Dissertation
on
Arsenious Acid
by
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Chemical History.

Arsenic (or its compounds) appear to have been known to the ancients, as we find the term ἀρρενικον & σανδαράκη (Realgar or Sulphuret of Arsenicum) made mention of by Hippocrates, & the word αρσενικον by Dioscorides. (Lib. v. Cap. 21.)

Hippocrates mentions Arsenic in the preparation of a liquid application to Ulcers called "Carricum". He says: "The medicine is prepared of the following ingredients:- of black Hellebore, of Sandarach, of the flakes of Copper, of Lead, washed with much Sulphur, Arsenic & Cantharides. (De Ulceribus: Trans. of Sydenham Society). The first procss for obtaining Arsenious Acid is mentioned in the Pharmacopœia of Schroeder published in the year 1649, but it seems to have been but little known until 1733 when Brandt, a German Chemist, determined its nature & chief properties. Both Arsenic & its Oxide are met with in Nature comparatively pure or in combination with other Metals, as with Iron, Copper, Cobalt, Silver & Gold; or united with Sulphur as Arsenical Pyrites, or as Realgar.

Arsenic is found in Sicily, Italy, Hungary & Germany & is prepared chiefly in Silesia, Bohemia & Saxony as Arsenious Acid

In the preparation of this substance the ore is first reduced to powder & then roasted in a muffle furnace, where the Arsenic is converted into the white oxide.

The Arsenious Acid is then conveyed in a state of vapour into a condensing chamber, where it is deposited in the form of a rough powder: this coarse powder is then refined by sublimation in cast-Iron pots, where tolerably pure Arsenious Acid is deposited on the sides & top: but this is sometimes subjected to a second & even third sublimation. Arsenious Acid is also formed in a rough impure state in the flues of the tin-burning-houses in Cornwall & is afterwards purified by the refiner.

Properties. Arsenious Acid, when recently prepared, is in the form of large glassy transparent cakes, sometimes colourless, at others having a yellowish tinge, & with one side of the cake convex & the other concave.

Arsenious Acid is dimorphous, i.e.

it crystallizes in two forms, belonging to two classes of crystallization. By slow sublimation in a glass tube it is always obtained in octaëdral crystals perfectly transparent. It is also sometimes found as six-sided scales derived from a rhombic prism: these crystals when sublimed also assume the octaëdral form. (Thomson.).

The glassy transparent cakes, when exposed to light, assume an opaque appearance but it does this very slowly, often taking years to reach the centre of a small piece.

There seems to be great discrepancy of opinion as to the cause of this opacity. Krüger & Phillips ascribe it to the absorption of moisture from the atmosphere, for, they say, it only takes place in moist air & attains an increase in weight amounting to $\frac{1}{163}$ of the whole mass. Berzelius observes that the increase of weight is too trivial to admit of such an explanation, & Dr. Pereira says that he has observed pieces of benzoïc acid become opaque when kept in air-tight bottles, & he thinks that the change may be owing to minute cracks

minute & imperceptible fissures, while Dr. Christison thinks that it is owing merely to a different molecular arrangement.

Authors do not agree as to the density of Arsenious Acid. Guibourt & Dr. Christison state the density of the transparent variety at 3.73, & the opaque at 3.69. Mr. Durand & Dr. Mitchell found the transparent variety to vary from 3.208 to 3.338, while the opaque was 3.656. Mr. Taylor found a perfectly opaque specimen, which had been kept for 4 years, to possess a density of 3.529, while a recently prepared & perfectly transparent specimen was 3.798.

The Arsenious Acid is sublimed according to Dr. Christison at 380° F.; according to Thomson at 383°; & according to Bergman at 388°.

The opaque variety of Oxide of Arsenic is more soluble than the transparent. Temperate Water, according to Dr. Christison, takes up with difficulty about a 400th of its weight of the oxide: boiling Water dissolves about a ninth of its weight, but, on cooling to 60° F. retains only a 35th. According to Klaproth 13 parts of boiling Water dissolve 1. of Arsen.

ous Acid: he also agrees that 100 parts of the water which had been boiled, & arsenious acid dissolved in it, retained 3 parts when cold. Guibourt had found that 1000 parts of temperate water dissolve in 36 hours 9.6 of the transparent & 12.5 of the opaque variety, & that the same quantity of boiling water dissolves 97 parts of the transparent oxide, retaining 18 when cold, but takes up 115 of the opaque, & retains 29 when cold. Agitating the substance with water seems greatly to increase its solubility, for Dr. A. Taylor has observed that when water is simply poured on the opaque variety & left for 72 hours, the water took up but 1 part in 1000, but, when they were frequently agitated 1000 parts of water took up 8.5 parts. The solubility of Arsenious Acid is greatly impaired by the presence of organic matters in the water as milk, mucus, &c. Hot tea & cold Porter will not, according to Dr. Taylor, take up more than about half a grain to the ounce, while hot coffee & cold brandy do not dissolve more than a grain to the ounce. These results are very important for they explain in some measure why

Arsenious Acid is so often found in an insoluble state in the contents of the stomach

It appears according to Mr. Taylor's experiments that a boiling saturated solution, perfectly cooled, will retain from 10 to 20 times more of the oxide than it will take up at a common temperature without heat. Arsenious Acid is rendered more soluble in water by the addition of most acids: it is sparingly soluble in fixed oils.

