

They next proceeded to distill a portion of the acid liquor produced by the slow oxydation of phosphorus; a very gentle heat was applied, and about one third of the liquor distilled over; the vapors were received in a solution of strontian; at the close of the operation, this had lost its alkaline reaction; a little more strontian was added, and the whole evaporated to dryness; by re-solution and crystallization, a quantity of salt in fine crystals was obtained, weighing about one and a half grains. This salt gave the same reactions as that above, which must be regarded as decisive evidence of nitric acid; the test with gold, and above all the red fumes evolved by the mixture with bisulphate of potassa, place its nature beyond all doubt.

From these experiments they concluded, that the reactions attributed to ozone, are in reality due to the presence of a small portion of nitrous acid; and they found that air mixed with a very small portion of nitrous gas, acquired an odor similar to that of ozone, blanching turmeric, dahlia and indigo papers, and presenting generally the same phenomena as ozonized air. They supposed that the acid first formed is the nitrous, as pure nitric acid when very much diluted, does not render blue a mixture of starch and iodide of potassium, which reaction is readily produced by the nitrous acid; and that the nitrites formed are converted into nitrates by the absorption of oxygen during the subsequent evaporation.

These experiments seemed to show, that a close relation certainly exists between nitric acid and ozone, and many chemists were disposed to regard them as identical; but the late researches of M. Schonbein\* have cleared up to some extent the difficulties which seemed to envelop the subject.

M. Schonbein has suggested, that when water acts on hypo-nitric acid, there is formed besides hydrated nitric acid, a compound having the formula  $\text{NO}_2 + \text{HO}_2$ , and which he calls the peroxide of azote and hydrogen. It is to the presence of this in the solution of hypo-nitric acid, that we are to attribute its remarkable powers of oxydation. The same reaction takes place when the hypo-nitric acid is introduced into a flask of moist air.

If having ozonized the air of a jar by phosphorus, we suspend in it a piece of carbonate of ammonia, till the air acquires the property of immediately bleaching litmus paper, we shall find that it still retains all the properties of ozone—the peculiar odor, the power of decomposing iodide and ferro-cyanide of potassium. This body can then exist in an atmosphere of carbonate of ammonia, and also, as is found by experiment, in one of pure ammonia.

If we take a portion of hypo-nitric or fuming nitric, and dilute it with water till it loses its color, and having poured a small portion of it into a flask, suspend in the air of the flask a piece of carbonate of ammonia, till the air acquires an alkaline reaction, we shall find that it is capable of decomposing iodide of potassium, and blanching indigo paper, and even of converting a crystal of ferro-cyanide of potassium into the ferro-cyanide in the course of twenty-four hours; in fact it possesses all the properties of ordinary ozonized air. The circumstances under which these reactions are exhibited, do not admit of the view that the oxydizing agent is any acid of nitrogen, and hence M. Schonbein concludes that there exists the compound  $\text{NO}_2 + \text{HO}_2$ .

An interesting fact bearing on this, is the manner in which the mixture of hypo-nitric acid decomposes ferro cyanide of potassium. If we mix in a tube closed at one end, a solution of the ferro-cyanide with an acid solution prepared as above described, and then invert the tube in water, a violent disengagement of gas takes place, which is found to be pure nitric oxide, and the solution contains nitrate of potassa and the ferricyanide.

This decomposition cannot be attributed to the nitric acid contained in the mixture, for we find that pure nitric acid if slightly diluted, does not decompose the salt, as neither the hypo-nitric nor nitrous acids can exist in the presence of water.

It is well known that ozone decomposes the iodide of potassium, liberating iodine. If to a solution of the iodide, we add the acid liquor above mentioned, an abundant escape of nitric oxide takes place, while iodine is precipitated and nitrate of potassa forms. Pure nitric when diluted with the same portion of water as in the acid mixture, does not decompose pure iodide of potassium.

