Final Report of the Cosmetic Ingredient Review Expert Panel; Final Report on the Safety Assessment of Aluminum Silicate, Calcium Silicate, Magnesium Aluminum Silicate, Magnesium Silicate, Magnesium Trisilicate, Sodium Magnesium Silicate, Zirconium Silicate, Attapulgite, Bentonite, Fuller's Earth, Hectorite, Kaolin, Lithium Magnesium Silicate, Lithium Magnesium Sodium Silicate, Montmorillonite, Pyrophyllite, and Zeolite; International Journal of Toxicology 22 (Suppl 1): 37-102 (2003)] **PEER REVIEWED**

Consumption Patterns:

32% FOR IRON ORE PELLETIZING; 26% FOR DRILLING MUD; 25% FOR FOUNDRY SAND; 6% FOR MFR OF ANIMAL FEED; 4% FOR PURIFYING OILS; 1% FOR WATERPROOFING AND SEALING; 1% FOR PET LITTER ABSORBENT; AND 5% FOR MISCELLANEOUS USES (1975)
[SRI] **PEER REVIEWED**

Domestic consumption decreased by approximately 2% in 1998. ... Domestic sales of bentonite for major markets were 869,000 ton for foundry sand bond, 773,000 ton for pet waste absorbent, 665,000 t for drilling mud, 529,000 ton for iron ore pelletizing, and 236,000 ton for sealant applications.
[USGS; Minerals Yearbook 1998 Database on Clay and Shale. Available from, as of August 25, 2000: [illegible]] **PEER REVIEWED**

Total sales (domestic and exports) of swelling bentonite were approximately 725,000 t for drilling mud, 840,00 t for foundry sand bond, 588,000 t for pelletizing iron ore, 775,000 t for pet waste absorbent, and 143,000 t for waterproofing and sealing.
[USGS; Minerals Yearbook 1998 Database on Clay and Shale. Available from, as of August 25, 2000: [illegible]] **PEER REVIEWED**

Reported domestic sales of bentonite were 1.02 million metric tons (Mt) for drilling mud (all swelling bentonite), 423,000 tons for foundry sand bond (more than 99% was swelling bentonite), 595,000 tons for pelletizing iron ore (all swelling bentonite), and 967,000 tons for pet waste absorbent (all swelling bentonite). Bentonite also was sold for civil engineering and sealing; fillers, extenders, and binders; waterproofing and sealing; and a variety of other applications. ... Domestic sales of bentonite increased for pet litter, drilling mud, pelletizing iron ore, waterproofing and sealing, and miscellaneous uses. Domestic sales of bentonite for drilling mud use increased by 74%, and export sales increased by 52%. Drilling activity increased domestically and overseas in 2010 compared with 2009. ...
[USGS; Minerals Yearbook 2010 Database on Clay and Shale. Available from, as of Mar 23, 2013: [illegible]] **PEER REVIEWED**

/Bentonite Uses (estimated):/ 30% drilling mud, 27% absorbents, 14% iron ore pelletizing, 16% foundry sand bond, and 13% other uses.
[USGS; Mineral Commodity Summaries 2013. Clays. Available from, as of March 28, 2013: [illegible]] **PEER REVIEWED**

Bentonite sold or used by producers in the United States, by type and use. (Data are rounded to no more than three significant digits; may not add to totals shown.)

Bentonite sold or used producers in the United States, by type and use (Thousand metric tons and thosuand dollars)

	Quantity (2009)	Value (2009)	Quantity (2010)	Value (2010)
TYPE:				
Nonswelling	116	8,140	123	9,320
Swelling	3,530	198,000	4,510	252,000
Total	3,650	207,000	4,630	261,000
-				
USE: Domestic				
Pet waste absorbents	925 (estimated)	Not Available	967 (estimated)	Not Available
Adhesives	9	Not Available	8	Not Available
Animal feed	60	Not Available	71	Not Available
Drilling mud	587	Not Available	1,020	Not Available
Filler and extender applications (Includes asphalt tiles, asphalt emulsions, cosmetics, fertilizers, ink, medical, miscellaneous fillers and extenders applications, paint, paper coating, paper filling, pesticides and related products, pharmaceuticals, and plastics.)	69	Not Available	104	Not Available
Foundry sand	443 (estimated)	Not Available	423 (estimated)	Not Available
Pelletizing (iorn ore)	445 (estimated)	Not Available	595 (estimated)	Not Available
Waterproofing and sealing	102	Not Available	122	Not Available
Miscellaneous civil engineering	190 (estimated)	Not Available	192 (estimated)	Not Available