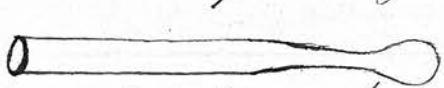
Taste. It was long erroneously believed that the taste of Arsenious Acid was acrid, but Dr. Christison has shown that it possesses scarcely any taste except a slightly sweet one. It has certainly been often swallowed in articles of food without the individual being aware, or even suspecting its presence: the supposition of its having an acrid taste may have arisen from confounding the inflammation subsequently produced with the act of swallowing. Otto Tachenius, a Chemist of the 16th century, in speaking of Arsenic thus refers to its taste: "Once," says he, "when I happened to breathe incautiously

the fumes of Arsenic I was surprised to find my palate impressed with a sweet, mild, grateful taste, such as I never experienced before." Arsenic is an irritant poison but does not seem to possess any corrosive action: i.e. it has no chemical action on the tissues

Chemical Analysis.

The Tests for Arsenious Acid may be arranged under 3 heads: 1. The test for oxide of Arsenic in a solid state: 2. The tests for this substance in solution: & 3. The tests for it in organic mixtures.

1. Arsenic as a solid. The most characteristic test for the solid oxide is that of Reduction.

The only instrument required for this purpose is a glass tube, & the best form of it is that recommended by Berzelius: its length should be  about 3 inches, & its diameter from $\frac{1}{7}$th. to $\frac{1}{10}$th. of an inch, & the matter to be tested should not fill more than $\frac{3}{4}$ths. of an inch. When the quantity of oxide is small it should be mixed with recently ignited charcoal, for, when any of the alkaline

fluxes are used a part of the Arsenic is retained, probably in the form of Arseniuret of the alkaline metalloid. When the quantity of oxide, however, is large, it should be mixed with an alkaline flux, &, for this purpose a flux made by grinding together Carbonate of Soda with an eighth of its weight of charcoal & heating the mixture to redness, in order to drive off the Water, is probably the best. Dr. M'Gregor has recommended the Oxalate of Soda in preference to any other substance as a flux.

Heat should be applied to the mixture, after its introduction into the tube, by means of a Spirit-lamp; the upper part of the contents of the tube being heated first, by means of a small flame, & then the lower part by means of an enlarged flame: any Water wh: may form on the sides of the tube must be removed by means of a roll of filtering paper, & by these means a crust of metallic Arsenic will be deposited on the cold part of the tube in the form of a ring. The physical properties of this crust are thus accurately described by Dr.

Christison; "The surface near the tube is very like polished steel, being a little darker in colour but equal in brilliancy & polish: & the inner surface is either brilliantly crystalline to the naked eye, like the fracture of cast-iron, or has a dull greyish-white colour but appears crystalline before a common magnifying lens of 4 or 5 powers."

Objections have been raised against this test by supposing that other substances, as charcoal &c., yield a crust similar in appearance, & Dr. Paris states that a film of finely divided Charcoal has been mistaken for arsenic by a person "by no means deficient in chemical address." The outer surface of Charcoal might, in my opinion, certainly be mistaken for the arsenical crust by a careless observer, but bearing in mind the characteristic properties of the sublimed Arsenic as accurately described by Dr. Christison it is impossible to err. Mr. Donovan & others have stated that the preparations of Antimony yield, by reduction, a similar crust to that of Arsenic, but since it has been denied by two such eminent authorities as Drs. Turner

& Christison that any preparation of antimony, reduced by charcoal, or the black-flux, & by the aid of the fullest red-heat of the blow-pipe will yield a metallic sublimate, I deem it needless to enter into any particulars on this head. Dr. Mitchell has stated that Cinnabar, when mixed with charcoal, & heated, exactly simulates Arsenic in appearance, & I have found that under these circumstances Cinnabar actually does produce a crust, viz., is at first sight, extremely like metallic Arsenic, but on careful examination it may readily be distinguished from the Arsenical crust.

Lead contained often in the glass has been said to form a crust similar in appearance to that given by Arsenic, but Dr. Christison says that the Lead merely gives that part of the tube, viz. contains the flux, a glimmering appearance, & impairs its transparency, but that it is impossible to obtain a sublimate from it. It has also been asserted that Arsenic is used in the manufacture of glass & might thus give out the arsenical crust by heat, but Chevalier & Ozanam (Ed. Med. & Surg. Journal Vol. 48 p. 440.)

have shewn this to be a perfectly futile objection. Zinc has been said to produce a metallic crust similar to that of Arsenic, but the sublimation of Zinc seems to require a full white heat. Tellurium, Cadmium & Potassium sublime at a lower heat, but they are so extremely rare as to call for no remarks on this head. "It may therefore be safely laid down", says Dr. Christison, "that the appearance exhibited by a well-formed Arsenical crust, even in the minute quantity of a 300th. part of a grain, are imitated by no substance in nature wh: can be sublimed by the process for the reduction of Arsenic". There are other additions to this test wh: when properly performed render "assurance doubly sure", & the first is the oxidation of the metallic Arsenic by heat.

