XXVIII. *Some further Observations on a new detonating Substance. In a Letter from Sir* Humphry Davy, *LL.D. F.R.S. V.P.R.I. to the Right Hon. Sir* Joseph Banks, *Bart. K.B. P.R.S.*

Read July 1, 1813.

My dear Sir,

Berkeley-square, June 20, 1813.

I have already described, in a letter which you were so good as to communicate to the Royal Society, a few facts respecting a new detonating compound. I shall now do myself the honour of mentioning to you some other particulars on the subject.

I received, in April, a duplicate of the letter in which the discovery was announced, containing an Appendix, in which the method of preparing it was described. M. Ampere, my correspondent, states that the author obtained it by passing a mixture of azote and chlorine through aqueous solutions of sulphate, or muriate of ammonia. It is obvious, from this statement, that the substance discovered in France, is the same as that which occasioned my accident. The azote cannot be necessary; for the result is obtained by the exposure of pure chlorine to any common ammoniacal salt.

Since I recovered the use of my eyes, I have made many experiments on this compound; it is probable that most of them have been made before in France; but as no accounts of the investigations of M. Dulong on the substance have

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appeared in any of the foreign journals which have reached this country, and as some difference of opinion and doubts exist respecting its composition, I conceive a few details on its properties and nature will not be entirely devoid of interest.

I have been able to determine its specific gravity, I hope, with tolerable precision, by comparing its weight at 61° FAHRENHEIT, with that of an equal volume of water. 8,6 grains of the compound, carefully freed from the saline solution in which it was produced, filled a space equal to that filled by 5,2 grains of water, consequently its specific gravity is 1,653.

When the compound is cooled artificially, either in water or in solution of nitrate of ammonia, the fluid surrounding it congeals at a temperature a little below 40° FAHRENHEIT, which seems to be owing to its becoming a solution of chlorine; for, as I have stated in a paper published in the Philosophical Transactions, the saturated solution of chlorine in water freezes very readily. The congelation of the fluid, in contact with the new compound, led me, when I first operated on it in very small quantities, to suppose it readily rendered solid by cooling; but I find in experimenting upon it, out of the contact of water, that it is not frozen by exposure to a mixture of ice and muriate of lime.

The compound gradually disappears in water, producing azote, and the water becomes acid, and has the taste and smell of a weak solution of nitro-muriatic acid.

The compound, when introduced into concentrated solution of muriatic acid, quickly resolves itself into gas, producing much more than its own weight of elastic fluid, which proves to be pure chlorine, and the solution evaporated affords muriate of ammonia.

In concentrated nitric acid it afforded azote.

In diluted sulphuric acid it yielded a mixture of azote and oxygen.

It detonated in strong solutions of ammonia. In weak solutions it produced azote.

It united to or dissolved in sulphurane, phosphorane, and alcohol of sulphur, without any violence of action, and dissolved in moderately strong solution of fluoric acid, giving it the power of acting upon silver.

When it was exposed to pure mercury, out of the contact of water, a white powder and azote were the results.

The first attempt that I made to determine the composition of the detonating substance, after my accident, was by raising it in vapour in exhausted vessels, and then decomposing it by heat; but in experiments of this kind, even though the whole of the substance was expanded into elastic matter, yet the vessel was often broken by the explosion, and in several instances violent detonations occurred during the process of exhaustion, probably from the contact of the vapour of the substance with the oil used in the pump.

In the only instance in which I was able to examine the products of the explosion of the substance in an exhausted vessel, no muriatic acid or water was formed, and chlorine and azote were produced; but it was impossible to form any correct opinion concerning the proportions of the gaseous matter evolved, as an unknown quantity of common air must have remained mixed with the vapour in the vessel.

The action of mercury on the compound appeared to offer a more correct and less dangerous mode of attempting its analysis; but on introducing two grains under a glass tube

filled with mercury and inverted, a violent detonation occurred, by which I was slightly wounded in the head and hands, and should have been severely wounded, had not my eyes and face been defended by a plate of glass attached to a proper cap, a precaution very necessary in all investigations of this body.