Miscellaneous (Includes ceramics, chemical manufacturing, clarifying and decolorizing, heavy-clay products, oil and grease absorbents, refractories, and other unknown uses.)	170	Not Available	310	Not Available
Total	3,000 (estimated)	Not Available	3,810 (estimated)	Not Available
-				
USE: Exports, reported by producers				
Drilling mud	105 (estimated)	Not Available	160 (estimated)	Not Available
Foundry sand	192	Not Available	121	Not Available
Other (Includes absorbents, fillers and extenders, refractories, pelletizing, and other unknown uses.)	349	Not Available	536	Not Available
Total	646 (estimated)	Not Available	817 (estimated)	Not Available
-				
Grand total	3,650	207,000	4,630	261,000

[USGS; Minerals Yearbook 2010 Database on Clay and Shale. Available from, as of Mar 23, 2013: [illegible] **PEER REVIEWED**

U. S. Production:
(1972) 2.51X10+12 GRAMS
[SRI] **PEER REVIEWED**

(1975) 2.52X10+12 GRAMS
[SRI] **PEER REVIEWED**

In thousand metric tons: (1995) 3,820; (1996) 3,740; (1997) 4,020; (1998) 3,820; (1999, est) 3,850
[USGS; Minerals Commodity Summaries 2000 Database on Clays. Available from, as of August 25, 2000: [illegible] **PEER REVIEWED**

Production volume for non-confidential chemicals reported under the 2006 Inventory Update Rule. Chemical: Bentonite. Aggregated National Production Volume: 10 to < 50 million pounds.
[US EPA; Non-Confidential 2006 Inventory Update Reporting. National Chemical Information. Bentonite (1302-78-9). Available from, as of March 28, 2013: [illegible] **PEER REVIEWED**

Non-confidential 2012 Chemical Data Reporting (CDR) information on the production and use of chemicals manufactured or imported into the United States.

Chemical: Bentonite. National Production Volume: 1,000,000,000 - 5,000,000,000 pounds/year.
[USEPA/Pollution Prevention and Toxics; 2012 Chemical Data Reporting Database. Bentonite (1302-78-9). Available from, as of March 29, 2013: [illegible] **PEER REVIEWED**

Bentonite: Salient Production Statistics for the United States

Data in thousand metric tons

Production (sold or used)	2008	2009	2010	2011	2012 (estimated)
Bentonite	4,910	3,650	4,630	4,810	4,800

[USGS; Mineral Commodity Summaries 2013. Clays. Available from, as of March 28, 2013: [illegible] **PEER REVIEWED**

Bentonite world mine production and reserves:

Bentonite World Mine Production and Reserves (Data in thousand metric tons)

	Year 2011	Year 2012 (Estimated)
United States (sales)	4,810	4,800
Brazil (beneficated)	532	540
Czech Republic (crude)	160	180
Germany (sales)	350	350
Greece (crude)	850	900
Italy	110	110
Mexico	54	54
Spain	155	160
Turkey	1,000	1,000
Ukraine (crude)	185	210
Other countries	2,100	2,000
World total (rounded)	10,300	10,000

[USGS; Mineral Commodity Summaries 2013. Clays. Available from, as of March 28, 2013: [illegible] **PEER REVIEWED**

U. S. Imports:
(1972) 2.59X10+9 GRAMS
[SRI] **PEER REVIEWED**

(1975) 2.14X10+9 GRAMS

[SRI] **PEER REVIEWED**

Bentonite imports consisted mainly of untreated bentonite clay and chemically or artificially activated materials. ... untreated bentonite were 6,600 t ... chemically activated material were 18,900 t ...
[USGS; Minerals Yearbook 1998 Database on Clay and Shale. Available from, as of August 25, 2000: [illegible] **PEER REVIEWED**