To effect this the ball, wh: contains the flux deprived of the Arsenic, should be heated, & a portion of glass-tube being attached to its end, it is drawn gently off so as to leave the crust free from any danger of contact with the flux: then the crust is to be chased up & down the

tube by means of a spirit-lamp (the flame being diminished), & thus converted into the white oxide. This (the white oxide) will be found to possess distinct octahedral crystals, generally distinguishable by the naked eye when the tube is held up before a flame or ray of sunshine, but more distinctly by means of a common lens. A portion of the tube, containing the oxide, should now be filed off & boiled in another tube containing distilled Water until the whole of the oxide disappears, then this fluid is to be tested by means of the liquid reagents.

Arsenic in Solution. - Liquid Tests. Arsenic when dissolved in Water is clear & colourless & possesses scarcely any taste. It may be detected in this state by 4 different means.

1. By precipitating it by another Solution: the colour of the precipitate being the characteristic of its presence

2. By collecting the precipitate, thrown down by means of the last test, & subliming metallic Arsenic from it.

3. By disengaging the Arsenic in the form of a Gas (Arseniuretted Hydrogen)

& decomposing this Gas by combustion: this is "Marsh's process."

4. By obtaining Arsenic as a deposit upon the surface of Copper & then further examining this deposit by heat: this is "Reinsh's process".

I shall notice each of these processes separately, & first of the Liquid Reagents. There have been many of these recommended but three only seem to call for special notice: they are 1. Sulphuretted Hydrogen, 2 Ammonio-nitrate of Silver & 3. Ammonio-Sulphate of Copper.

1. Sulphuretted Hydrogen. This Gas may either be passed directly through the suspected fluid as it is disengaged or used in a liquid form (solution). Great care must be taken in using this test that the arsenical fluid be not alkaline, as the precipitate it would otherwise form is soluble in an excess of Alkali. If, on being tested, it is found to possess an alkaline reaction it must be acidulated with Acetic or Hydrochloric Acid. If, on the other hand, the fluid possess an excess of acidity it must be neutralised by means of a solution of Potash & again acidulated by Acetic or Hydro-

chloric Acid, for if the acidity be owing to Nitric or Sulphuric Acid the precipitate will be decomposed.

If these precautions be attended to the Sulphuretted Hydrogen will cause in the Arsenical fluid, first a bright lemon-yellow colour, & subsequently a Sulphur-yellow or lemon-yellow precipitate. Dr. Christison says that this test is so delicate when properly managed "as to act on the oxide in a hundred thousand parts of water". The precipitate thus formed is soluble in an excess of Ammonia & this seems to be sufficient to distinguish it from other substances, which, in some other respects, resemble it:- thus the salts of Cadmium & of Selenic Acid form a precipitate with Sulphuretted Hydrogen similar to the Sesquisulphuret of Arsenic, but the former are not dissolved by an excess of Ammonia & the latter are so rare as to require no comment. Peroxide of Tin & some salts of Lead (when acidulated with Hydrochloric Acid) yield a similar precipitate with Sulphuretted Hydrogen, but the former is rendered brown by Ammonia & the latter becomes black when more gas is transmitted

through it.

2. Ammonio-Nitrate of Silver. This test is prepared in the following manner:- One part of lunar caustic having been dissolved in 10 parts of Water, Ammonia (in solution) is added until the oxide of Silver is first thrown down, then almost (but not entirely) redissolved.

When this test is added to a solution of Arsenic it causes a rich lively lemon-yellow precipitate of Arsenite of Silver, which however in the course of a short time, under exposure to light, passes to a dark brown colour.

There are many impediments to the perfect action of this test. Most of the acids, (especially Nitric & Tartaric) as well as an excess of Ammonia, prevent its due operation: but the most important is Chloride of Sodium as it occurs in many of the fluids likely to form the subject of inspection, & this, as well as some other salts which form a white precipitate with Nitrate of Silver, will act in lessening the intensity of the yellow colour.

Dr. Marcet has however proposed ~~an~~ easy method in order to obviate this difficulty;

he uses the Nitrate of Silver alone, so long as any precipitate is thrown down, then adds a slight excess of the Nitrate, & lastly, drops in the Ammonia upon which the Arsenic, if present, is thrown down in the form of yellow Arsenite of Silver. Dr. Traill has proposed an easy method for showing the delicacy of this test; he places a drop of the suspected liquid on a clean glass plate, & near to this, another drop of the Ammonio-Nitrate of Silver, the two fluids are then joined (but not mixed) by means of a glass rod. He says that this test, when properly applied, is capable of detecting the 10,000 th. part of a grain of Arsenic.

3. Ammonio-Sulphate of Copper. This test is to be prepared as the last, merely substituting the Copper salt for the Silver one.

In solutions of Arsenic it forms a precipitate of a colour intermediate between grass-green & Apple-green; this is the Arsenite of Copper. The operation of this test like the last is prevented by most of the Acids & by an excess of Ammonia. It is not generally considered so good a test as the Silver one.

The three foregoing tests are all liable to fallacies, & Dr. Christison remarks that "the indications of the three tests must concur, otherwise, in a medico-legal case, no one can be entitled to speak with certainty to the existence of Arsenic. But when they do concur, the evidence is unimpeachable."

Reduction of the Precipitate. For this process the precipitate should be taken as thrown down by sulphuretted Hydrogen, for this will generally be found to be the most bulky & the colour very characteristic. The supernatant fluid having been withdrawn, by means of a Pipette, the remainder is to be thrown upon a filter & carefully washed; then, the precipitate having been gently pressed between two folds of bibulous paper, is removed with the point of a pen-knife & dried by means of a very gentle heat. The precipitate is then put into a Berzelius' reduction tube & reduced in the manner previously described.