In using smaller quantities and recently distilled mercury, I obtained the results of the experiments, without any violence of action; and though it is probable that some accidental circumstance might have occasioned the explosion of the two grains, yet I thought it prudent, in my subsequent experiments, to employ quantities which, in case of detonation, would be insufficient to do any serious mischief.

In the most accurate experiment that I made, $\frac{7}{10}$ths of a grain of the compound produced, by its action upon mercury, 49 grain measures of azote. I collected the white powder which had been formed in this and other operations of the same kind, and exposed it to heat. It sublimed unaltered, without giving off any elastic or fluid matter, which there is the greatest reason to believe would not have happened, if the compound had contained hydrogen, or oxygen, or both. The sublimed substance had the properties of a mixture of corrosive sublimate and calomel.

If the results of this experiment be calculated upon, it must be concluded that the compound consists of 57 of azote to 643 of chlorine in weight, or 19 to 81 in volume; but this quantity of azote is probably less than the true proportion, as there must have been some loss from evaporation, during the time the compound was transferred, and it is possible that a minute quantity of it may have adhered to mercury not immediately within the tube.

The decomposition in this process is very simple, and must be supposed to depend merely upon the attraction of the mercury for chlorine, in consequence of which the azote is set free; and if the result does not strictly demonstrate the proportions of chlorine and azote in the compound, yet it seems at least to shew, that these are its only constituents.

As muriate of ammonia and chlorine are the only products resulting from its action upon solution of muriatic acid, it seems reasonable to infer, that this action depends on a decomposition of part of the muriatic acid, by the attraction of the new compound for hydrogen to form ammonia, which, at the moment of its production, combines with another portion of the acid, the chlorine of both compounds being set free.

On this view, the quantity of chlorine formed from a certain quantity of the compound being known, it becomes easy to determine the composition of the compound; for, ammonia being formed of three volumes of hydrogen and one of azote, and muriatic acid of one volume of hydrogen and one of chlorine, it is evident, that for every three volumes of chlorine evolved by the decomposition of muriatic acid, one volume of azote must be detached from the compound; and the weight of chlorine in the compound must be less than the weight of the whole quantity of chlorine produced by a portion, which is to the azote in the compound as 295 to 2295, if the relative specific gravities of the two gases be considered as 2,627 and 1.

Two grains of the compound, when exposed at the temperature of 62° FAHRENHEIT, and under a pressure of the atmosphere equal to that of 30,1 inches of mercury to strong solution of muriatic acid in a proper apparatus, afforded 3,91 cubic inches of chlorine.

In another experiment, one grain of the compound afforded 1,625 cubic inches of chlorine.

In a third experiment, one grain produced only 1,52 cubic inches.

In the two last experiments the compound was acted upon much more slowly, and the gas generated exposed to a much larger surface of solution of muriatic acid, and the appearance of a smaller relative proportion of chlorine must be ascribed to the absorption of a larger proportion of that gas by the liquid acid; and I found by exposing concentrated solution of muriatic acid to chlorine, that it soon absorbed nearly its volume of that gas.

I attempted to remove the source of error in the experiment, by using liquid muriatic acid holding chlorine in solution; but in this case the quickness of the action of the compound on the acid was greatly diminished, and it not being easy to obtain the point of absolute saturation of the acid with chlorine, some of the gas was absorbed in the nascent state during its slow production; and in most of my experiments made in this manner, I obtained less chlorine from a given weight of the compound, than in operating on pure solution of muriatic acid.

Liquid muriatic acid, whether concentrated or diluted in its pure state, does not affect the colour of the sulphuric solution of indigo; but it is immediately destroyed by solutions containing chlorine dissolved in them. The quantity of solution of indigo, which is deprived of colour by a given quantity of solution of chlorine, is directly as the proportion of chlorine it contains; and I found that the same quantity of chlorine, whether dissolved in a large or a small quantity of solution of

muriatic acid, destroyed the colour of the same quantity of the blue liquor.