The results of Fellenberg are certainly possessed of great interest. The production of nitric acid from the elements of the atmosphere by electricity, was long since noticed by Cavendish,

and is a well established fact; but that this acid is formed by the action of phosphorus on air, is a new and highly interesting result. That this highly oxydized body should be generated in the presence of phosphorus, seems at first paradoxical, and we can only refer it to that mysterious force, which Berzelius has named *catalysis*, and which is in fact only a manifestation of the law announced by La Place, that "a molecule set in motion by any power, can impart its own motion to another molecule with which it may be in contact." In other words, the phosphorus, while in the act of oxydation, communicates its own peculiar state to the nitrogen, which is thus enabled to combine with the oxygen and generate nitrous acid. This certainly affords us a very striking illustration of that law, and we think that this phenomenon is incapable of explanation on any other principle. M. Marignac has suggested that electricity generated by the oxydation of the phosphorus may be the cause. This however seems improbable, as it has not been shown that it is excited during the process, and the theory rests on the idea that all chemical action is attended by a development of electricity. But when we consider that our most powerful electrical discharges can generate comparatively very minute quantities of ozone, the amount of electricity that can be supposed, under any circumstances, to be generated by the oxydation of a small piece of phosphorus, seems utterly inadequate to the result.

The experiments of Fellenberg, it will be seen, do not really militate against the existence of ozone; they have only shown that in the ordinary processes by which ozone is generated, nitric acid is also produced, and the similarity between the reactions of air mixed with a little nitric oxide, (by which hypo-nitric acid is generated,) and ozonized air, is readily explained by the researches of Schonbein.

In explanation of the production of nitric acid and ozone by the slow oxydation of phosphorus, we may suppose that nitrous or hypo-nitric acid is generated in the manner before suggested, which, by the action of aqueous vapor in the atmosphere, is converted into nitric acid, and the hypothetical peroxide of azote and hydrogen.

Although ozone produced by chemical means is probably always associated with nitric oxide, yet we cannot avoid the conclusion, apparently overlooked by Schonbein, that the ozone generated under certain circumstances, by the agency of electricity, (as in the experiments of Marignac above mentioned,) must be independent of, and free from nitric oxide. This has the odor and all the other properties of ozone produced by chemical means, and it is difficult to suppose that there can be two compounds, one of which is  $\text{HO}_2$  and the other  $\text{NO}_2 + \text{HO}_2$ , identical in all their properties, and we are hence led to conclude, that, although such a compound may exist in the mixture of hypo-nitric acid and water, it does not exist in the ozonized air, whether this impregnation is effected by the action of phosphorus, or by agitation with the acid solution in question.

MM. Marignac and de la Rive\* have recently obtained some results that seem to prove that water is not essential to the production of ozone. They find that if a series of electrical sparks are passed through oxygen, however carefully dried, ozone is formed, and they suggest that ozone may be nothing more than oxygen, to which "a peculiar state of chemical activity," is given by the influence of the electric current, M. Schonbein, however, regards the formation of ozone as a certain indication of the presence of water in the gas, but in quantities so minute as to escape the action of the ordinary hygrometric substances. The gentlemen above quoted however, find that the oxygen evolved from very pure chlorate of potassa previously fused, gave ozone, when exposed to the action of the electric spark, as abundantly and rapidly as moist oxygen.

M. Schonbein's hypothesis, consequently, rests on the assumption that the gas obtained as above and apparently perfectly dry, still contains water. The suggestion that it is modified oxygen, is one of great interest, and derives some weight from the recently observed facts regarding the allotropism of elementary bodies; and particularly the late researches of Draper on the allotropic condition of chlorine. If oxygen, by the influence of the electric fluid assumes a state of exalted energy and chemical affinity, we are furnished with a key to the *modus operandi* of electricity, in causing many chemical combinations. But in a science which is based on experimental knowledge, we must carefully avoid deducing our conclusion from isolated experiments or theoretical

\*Archives de l'Electricité, No. 20, Tome v. 1845.

\*Archives de l'Electricité, No. 18, Tome v. 1845.