Marsh's Test. The principle of this test is to generate Hydrogen Gas slowly, & in combination with Oxide of Arsenic, or any other soluble salt of the Metal, so as to form a compound of the two bodies, (Arseniuretted Hydrogen,) & then

the Gas being ignited is subjected to a further test. The Apparatus required for this test should consist of a "Döbereiner's Lamp" or an instrument of similar construction: it may be formed of two cylinders of Glass connected by a tube wh. should reach nearly to the bottom of the lower vessel, the latter having a stop-cock attached to its side. The suspected fluid having been put into the lower chamber along with a piece of Zinc & some Sulphuric Acid, the Gas as it forms will force the contents of the lower vessel through the tube into the upper one. To the stop-cock at the side of the lower cylinder is attached a glass-tube having a capillary bore at its free end, & the Gas as it is allowed to escape is ignited as it passes out through this narrow opening. If this Gas be arseniuretted Hydrogen it will be found to burn with a bluish-white flame & thick white smoke, & if a portion of Glass or Porcelain be held over the flame a deposit of a dark stain will be perceived, & in the middle of this stain, will be observed a deposit of pure metallic Arsenic. If a white saucer or card be moistened with Ammonio-nitrate of Silver & held above the flame, a

yellow deposit of Arsenite of Silver will be formed if any Arsenic be present. Dr. Christison has proposed an excellent modification of this test: for this he uses a tube with a hollow globe of glass at one end (the globe being at right angles with the tube); into the hollow ball the flame is directed, & a stream of cold water being poured over it, the Arsenic will be deposited on the interior of the tube; this may afterwards be removed by means of distilled water & subjected to the liquid tests. Dr. Traill has pointed out that when this apparatus has been used once or twice, as much Arsenic will be deposited in the interior of the stop-cock as to give evidence of that substance, although none may be present in the fluid suspected. This is of great importance, but may be obviated by heating the stop-cock before using it a second time.

"Reinsch's Test". The discovery of this process seems to be due to Dr. Traill, as he asserts that he made use of it for the detection of Arsenic in 1833, & I believe it was not until 1842 that Reinsch published his account of it.

In the application of this delicate process the liquid suspected to contain Arsenic is boiled

with about one-tenth of its volume of Muriatic Acid & a slip of bright copper-foil or wire introduced into the liquid. If Arsenic be present the Copper acquires a coating of a dark iron-grey colour from a deposit of that metal. The Copper is then to be removed, cut into small thin pieces & introduced into a reduction tube: this being heated a ring of metallic Arsenic, or more frequently small sparkling crystals, are deposited. After the deposit has been carefully examined it may either be dissolved out by means of boiling distilled water & subjected to the liquid tests, or preserved as a convenient proof.

This test is extremely minute: Dr. Christison says it will detect a 250,000th part of Arsenic in solution & removes every particle present in the fluid.

Drs. Fresenius & Von Babo assert that "all Nitrates & various salts of Mercury & other metals, render the separation of Arsenic by Copper difficult or even impossible"; but this I think is not the case, for I obtained very distinct traces of Arsenic on the Copper, & also by reduction, even though a large proportion of Nitrate of Potash was present.

Tests for Arsenic in organic Mixtures. As these are the most important tests many have been proposed, but I shall confine my notice to four:

these are, 1., The process of Reinsch: 2. The process of Marsh: 3. Precipitation of the Arsenic as Sesquisulphuret, & 4., The process of Fresenius & von Babo.

Process of Reinsch. In this experiment any white or grey powder that can be discovered in the organic mixture, or detached from the organ to be tested, must be carefully collected &, either subjected to the reduction process, or liquid tests, or both if there be sufficient, & frequently, if this end can be obtained, it will be unnecessary to proceed further. If however the Arsenic be in too small quantity for this purpose, the soft solids must be cut very small & distilled Water added if necessary; then Hydrochloric Acid, to the amount of a-tenth of the whole, is to be added to the mixture, more acid however will be required if the parts are anyway decomposed. The mixture must then be boild until all the solids are broken down or dissolved, & then filtered through calico & subjected to the test of boiling with Copper as formerly described.

Process of Marsh. The chief difficulties which are encountered in this test are 1., The tendency of the oxide of Arsenic to adhere to the organic matter from which it is with difficulty separated, & 2., The

tendency of the Gas disengaged to carry up the organic fluid along with it through the exit tube.

These difficulties seem to have been obviated by a method proposed by Dr. Christison & which he thus describes: "Heat the organic matter with a sixth of its weight of strong Sulphuric Acid: when complete solution has taken place concentrate the fluid to a friable almost dry charcoal: add a little concentrated Nitric Acid gradually to this, when cold, & again evaporate to dryness: then act on the residue with boiling distilled Water, & a solution of a reddish-brown colour is obtained which may be used in such an apparatus as that of Döbereiner without risk of obstruction from froth. --------- The Sulphuric Acid, aided by heat, destroys organic matter sufficiently to prevent frothing in the Apparatus & dissolves out Arsenic from a state of combination with organic principles, & Nitric Acid afterwards converts any Arsenic in the half-charred mass into the soluble Arsenic Acid." On Poisons p. 275.