On this circumstance it was easy to found a method of determining the precise quantity of chlorine produced in solution of muriatic acid, from a given quantity of the compound; namely, by comparing the power of a given quantity of muriatic acid, containing a known quantity of chlorine, to destroy the colour of solutions of indigo, with that of the muriatic acid, in which the compound had produced chlorine.

Two experiments were made. In the first, a grain of the compound was exposed on a large surface beneath a tube inverted in about six cubic inches of solution of muriatic acid, and the chlorine absorbed by agitation as it was formed. The acid so treated destroyed the colour of seven cubic inches of a diluted sulphuric solution of indigo; and it was found, by several comparative trials, that exactly the same effect was produced in another equal portion of the same solution of indigo, by 2,2 cubic inches of chlorine dissolved in the same quantity of muriatic acid.

In the second experiment, 1,3 cubic inches of chlorine were evolved in the gaseous form, the thermometer being at 58°, and barometer at 30,33, and suffered to pass into the atmosphere; and by the test of the solution of indigo, it was found that ,75 of a cubic inch remained dissolved in the acid.

Now, if the mean of these two experiments be taken, it appears that 1,61 grains of chlorine are produced in solution of muriatic acid by the action of a grain of the compound; and calculating on the data just now referred to, the compound must consist of 91 of chlorine and 9 of azote in weight, which

in volume will be nearly 119 to 30; and this estimation differs as little as might be expected from that gained by the action of mercury upon the compound.

It may fairly be concluded, that M. GAY LUSSAC's principle of the combination of gaseous bodies, in definite volumes, strictly applies to this compound, and that it really consists of four volumes of chlorine to one of azote; and the volumes likewise exactly coincide with the laws of definite proportions; and the detonating compound may be regarded as composed of one proportion of azote 26, and four proportions of chlorine 261.

I attempted a comparative experiment on the proportions in the compound, by estimating the quantity of azote produced in the decomposition of ammonia by it; but I found that this process was of no value for the purpose of analysis, for water appeared to be decomposed at the same time with the ammonia, and nitric acid formed; and, in consequence, the quantity of azote evolved was much less than it would have been, supposing the ammonia decomposed by the mere attraction of chlorine for hydrogen.

The results of the analysis of the new compound are interesting for several reasons.

They shew, what seemed probable from other facts, that there is no strict law of analogy, which regulates the combinations of the same substance with different substances. As three of hydrogen combine with one of azote, and one of hydrogen with one of chlorine, I thought it probable that the new compound would contain three of chlorine to one of azote, which is not the case.

This compound is the first instance known of one proportion

of a substance uniting to four proportions of another substance, without some intermediate compound of 1 and 1, 1 and 2, and 1 and 3; and the fact should render us cautious in adopting hypothetical views of the composition of bodies from the relations of the quantities in which they combine. Those who argue that there must be one proportion of oxygen in azote, because there ought to be six proportions in nitric acid, instead of five, which are produced from it by analysis, might with full as much propriety contend, that there must be azote in chlorine in some simple multiple of that existing in the compound.

It may be useful to shew, that many hypotheses may be framed upon the same principles; and which, consequently, must be equally uncertain. Views of this nature may be important in directing the practical chemist in his researches; but the philosopher should carefully avoid the developement of them with confidence, and the confounding them with practical results.

The compound of chlorine and azote agrees with the compounds of the same substance with sulphur, phosphorus, and the metals, in being a non-conductor of electricity; and these compounds are likewise decomposable by heat, though they require that of Voltaic electricity.

Sulphur combines only in one proportion with chlorine; and hence the action of *Sulphurane*, or Dr. THOMSON's muriatic liquor upon water, like that of the new compound, is not a simple phenomenon of double decomposition.

It seems proper to designate this new body by some name: *Azotane* is the term that would be applied to it, according to my ideas of its analogy to the other bodies which contain chlorine; but I am not desirous, in the present imperfect and

fluctuating state of chemical nomenclature, to press the adoption of any new word, particularly as applied to a substance not discovered by myself.

I am, my dear Sir,

very sincerely yours,

HUMPHRY DAVY.