Validation of qualitative test for phosphine gas in human tissues

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Phosphine has been known to science since the birth of modern chemistry. WHO reports that the technical product usually has a foul odour, like “fishy” or “garlicky” because of the presence of substituted phosphines and diphosphine (P₂H₄). Many medic-legal autopsy cases have been reported positive for aluminium phosphide even though there was neither any suspicion of consuming aluminium phosphide nor any clinical findings, postmortem findings or circumstantial evidences. The present study was carried out to validate the qualitative test, presently applied in many laboratories for testing phosphine. It was observed that 65% of human tissues in saturated solution of common salt show positivity for phosphine gas on the first day of autopsy.

Keywords: Aluminium phosphide, Decomposition, Human tissues, Phosphine, Zinc phosphide

Phosphine has been known to science since the birth of modern chemistry. Indeed, Lavoisier¹ in 1789, described the product of the binary combination of phosphorus with hydrogen as “hydriuret of phosphorus, or phosphuret of hydrogen”. Johnston and Church² in 1879 mention that “it is easily prepared in the laboratory. It is one of the compounds of phosphorus, which is naturally produced along with other disagreeable substances during the decay of animal bodies, and contributes to the repulsive character of the smells which decaying animal matter gives off. Phosphine, or hydrogen phosphide, is reported as a colourless gas and odourless gas when pure³. WHO reports that the technical product usually has a foul odour, like “fishy” or “garlicky”, because of the presence of substituted phosphines and diphosphine (P₂H₄).

Aluminium phosphide ingested orally reacts rapidly with water and stomach acids to produce phosphine gas, which may account in a large part for observed toxicity⁴⁵. Hydrogen phosphide (phosphine) gas, considered as genotoxic and cytotoxic in mammals, is produced by reaction with aluminium phosphide in contact with water (even at ambient humidity), reacts with moist air, violently with acids, producing phosphine⁶⁷. Phosphine generated in the gastrointestinal tract is readily absorbed in to the bloodstream, and it is readily absorbed through the lung epithelium⁸. Phosphine is reported to cause denaturing of oxyhemoglobin (the carrier for systemic distribution of oxygen) as well as enzymes important for respiration and metabolism, and may also have effects on cellular membranes⁹. Phosphine (PH₃) is also known as phosphane, hydrogen phosphide or phosphorous hydride is a many things to many people. It is a grain fumigant, an industrial gas used in silicon chip manufacture, an air pollutant and a natural product of swamps and sewers. It is marketed in India as Celphos and Quickphos. It is considered toxic as well as intriguing gas.

That phosphine which is not expired through the lungs may be metabolized to phosphates, hypophosphite and phosphite¹⁰¹¹. The lethal dose for humans has been estimated as 150-500mg for a 70 kg person. Anger et al.¹² observed that the phosphine gas was absent in the blood and urine but present in the brain (94 ml/g) the liver (24 ml/g), and kidneys (41 ml/g). High levels of phosphorus were found in the blood (76.3mg/l) and liver (8.22 mg/g). Aluminium concentrations were very high in the blood (1.54 mg/L), brain (36 µg/g), and liver (75 µg/g) compared to the usual published values.

Suicides or accidental intake are well known with this poison. Singh et al.¹³ conducted a study and revealed a steep increase (from 45-72%) in the incidence of acute aluminium phosphide poisoning since 1987. Most of the victims were agriculture workers. Earlier in 1985, a report indicated high...
The sensitivity of the test is high even with low concentrations of \( \text{PH}_3 \). Its specificity is also high except that sometimes silver nitrate produces blackening due to reaction with \( \text{H}_2\text{S} \), which is also, one of the gases formed during the process of decomposition, however it can be ruled out by adding lead acetate to these tissues during silver nitrate test.

The human tissues were stored up to 30 days. They were tested repeatedly. Out of 20 samples, 13 (65\%) showed positivity on the very first day of postmortem (Table 1), and 14 (75\%) showed positivity after 15 days of postmortem. The increase in percentage could be due to the increasing decomposition of tissues. This percentage decreased gradually as the samples were stored for longer duration. The test was conducted again after 25 days and 11 out of 20 samples (68.75\%) showed the presence of phosphine gas with silver nitrate test as well as steam distillation procedure. This percentage decreased slightly to 66.2\% when these samples were tested after 30th day of the study. This decrease could be for the reason that the container is opened several times due to which the gas gets released. Further, there is a possibility that the decomposition of these tissues may be complete resulting in total release of the phosphine gas from the tissues. Shaheen\(^{10}\) reported that about 20 ppb of phosphine gas was detected in landfill garbage dumps, sewage works, compost processing and river sediments; and concluded that phosphine is a universal trace component in gas emitted from the anaerobic biosphere.

The test may be giving positivity for the phosphine due to decomposition, not for exogenous phosphine. Therefore, we have to look for some other technique to establish that the person has consumed salt of phosphine (zinc, aluminium). Till such time it is not advisable to rely upon present test being reported for phosphine/phosphide or Aluminium or zinc phosphide to establish the cause of death. In the present test, the zinc/aluminium and Phosphine were being tested separately in the tissues or stomach contents which does not make an absolute conjecture for the consumption of Zinc phosphide or Aluminium phosphide. The presence of elements in the stomach may be a coincidental finding due to exogenous consumption of various food materials or drugs containing these elements or could be a normal constituent\(^{16}\). Therefore, cannot be relied upon unless until corroborated by strong circumstantial and other
autopsy findings or clinical observations. As a general principle this conjecture is invalid particularly in view of such a high rate of positivity of test due to decomposition.

References
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