Process by Hydrosulphuric Acid. This method was first recommended by Dr. Christison. The soft solids having been cut very small distilled Water is added, as in the last case, if necessary: the mixture must then be boiled for half an hour, allowed to cool &—

then filtered. A little Acetic Acid must now be added & if any precipitate form, the fluid must be again filtered & then evaporated to dryness, first by boiling, & then over the vapour-bath. The portion that remains must be dissolved in boiling distilled water & filtered.

A small portion of Acetic Acid is now added to the fluid & Sulphuretted Hydrogen transmitted through it until an excess of the Gas is indicated by its smell, this excess of gas must now be expelled by boiling & a little Carbonate of Ammonia added to aid the precipitation of the Sesquisulphuret. The supernatant fluid having been withdrawn by means of a Pipette, the precipitate must be collected, dried & subjected to the reduction process.

Berzelius's & von Babo's process. This is based, like the preceding, on the precipitation of Arsenic in the form of Sulphuret. The soft solids, being cut into small pieces, the whole is put into a porcelain basin & as much Hydrochloric Acid added as will equal the probable weight of the whole mass, then, distilled water being added until a thin pulp is formed, the whole is heated over a vapour bath & the liquid stirred, adding, about every 5 minutes, a small portion of Chlorate of Potash until the liquid become thin & homogeneous. A layer

proportion of the Chlorate must now be added & the whole filtered through linen & concentrated to about a third of its weight. This residue is mixed with an excess of strong solution of Sulphurous Acid & this excess again expelled by heat. Sulphuretted Hydrogen must now be transmitted through the fluid in a slow stream for 12 hours, & then the liquid is subjected to a low heat until the Sulphurous smell disappears. The precipitate, which will contain organic matter as well as the Sulphuret, having been collected must be washed & dried over the vapour-bath & fuming Nitrous Acid dropped upon it in order to destroy organic matter & convert the Sulphuret into Arsenic Acid. This is then dried over the vapour-bath & the residuum moistened with strong Sulphuric Acid, & again heated over the sand-bath, until a charred brittle mass is obtained

This is again heated over the sand-bath with about 20 parts of distilled water & washed until it ceases to redden Litmus. The solution is next acidulated with Hydrochloric Acid & treated again, as before, with Sulphuretted Hydrogen. The Sulphuret thus obtained may now be weighed, & one grain is equal to 0·803 of the oxide of Arsenic

On the action of Arsenic on Man.

It is now generally admitted that Arsenic produces two different classes of symptoms. One action is purely irritant &, by virtue of which, it excites Inflammation in the Stomach, Rectum &c., & the other resembles in some respects the action of a narcotic, causing disorder of parts or organs remote from the seat of its application. It has been also ascertained that this poison causes death oftener through the latter than through the former action, nay, that many cases prove fatal where no local inflammation can be detected after death. On the other hand, the local action does sometimes predominate, though in comparatively very few cases, & the morbid change in the part, to which it has been applied, are alone found adequate to account for death.

It has long been a matter of discussion whether Arsenic acts on remote organs through absorption or through sympathy: the most favourable view however seems to be that its action is dependant upon its absorption into the blood, & this has been strengthened, if not proved, by observations of Professor Orfila, who first pointed out that Arsenic may be detected in organs to which it had not originally been applied, especially in the

Liver, Spleen & Kidney. Dr. Christison has detected Arsenic in the Liver in two cases after 4. months interment. When Arsenic has been absorbed, the blood seems to undergo some change for, after death by this substance, the blood is found in an unusual fluid condition, & Mr. James has observed that when venous or arterial blood is freshly drawn & mixed with Arsenic a viscous-like jelly is formed & lumpy clots afterwards produced.

When Arsenic produces its remote action the organ which appears to be most affected is the heart, for, in cases of rapid death by this substance, the irritability of the heart has been found to be lost while that of the Intestines &c. continues as usual.

Arsenic acts as a poison with nearly the same violence to whatever organ or texture it is applied, whether internally by the mouth, or when introduced into the Vagina or Rectum, or externally by being applied to a wound or even to the healthy skin.

Internal administration. 1. By the Mouth. The symptoms of poisoning by Arsenic may be conveniently divided into three classes: 1., When death takes place between 24 hours & 3 days, 2. When the death is somewhat delayed beyond the fifth or sixth hour, & 3. When life is prolonged 6, 8 or 10 days, or the patient is altogether

restored after some illness: this is the classification adopted by Dr. Christison & which seems to be the most convenient.

1. When death occurs between 24 hours & 3 days. This is the most frequent result in cases of poisoning by Arsenic.

The first symptom is sickness or faintness occurring, in some instances, within a few minutes after the poison has been swallowed, but usually not commencing until after half an hour has elapsed.

Several cases on the other hand are mentioned by Dr. Christison in which the intervention of sleep seems to have delayed the action of the poison for a considerable time. To the faintness or sickness first produced succeeds pain in the region of the stomach, which is usually described as being of a burning character & much increased by pressure; violent vomiting & retching then ensue attended with a dryness, heat & sense of constriction of the throat, causing an incessant desire for drink: with these are generally combined hoarseness & difficulty of speech. The matter vomited is usually of a green or yellowish colour & sometimes streaked or even mixed with blood. The affection of the throat may precede the faintness or vomiting, or it may be absent altogether, or so violent as to be attended

with fits of suffocation, or convulsions at the sight of fluids. Diarrhea usually sets in after a time, or, in its place, the patient is affected with violent Tenesmus: the belly is usually tense & tender, & occasionally it is swolen. Sometimes there is bloody purging (Beck). In many instances the burning pain extends along the whole course of the Alimentary canal from the mouth to the Anus: the mouth & lips may be inflamed & present dark spots or blisters. Sometimes there are present dyspnœa & a sense of constriction across the chest; occasionally Pneumonia exists.

