



Acute Phosphine (PH₃) Poisoning Released from Aluminum Phosphide (ALP) Led to Fatal Cases in Jeddah, Saudi Arabia

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Abstract

Aiming to identify aluminum phosphide (ALP) pills, which turn water or moist air into dangerous phosphine gas (PH₃), we completed a retrospective study of cases of poisoning in the Kingdom of Saudi Arabia. Research on the problem of acute phosphine poisoning released from aluminum phosphide using a case analysis of fatalities in Jeddah, Saudi Arabia, used data obtained from entities responsible for preventing toxicology and included some families that were exposed to phosphine gas and aluminum phosphide. Deaths from aluminum phosphide and phosphine gas have increased in Saudi Arabia in recent years, even though their sale to individuals is forbidden. In addition, there is a lack of knowledge of this issue among doctors in hospital emergency rooms, which can lead to a delay in giving the appropriate medicine and, consequently, death. Acute phosphine poisoning released from aluminum phosphide has led to fatal cases in Saudi Arabia. Intervention programs are recommended to address the problem of selling aluminum phosphide illegally, and there is criminal liability for private companies in the fight against pests and insects. Additionally, awareness should be increased among youth through cooperation between public education and the media, which should include further research on this problem.

Keywords: Aluminum Phosphide, Poisoning, Mortality, Inhalation, Phosphine

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1. Introduction

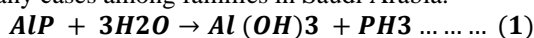
Aluminum phosphide (ALP) pills are used to protect grain crops, such as wheat and corn, from insects and rodents. It is a solid fumigant that has been extensively used since the 1940s and is easily available and purchased under some trade names such as fumitoxin, Gastoxin, phostoxin, phosfume, and weevil-cide. Poisoning is a common mode of suicide in many countries, and pesticide use or abuse causes 100,000 deaths annually around the world. ALP poisoning, if not treated, causes death within 24 hours [1-2]. ALP is available as tablets (3 g), releasing 1 g of PH₃, and coming in green, brown, or grey, with each tablet containing 56% ALP and 44% aluminum carbonate [3]. This highly toxic chemical is cheap and usually formulated in tablets, pellets, granules, or as dust. Although aluminum phosphide is not harmful on its own, it quickly turns into phosphine gas when it comes into contact with water (Equation 1), moisture in the air (Equation 2), or hydrochloric acid (Equation 2) in the stomach. This gas is quickly absorbed by breathing it in, swallowing it, or touching it on the skin or mucosa [3]. Pure phosphine gas is colorless and odorless, but when exposed to air, it may give off a foul odor (resembling garlic or decaying fish) due to the presence of substituted phosphines and diphosphines.

Phosphine gas spreads quickly due to being heavier than air and explodes in concentrations of more than 1.8% in air, being spontaneously flammable at 38°C. It also has effects on central nervous system, with an exposure limit for

humans of 0.3 ppm [1]. AIP also poses a threat as a form of chemical terrorism due to immediate release of this lethal phosphinegaluminiu. Maluminum phosphide pills are strictly regulated, and they are classified as category I toxicants (high toxicity) in the United States of America and acute toxicity category II in the European Union due to a threat to people's lives in certain conditions [5]. In recent years, a high mortality rate has reported following significant exposure to phosphide gas [6]. Scientists are still not sure how phosphine gas hurts cells, but they have found that it stops cytochrome oxidase from doing its job. This stops mitochondrial oxidative phosphorylation and may stop amino acids from being added to myocardial [6-7]. Over past two decades, a dramatic increase in human casualties following accidental or suicidal ingestion of phosphide pesticides has observed in developing countries, such as India and Iran [5].

Upon contact with moisture in environment, undergoes a chemical reaction, yielding phosphine gas, which is active pesticides component. It emerged as a poison for suicidal deaths because it has no effective antidote [3]. In many emergency cases in Saudi Arabia, doctors do not know the cause of poisoning at the beginning of such an event, which leads to the death of the victims. Some patients have been treated with supportive treatment, including gastric lavage with diluted potassium permanganate, coonusodium bicarbonate, intravenous magsulfatesulfate, and vasopressors. In these cases, four out of seven patients

survived, thus suggesting the role of such supportive measures in the absence of a specific antidote for ALP poisoning [7]. The rapid onset of shock, metabolic acidosis, cardiac arrhythmias, and respiratory distress syndrome all contribute to mortality. In this article, we describe an accidental, severe poisoning by inhalation of phosphine gas in many cases among families in Saudi Arabia.



2. Materials and Methods

This study conducted research on problem of acute phosphine poisoning released from aluminum phosphide by performing a case analysis of an analytical retrospective study of all fatalities in Jeddah, Saudi Arabia, using data obtained from entities responsible for preventing toxicology.