U. S. Exports:
(1972) 4.73X10+11 GRAMS
[SRI] **PEER REVIEWED**

(1975) 4.05X10+11 GRAMS
[SRI] **PEER REVIEWED**

Domestic bentonite producers reported exports of 427,000 t. ... exports destined for Canadian and Mexican markets (approximately 250,000 t).
[USGS; Minerals Yearbook 1998 Database on Clay and Shale. Available from, as of August 25, 2000: [illegible] **PEER REVIEWED**

The major export markets /for swelling bentonite/ were in drilling mud, foundry sand, and iron ore pelletizing applications.
[USGS; Minerals Yearbook 1998 Database on Clay and Shale. Available from, as of August 25, 2000: [illegible] **PEER REVIEWED**

Exports /for nonswelling bentonite/ were limited to filtering, clarifying, and decolorizing of oils and greases and foundry sand applications.
[USGS; Minerals Yearbook 1998 Database on Clay and Shale. Available from, as of August 25, 2000: [illegible] **PEER REVIEWED**

Bentonite: Salient Export Statistics for the United States

Data in thousand metric tons

Exports	2008	2009	2010	2011	2012 (estimated)
Bentonite	1,090	709	953	1,020	1,000

[USGS; Mineral Commodity Summaries 2013. Clays. Available from, as of March 28, 2013: [illegible] **PEER REVIEWED**

Laboratory Methods:

Clinical Laboratory Methods:
Energy-dispersive X-ray analysis (EDXA) - also referred to as energy-dispersive X-ray microanalysis, X-ray microanalysis, electron microscopic microanalysis, and energy-dispersive X-ray spectrometry - and electron diffraction may permit the rapid identification of individual clay mineral particles and have been applied particularly to the identification of inhaled particles sampled via bronchoalveolar lavage or from lung specimens. EDXA requires a scanning or transmission electron microscope equipped with an energy-dispersive X-ray spectrometer and appropriate mathematical tools for analysing the resulting spectra. EDXA identifies and quantifies elements above atomic number 8. Since the basic classification of clay minerals is based on structural formula and the atomic composition is similar for many different clay minerals, EDXA cannot provide secure identification except by comparison with standards previously identified by other means. Application of EDXA without appropriate standards is likely to generate significant errors. In practice, EDXA is ordinarily combined with conventional transmission electron microscopy to first visualize a particle. Probe size is then adjusted downward so that only the selected particle is analysed. The best results are obtained by operating the microanalysis in scanning transmission mode. /Clay mineral particles/
[WHO; Environ Health Criteria 231: Bentonite, Kaolin, and Selected Clay Minerals (2005). Available from, as of April 3, 2013: http://www.inchem.org/pages/ehc.html **PEER REVIEWED**

Analytic Laboratory Methods:
There is no single or simple procedure for the positive identification of montmorillonite-group or other aluminosilicates or for their quantification in dust and other samples. The application of several methods may be necessary for even approximate identification and rough quantification. These methods include X-ray diffraction, electron microscopy, energy-dispersive X-ray analysis, differential thermal analysis, and infrared spectroscopy. In the past, chemical methods based on differences in resistance of various clay minerals to chemical attack, the so-called "rational methods of analysis," were used.
[WHO; Environ Health Criteria 231: Bentonite, Kaolin, and Selected Clay Minerals (2005). Available from, as of April 3, 2013: [illegible] **PEER REVIEWED**

Special References:

Special Reports:
Final report on the safety assessment of aluminum silicate, calcium silicate, magnesium aluminum silicate, magnesium silicate, magnesium trisilicate, sodium magnesium silicate, zirconium silicate, attapulgite, bentonite, Fuller's earth, hectorite, kaolin, lithium magnesium silicate, lithium magnesium sodium silicate, montmorillonite, pyrophyllite, and zeolite.
[Elmore AR, Cosmetic Ingredient Review Expert Panel; Int J Toxicol 22 (Suppl 1): 37-102 (2003)]

Synonyms and Identifiers:

Related HSDB Records:
8118 [Montmorillonite] (mixture)