In many instances the urinary organs are affected & there is painful & difficult micturition & the genital organs in both sexes may be swolen & excoriated.

Sometimes the irritation of the urinary organs is so great as to be attended with total suppression of Urine.

In a contention in France, during the trial of Madame Lafrage, some stated that in poisoning by Arsenic the Urine was suppressed, another party that it was increased in quantity, & another that it was diminished, but Dr. Christison observes that there is no invariable rule in the matter & that urinary symptoms are seldom present unless the lower bowels are strongly irritated. When the symptoms of irritation of the Alimentary canal have existed

for a few hours convulsive motions often ensue, such as cramps of the legs & arms, tremors & twitches of the trunk or of the whole body. The pulse is feeble & rapid, the skin cold, the feet & hands are livid & the body covered with clammy sweats: the eyes are red & sparkling, & the whole countenance betrays great anxiety.

Delirium & stupor often accompany the advanced stage. Coma sometimes precedes death, but the latter usually comes on calmly & the patient is sensible to the last; sometimes however the fatal termination is ushered in by violent convulsions, occasionally it takes place rapidly as if from sudden deliquium.

Eruptions are frequently observed to break out over the body & they may be either petechial or miliary, & are sometimes succeeded by abatement of the symptoms & desquamation of the cuticle. Swelling of the whole body, but particularly around the eyes, has also been noticed. Such are the usual symptoms in this class of poisoning by Arsenic & many of them are present in the other varieties. These symptoms may not however be all present, many may be found wanting, whilst others may be modified. Pain & vomiting have even been found absent, & even on purpose, the former has not been recognised. Sometimes the pulse has been found very slow, not more than 30

or 40 beats in a minute. When death has been retarded to the second or third day there is frequently a remission of all the symptoms & the patient is left in a dozing stupor, this however is merely temporary, for the symptoms soon return with equal or increased violence. Many cases are on record where this train of symptoms was followed by death in a few hours, & where the indications of irritation of the Alimentary canal were well marked during life, & proved by dissection after death.

The deviations from the above ordinary signs are upon the whole rare & symptoms of this class of poisoning by Arsenic are pretty uniform.

2. When death is seldom delayed beyond the fifth or sixth hour.

In this class of cases death usually takes place before the true signs of inflammation have had time to become developed, & consequently the symptoms are by no means so striking as in the first variety, in fact the signs in such cases are very obscure & referable to the mode of action of the poison, which either exerts a powerfully depressing influence on the circulation or on the nervous system.

In some Animals operated on by Sir B. Brodie these symptoms amounted to actual Narcotism & the animal died in convulsions in

about 50 minutes after the poison had been administered. This narcotic action has also been observed in man, but it is extremely rare.

In some cases of this class vomiting occurs at the usual time after taking the poison but it seldom continues. The most constantly present symptom in this variety is extreme fainting, amounting at times to complete deliquium. Occasionally there are observed slight convulsions, oppression & some degree of stupor. Pain is generally felt at the pit of the stomach, but it is slight & seldom accompanied with other signs of inflammation.

This variety of poisoning has been observed only under the three following circumstances: 1., When the dose of the poison was large, 2. When it was in little masses, & 3., When it was in a state of solution.

The first & last of these circumstances may be accounted for by the fact that they are favourable to absorption, but it is not easy to account for the second circumstance in this way.

The poison does not invariably act in this manner when administered under the above ways, for there is one case recorded where Arsenic in solution produced all the symptoms of an irritant poison.

The cases of poisoning by Arsenic which come

under this head are rather uncommon; Dr. Christison however quotes 9 cases of this variety & they sufficiently prove that Arsenic does not always act as an irritant poison.

3 When life is protracted from 6 to 10 days, or altogether restored.

In this class the first symptoms are the same as those produced by the first or inflammatory variety, but the subsequent affections are referable to nervous disorder. The nervous symptoms usually come on when the inflammatory begin to recede, but some times they occur when the inflammatory signs are still present, & more rarely they both begin at the same time. They vary in their intensity from coma to an imperfect palsy of the arms or legs, & between these two extremes there may be Epileptic fits, Tetanus or Mania. Dr. Roget records a case where the patient, after recovering from the ordinary effects of Arsenic, was seized with Epileptic fits on the 6th day, & which returned occasionally until the 19th, & Portal mentions a case where the nervous affection assumed the form of pure Tetanus.

A common nervous affection in the latter stages is Palsy, & Paraplegia is perhaps the most usual form of it: this Palsy is generally very obstinate, & if the patient be fortunate enough to survive the af-

fects of the poisoning, the Palsy may remain incurable. Sometimes the limbs become extremely rigid so that they cannot be bent. Mania has also been known to result from this variety of poisoning.

The preceding remarks contain most or all that is known with certainty of the effects of Arsenic as a poison: there are however a few things of a more chronic nature which are deserving of mention, these are Dyspepsia, Irritability of the Stomach, attended with constant vomiting of food, Falling off of the hair & nails, & Desquamation of the Cuticle.