3. Mechanism of Toxicity and Symptoms

Human toxicity occurs either due to the ingestion of AIP (the most common mode) in suicide cases or by accidental inhalation of phosphine, where, after ingestion, toxic features usually develop within a few minutes. AIP releases phosphine gas in the presence of HCl in the stomach, after which the phosphine is rapidly absorbed through the lungs and metabolized into hypophosphite, phosphate, and phosphite, leading to systemic toxic effects involving the heart, lungs, kidney, and liver, with a manifestation of serious cardiac arrhythmias, intractable shock, acidosis, and pulmonary edema. After absorption, phosphine is oxidized into oxyacids. Phosphine is excreted in the urine as hypophosphite and through the lungs in an unchanged form [9]. In addition, the mechanism of toxicity includes failure of cellular respiration. However, exact underlying mechanism of cardiotoxicity and acute circulatory failure caused by phosphine is not well defined. The permissible exposure limit of phosphine is < 0.3 ppm in working environment, and levels greater than 50 ppm are dangerous to life, while at 400–600 ppm it is lethal within half an hour. The signs and symptoms depend on dose, route of entry, and time-lapse since exposure to poison. After inhalation exposure, patients commonly experience airway irritation, breathlessness, dizziness, and easy fatigability, tightness in the chest, headache, nausea, vomiting, diarrhea, ataxia, numbness, paresthesia, tremor, muscle weakness, diplopia, and jaundice. Symptoms often resulting in death include cardiac failure, cardiac arrhythmias, convulsion, and coma [9].

4. Diagnosis

Exposure to aluminum phosphide is dangerous to life, particularly because, in most cases, the cause of poisoning is not known at treatment, which causes delays in treating the cases appropriately. It is possible to determine phosphine poisoning by laboratory tests on samples of remnants of stomach contents or breath. However, testing for phosphine in blood or urine is not recommended, as phosphine is rapidly oxidized to phosphite and hypophosphite. It is possible to know the cause of poisoning through the following laboratory methods:

1). The principal method: silver nitrate test, in which diluted gastric content is heated in a flask up to 50°C for 15-20 minutes, keeping silver nitrate paper on the mouth of the flask. If phosphine is present, then the paper will turn black due to silver phosphate. As hydrogen sulfide also changes

color, its presence could be differentiated by using lead acetate paper, i.e., both papers will turn black in the presence of hydrogen sulfide. Further confirmation of phosphine can be performed by putting a drop of ammonium molybdate solution on the blackened filter paper, after which the color of the paper will change to blue [9].

2). Confirmation method: Chromatography with a nitrogen-phosphorous detector is the most specific and sensitive test, and it can be used for the analysis of airtight samples (viscera and gastric content) collected during autopsy for the detection of phosphine in samples [9-10].

5. Case Report

1). On September 25, 2008, two children and their mother were exposed to phosphine gas poisoning in the coastal city of Jeddah, which is characterized by extreme humidity in the summer and high temperatures. The family's neighbor brought aluminum phosphide pills to kill insects and rats in his house. This chemical compound, under the humidity and heat, converted into phosphine gas that the two children inhaled, resulting in their deaths, while the mother survived. This should be unusual, as there are strict instructions for importing and selling aluminum phosphide granules due to their danger, but it seems that there is a market for these pesticides that is out of government control [11].

2). In October 2011, a similar situation occurred with a family of four: a father, a mother, and two children. The family entered their home and smelled something strange, which they thought was coming from outside the house. After a few hours, symptoms such as nausea and vomiting began to appear in the two children. The symptoms continued to worsen, and after 24 hours, the symptoms began to affect the mother. The mother remembered some stories about insecticide infections, especially since she saw her neighbor taking out some furniture from her house, so she asked her if she had used any insecticide. She told her that she had used an insecticide with aluminum phosphide pills and also complained that her daughter suffered from the same symptoms, which included nausea, vomiting, and difficulty breathing. The family's condition developed, and the mother and two children entered intensive care. The doctors assisted the patients by giving them oxygen and some medicine, relying on the body's strength to expel the toxins. The mother survived, while the two children suffered from symptoms of severe hyperglycemia, with one of them succumbing to kidney failure because of the spread of the poison in his body. The other child was able to live with his mother [12].

3). In June 2013, a family contacted a company specializing in pest control after finding their number through a media outlet. The company sprayed the house and told the family to leave the house for 24 hours, so the family opted to travel during this period. Thirty-six hours after leaving the house, while the family was traveling, one of the brothers, aged 42, came and entered the house. After staying in the house, he felt symptoms, including cramps, pain, and shortness of breath. He started to be in pain, so the building guard heard his voice, went to him, and found him on the ground. He asked for an ambulance. When he arrived at the hospital, oxygen was given to him, and his condition began to develop as atrophy occurred in the heart muscles. Doctors performed pulmonary resuscitation for an hour and a half without knowing the cause of his shortness of breath, and finally, he died. The police came to solve the mystery of the cause of the death [13].

The investigation began with the family. They went to the house took a sample of substance and sprayed water on it, trying to clean it. The reaction of substance increased, and phosphine gas proliferated. The apartment was closed, and the building was evacuated due to the spread of the bad smell throughout the area. The apartment remained closed for two weeks until the end of the investigations. The police tried to contact company and inform them that they were responsible for death, but owner of the company has not answered the police, and as of yet, nothing is known about this company.