Synonyms:
Albagel Premium USP 4444
PEER REVIEWED

Bentonite 2073
PEER REVIEWED

Bentonite magma
PEER REVIEWED

COLLOIDAL CLAY
PEER REVIEWED

CI 77004
PEER REVIEWED

E558
PEER REVIEWED

MAGBOND
PEER REVIEWED

OTAYLITE
PEER REVIEWED

Soap clay
PEER REVIEWED

SOUTHERN BENTONITE
PEER REVIEWED

TIXOTON
PEER REVIEWED

Taylorite
PEER REVIEWED

Volclay
PEER REVIEWED

Wilkinite
PEER REVIEWED

WILKONITE
PEER REVIEWED

Formulations/Preparations:

Hollander & McClanahan base is/ a hydrophilic base containing bentonite... /it contains/ petrolatum 32 g, bentonite 13 g, sodium lauryl sulfate 0.5 g, water 54 g, methylparaben 0.1 g /Bentonite USP/
[Osol, A. and J.E. Hoover, et al. (eds.). Remington's Pharmaceutical Sciences. 15th ed. Easton, Pennsylvania: Mack Publishing Co., 1975., p. 1537] **PEER REVIEWED**

Bentonite USP: magma USP (5%) /contains/ bentonite 5 g /&/ purified water, to make 100 mL. Ointment /contains/ bentonite 15 g, propylene glycol 15 mL, /&/ petrolatum, to make 100 g. /Bentonite USP/
[American Hospital Formulary Service. Volumes I and II. Washington, DC: American Society of Hospital Pharmacists, to 1984., p. 84:2[illegible]2] **PEER REVIEWED**

Addition of a humectant (glycerin, sorbitol, etc) in amounts up to 10% will retard ... /drying/ action /of bentonite & water ointments/. /Bentonite USP/
[Osol, A. and J.E. Hoover, et al. (eds.). Remington's Pharmaceutical Sciences. 15th ed. Easton, Pennsylvania: Mack Publishing Co., 1975., p. 1537] **PEER REVIEWED**

Depending on sequence of mixing it is possible to prepare both oil/water and water/oil emulsions. When oil/water emulsion is desired, bentonite is first dispersed in water and allowed to hydrate so as to form a magma. The oil-phase phase is then added gradually with constant trituration. Because the aqueous phase is always in excess, the oil/water emulsion type is favored. To prepare water/oil emulsion, bentonite is first dispersed in oil; water is then added gradually.
[Troy, D.B. (Ed); Remmington The Science and Practice of Pharmacy. 21 st Edition. Lippincott Williams & Williams, Philadelphia, PA 2005, p. 331] **PEER REVIEWED**

"Flo-Fre" - trademark for flowability aid for soybean meal and other feeds
[Lewis, R.J. Sr.; Hawley's Condensed Chemical Dictionary 15th Edition. John Wiley & Sons, Inc. New York, NY 2007., p. 570] **PEER REVIEWED**

There are two varieties: (1) sodium bentonite (Wyoming or western), which has high swelling capacity in water; and (2) calcium bentonite (southern), with negligible swelling capacity.
[Lewis, R.J. Sr.; Hawley's Condensed Chemical Dictionary 15th Edition. John Wiley & Sons, Inc. New York, NY 2007., p. 132] **PEER REVIEWED**

Administrative Information:

Hazardous Substances Databank Number: 392

Last Revision Date: 20130617

Last Review Date: Reviewed by SRP on 5/16/2013

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Complete Update on 2013-06-17, 45 fields added/edited/deleted
Field Update on 2008-09-11, 1 fields added/edited/deleted
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Complete Update on 02/14/2003, 1 field added/edited/deleted.
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Complete Update on 04/26/2001, 22 fields added/edited/deleted.
Complete Update on 08/26/1999, 1 field added/edited/deleted.
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Field Update on 01/19/1996, 1 field added/edited/deleted.
Field Update on 12/21/1994, 1 field added/edited/deleted.
Field Update on 11/03/1994, 1 field added/edited/deleted.
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Complete Update on 03/25/1994, 1 field added/edited/deleted.
Field update on 12/12/1992, 1 field added/edited/deleted.
Field update on 08/13/1990, 1 field added/edited/deleted.
Complete Update on 12/14/1984
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