This appears to be a convenient place for enquiring How small a quantity of Arsenic will cause death. Hahnemann & other authors on this subject have stated that 2 grains of the white oxide is sufficient to prove fatal in a few days, but none of them have referred to actual cases. The smallest dose which Dr. Christison has found recorded, as proving fatal, is 4½ grains: death ensued in 6 hours, but the subject was a child of 4 years old & the poison was given in solution. Alberti mentions the case of a man who died from taking 6 grains. Renault found that a single grain in solution killed a large dog in 4 hours, & consequently it appears that Hahnemann's statement is not very wide of the actual truth.

By the introduction of Arsenic into the Rectum or Vagina.

This proves fatal by exciting inflammation, but it of course affects the Intestines when introduced by the Rectum more than the Stomach. Fodéré has mentioned a fatal case which occured by this means; a servant succeeded in destroying her mistress by mixing Arsenic with an injection which was afterwards administered to the victim. It is not likely in these cases that Arsenic will be found in the intestines from the facility with which the Rectum & Colon can be evacuated.

Arsenic may also prove fatal when introduced into the Vagina, & two fatal cases from this horrible crime are on record.

Arsenic may prove fatal when externally applied, 1. To a wound, Ulcer or to the true Skin. Fatal cases have occured in all of these ways. Roux excised the Scirrhous breast of a girl & afterwards applied an arsenical paste to the wound; the girl died two days afterwards in violent convulsions. There are other fatal cases recorded which were caused in a similar manner. Arsenic may even cause death by being applied to the true skin. Desgranges relates the case of a girl who rubbed her head with an arsenical paste for the destruction of vermin. She

had not the least scratch upon the part but in 6 or 7 days it began to swell to an enormous size, & soon after all the symptoms of poisoning by Arsenic supervened. She gradually recovered but during her convalescence her hair fell off.

2. By inhaling the vapours of Arsenic. There is no doubt that the inhalation of the fumes of Arsenic may prove fatal as well as the inhalation of Arseniuretted Hydrogen. The slighter effects of poisoning by Arsenic have been experienced in this country from the burning of Candles containing Arsenic, which is generally in the quantity of 3 to 4½ grains in each, & there can be no doubt that such Candles are highly injurious (when used) as well as dangerous, for birds were killed, & small quadrupeds severely affected, when confined in an atmosphere where they were burned.

Many cases are also on record of death from the incautious inhalation of Arseniuretted Hydrogen.

It is an important question whether poisoning by Arsenic may be determined by the symptoms alone. Many jurists assert that it can not, but Drs. Christison Beck & others seem to think that in a number of cases the poisoning may be made out from the symptoms, & these are precisely the cases where we are at a loss for chemical proof,

the patient having entirely recovered or lingered on with a train of almost unmistakeable symptoms for a considerable time before death, & there would appear to be no difficulty if the signs of irritation, & the secondary nervous affections, with all the symptoms which accrue from these two, be carefully noted.

Morbid appearances caused by Arsenic. In some cases of poisoning by Arsenic there is little if any morbid appearance caused, death having taken place before there has been any time for local inflammation to become established, & where the symptoms have generally indicated an influence on the heart or nervous system: cases are even on record where no morbid appearance whatever could be observed. On the other hand there have occured cases where the action of the poison was extremely rapid & yet attended with most of the appearances of protracted poisoning

1. Morbid appearances of the Alimentary canal. These consist for the most part of redness of the peritoneal & villous coats of the Stomach, blackness, sloughing & ulceration of the villous coat, effusion of blood or lymph on the external part or among the contents of the Stomach, redness of the throat & gullet, & redness & even ulceration of the Duodenum & other parts of the alimentary canal, & especially of the

Lecture.

Redness of the inner coat of the Stomach is a pretty constant occurrence, whereas redness of the throat & gullet appear to be comparatively rare. There is nothing however to distinguish this redness from the ordinary local inflammation of these parts.

Redness of the peritoneal coat is not often found but turgesence of the external veins is often present & is liable to be mistaken for inflammation of that membrane. One of the most remarkable appearances, when present, & which has been pointed out by Dr. Christison, is the presence of yellow patches on the inner coat of the Stomach: they are of a bright yellow colour & appear as if painted with Gamboge, they evidently arise from the oxide having been converted into the bright yellow Sulphuret by the Hydrosulphuric Acid set free during putrefaction, & they are consequently only present when the body has been buried or kept for a long time. Destruction of the coats of the Stomach though often mentioned by authors is not according to Dr. Christison a very common occurrence, but other appearances are liable to be mistaken for it. It does not usually occur unless the patient survive two days, although Dr. Taylor has met with a case where it occurred, & which case

was fatal in 17 hours. Complete perforation of the stomach does sometimes occur though very rarely, Dr. Christison has only met with two cases recorded, & one which happened to himself. Sloughing & Gangrene of the stomach are not now generally believed to take place, having been confounded by the older writers with the black extravasated patches which are so common. The secretion on the inner surface of the stomach is usually increased in quantity: it may consist of mucous (which has been mistaken for the mucous membrane itself), or of sanguinolent fluid, or of actual blood. Redness of the mucous surface of the Intestines is often present when the stomach is much inflamed, but it is very seldom that dissolution of that part exists. Ulceration occasionally takes place in lingering cases. The signs of inflammation of the Intestines are often confined to the Duodenum, but the Rectum is often much inflamed though the Colon & small intestines are healthy. Sometimes the Rectum is abraded & ulcerated & even redder than the Stomach.