4). In September 2013, a family of five members, consisting of a girl (23 years old) and two boys (15 years and 20 years, respectively), father (51) and the mother (59 years old), were exposed to phosphine gas poisoning as they lived in a building of 30 family apartments. An Indian man was living below the apartment of affected family. Before traveling to his country, he put aluminum phosphide in apartment to protect house's furniture from insects and mice. Unfortunately, due to Jeddah's high humidity, phosphine gas leaked from the air conditioner and infected the family. The girl, 23 years old, was first to be injured. Because girl's father was suffering from fatigue, he contacted his brother to take his daughter to hospital. She was suffering from cyanosis of her extremities with general fatigue and shortness of breath. Girl was taken to recovery room, and within a few minutes, her body systems began to shut down one after other. Within two and a half hours, all members of family began to suffer from same symptoms, including fatigue, shortness of breath, nausea, and vomiting, and mother died afterward. Considering that, the doctors in the hospital did not know about this poisoning, and at first, they thought it was food poisoning or chemical poisoning. Hospital administration told police to search for cause of poisoning and rapid death. Police discovered that poisoning was caused by an aluminum phosphide pesticide that was found in house of Indian man. Strangely man did not return to Saudi Arabia, although he had lived there for more than 20 years, and it is thought that this may be because of arrival of news about legal problems. The police do not know how substance, which is prohibited for sale to private individuals, reached Indian man [14-15].

6. Discussion

Although aluminum phosphide is one of the most hazardous chemical compounds, some people still use it to protect household furniture from pests and mice because it can turn into deadly phosphine gas in the presence of water

or high humidity. It may also be used in suicide attempts, as it turns into phosphine gas when it reacts with hydrogen chloride in the stomach. Aluminum phosphide is forbidden to be sold to individuals in Saudi market, but it may be obtained through black market, smuggling, or possibly through a lack of careful and strong follow-up from the regulatory authorities. It has been used by individuals due to a lack of knowledge and culture about the extent of its danger to life, in addition to its cheap price. Phosphine (PH₃) gas is an ideal fumigant for control of insect pests on stored commodities due to its low cost of application, ease of use, and lack of chemical residues. Phosphine is also environmentally benign, as it decomposes into phosphate [1-8]. Organophosphate, organochlorines, and aluminum phosphide (AIP) compounds are commonly used pesticides. AIP is commonly used as an outdoor and indoor pesticide in developing countries as it is cheap, effective, free from toxic residue, and does not affect seed viability. Jeddah, where poisoning cases occurred, is located in western part of Saudi Arabia, and it is a coastal city whose climate is characterized by high heat and humidity.

It should be noted that all phosphine poisoning incidents occurred during the summer season, when many workers and others left to visit their families, sometimes putting out pesticides, such as aluminum phosphide, to protect furniture from insects. Generally, aluminum phosphide is not allowed to be sold to individuals where there are restrictions, but it seems that there is an illegal market for these materials. The Food and Drug Authority, a body that examines these materials, also shares responsibility for general control of pesticides in the Kingdom of Saudi Arabia with the Ministry of Agriculture. The Ministry of Health as a treatment and prevention agency, as well as the Civil Defense as a community protection agency, share it, which has resulted in a loss of control over these materials. In addition, workers in pest control companies are not specialized, do not hold sufficient certificates to work in this field, and do not have appropriate training, which poses a danger to use of pesticides in general and aluminum phosphide in particular. AIP and phosphine poisoning are dangerous, so it should not be delayed for confirmatory diagnosis. Unfortunately, there is no known specific antidote. As each poison has a definite elimination time, so too is case with AIP. Early arrival, resuscitation, diagnosis, intensive monitoring, and supportive therapy may result in a favorable outcome. Care of patients with severe poisoning can be enhanced by consultation with a medical toxicologist or a regional poison center.

Table 1: From the list of pesticides registered in Saudi Arabia.

Common Name	Trade Names (Examples)	Restriction Reasons	Notes
Aluminum phosphide (phosphine)	Fumitoxin, Gastoxin, Phostoxin, PhosFume, Weevil-Cide	Very acute toxicity upon inhalation	Allowed to control store pests and under the supervision of the competent authority

7. Conclusions

The results of present study highlight importance of understanding acute phosphine poisoning released from aluminum phosphide has led to fatal cases in Saudi Arabia. It is clear from these cases that phosphine gas is dangerous and kills its victims very quickly, especially children due to their inability to resist phosphine gas poisoning, and gas can leak and reach neighboring apartments through air-conditioning devices. It is therefore important to set controls and

legislation that prevent sale of phosphine aluminum to individuals, and there is criminal liability for private companies dealing with pest control and related undertakings. Furthermore, staff safety procedures are important, and rescuers should not enter an area where phosphine is present without wearing an appropriate breathing apparatus.

Declaration of conflicting interests

The author has declared no conflict of interest.

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