Morbid appearances of the Respiratory System. These are neither remarkable nor constant & consist for the most part of redness of the Pleura, redness & congestion of the Lungs, redness of the inner surface

of the heart, & of the lining membrane of the Trachea. Redness of the diaphragmatic part or even of the whole of the Pleura has sometimes been observed as well as inflammation of the Lungs. The inner membrane of the Windpipe has sometimes been found inflamed.

Morbid Appearances of other parts. The organs of generation are sometimes affected. The Penis in the male & the Labia in the female have been found quite black & swoln, & the irritation has been said to extend sometimes to the Uterus & Fallopian tubes. The Conjunctiva of the eye frequently presents redness & spots of extravasation.

With regard to the state of the blood Sir B. Brodie asserts that as a general rule it is fluid, & this has been confirmed by other observers, though Dr. Campbell says that this is not constant.

Treatment of poisoning by Arsenic. - Antidotes.

Since it has been clearly proved that Arsenic acts in all its combinations as a poison, & nearly in direct ratio to their solubility, it follows, as Dr. Christison remarks, "that every supposed chemical Antidote must be useless which does not render the Arsenic insoluble, not only in Water, but likewise in the contents & secretions of the Stomach."

Hence Vinegar, Sugar Lime Water &c. are justly regarded as being of no service whatever. Liver of Sulphur long held the reputation of being an Antidote for Arsenic, but Renault & Orfila have proved by experiment that the combination of Arsenic & this substance are scarcely less poisonous than the oxide of Arsenic itself, & moreover Liver of Sulphur alone has been found to be a dangerous irritant poison when given in large doses.

Fine powders as Magnesia & Charcoal have appeared to be of service in enveloping the Arsenical powder. M. Bertrand swallowed 5 grains of Arsenic along with a quantity of Charcoal in one dose & sustained little or no inconvenience from it, but these remedies have been ascertained to be of no service unless mixed with the Arsenic before it is swallowed.

For some time past Toxicologists have sought for a substance which will render the Arsenic insoluble in the contents of the Stomach & they have at length succeeded in discovering that the Hydrated Sesquioxide of Iron (Ferrys) answers this purpose, & it is therefore now deemed a true Antidote. Dr. Douglas Maclagan has shown that this substance however must be given in large

quantity to be of any service, & in order to remove one part of Arsenic from a state of solution, 12 of the Ferrugo must be added if the latter be in a moist state, & 60 parts if it have been previously dried. The action of this Antidote is Chemical not mechanical as was once supposed.

The many cases of successful employment of the Ferrugo which have occured within these last 12 years leave no doubt of its utility as an Antidote, & it ought therefore always to be kept ready at hand & in a moist state.

In poisoning by Arsenic Antidotes are generally administered under unfavourable circumstances, for the poison is generally taken some time before medical aid can be procured & is therefore diffused over the Stomach, adhering to the villous coat, & excites the secretion of mucous which protects it from the action of the Antidote. In these cases vomiting must be freely excited in order to free the Stomach of any existing mucous, & large doses of dilutents, as pointed out by Mr. Kerr, seem to be contraindicated as they appear to prevent the Stomach from contracting upon itself & so freeing itself of the poison.

If vomiting have been delayed for some time

advantage should be taken of the interval & a large dose of Sulphate of Zinc administered. The Stomach-Pump does not appear to possess any advantage over Emetics, & even the latter may not be demanded if free vomiting be caused by the Arsenic itself.

After the poison has been removed from the Stomach two objects remain to be accomplished: 1. To allay the irritation of the Alimentary Canal, & 2., To counteract the depression which is usually caused by the poison. Were it not for the latter of these two effects the duty of the medical practitioner would be obvious & doubtless often effectual, but it is evident that from the remote depressing consequences, caused by large doses of Arsenic, the remedies which are chiefly trusted to in internal Inflammations cannot be enforced with that vigour which the symptoms would otherwise demand. Nevertheless it is certain that some few cases have been treated with the most favourable results by the strict antiphlogistic system. Bloodletting may be favourably resorted to in cases where the Inflammation runs high, yet it ought not to be had recourse to until the Arsenic has been all expelled from the Stomach, otherwise it will tend to promote the absorption of the poison. Orfila has however advocated its

use on the ground that it tends to eliminate the Arsenic which is circulating in the blood. Some Physicians have reprehended the use of bleeding & contend that the best method of treatment is the pure stimulant, whilst Orfila asserts that this latter is perfectly useless if not injurious. Dr. Christison remarks that "No one who has ever seen a case of poisoning by Arsenic can doubt that it is often necessary to counteract the overwhelming languor of the circulation by the moderate use of stimulants."

Opium, given in repeated doses after the bleeding, will prove of eminent service especially in subduing the harassing fits of vomiting which often continue for a long time: for this last purpose it should be given in the form of Enema. Tenesmus when present is best relieved by Castor Oil & Diarrhœa by emollient Clysters containing Opium. Prof. Orfila lays great stress upon the employment of diuretics after the Stomach has been cleared out in order to remove by the kidneys any Arsenic that may have been absorbed.

During convalescence the treatment to be carried out is certainly Antiphlogistic, although not too rigourously enforced, but strictly avoiding stimulant diet of every kind especially Wine & Spirituous Liquors.

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