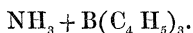


Lastly, in these experiments the significant fact appeared, that while the weight, strength, and general condition of the animals varied very widely under the different diets to which they were subjected, no considerable fluctuation was observed in their temperature. Even the slight variation from time to time recorded seemed rather to result from other causes than to depend directly on the food.

IV. "On a New Series of Compounds containing Boron." By  
Dr. EDWARD FRANKLAND, F.R.S. Received May 15, 1862.  
(Abstract.)

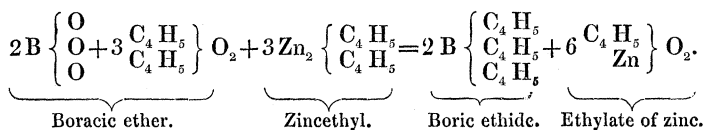
This paper contains the full details of the author's researches on boric ethide—a body partially described by Mr. B. F. Duppa and the author in the 'Proceedings of the Royal Society,' vol. x. p. 568, and also their extension to the homologous compound containing methyl.

Boric ethide combines with ammonia with great energy; if a few drops of boric ethide be passed up into a dry eudiometer filled with mercury, and dry ammoniacal gas be then admitted into the same tube, each bubble of gas collapses with a shock like that produced by a bubble of steam projected into cold water. The analysis of the body thus formed leads to the formula



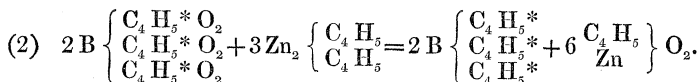
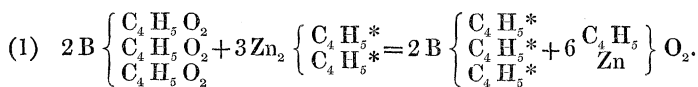
*Ammonia boric ethide* is a somewhat oily liquid possessing an aromatic odour and an alkaline reaction. It cannot be distilled, except *in vacuo*, without decomposition. Carbonic acid has no action upon it, even in the presence of water, but other acids decompose it instantly and liberate boric ethide. Exposed to atmospheric air, ammonia boric ethide scarcely absorbs a perceptible amount of oxygen, even after the lapse of several hours.

The author considers boric ethide to be formed from boracic ether and zincethyl by the substitution of the ethyl in zincethyl for the oxygen in boracic acid,



Another, but far less probable, view of the reaction presents itself in the supposition that the three atoms of ethyl in boric ethide were already present in the boracic ether, the action of the zincethyl being simply to remove the whole of the oxygen from the boracic ether. Kekulé has, in fact, unreservedly adopted this latter view of the reaction.

So long as the organic radical of the zinc compound and that of the boracic ether are identical, it is impossible to prove whether the three individual atoms of ethyl in boric ethide were originally present in the boracic ether, or have been derived from the zincethyl. Indicating by an asterisk the atoms of ethyl which finally become part of the boric ethide, it is impossible to prove conclusively whether the reaction takes place according to the first or second of the following equations:—

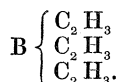


Although we cannot thus label, as it were, the atoms taking part in the reaction, we can unerringly trace the movements of the alcohol radicals, if we secure their identification by varying their composition in the two compounds used in the reaction. The study of the action of zincmethyl upon boracic ether would obviously thus decide between these views. If boric ethide were produced from these materials, Kekulé's hypothesis would be established; but if, on the other hand, boric methide were the result of the reaction, then the correctness of the view originally taken by Mr. Duppa and the author would be proved to be correct. The following results were obtained in pursuing this inquiry:—

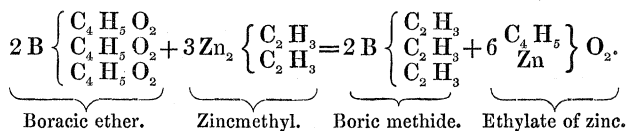
#### *Boric Methide.*

When a strong ethereal solution of zincmethyl is added to boracic ether, an elevation of temperature to the extent of 8° or 10° Cent. is observed, whilst at the same time a most intensely pungent odour is developed; this odour, although it resembles that of boric ethide, is far more powerful and more persistently irritating to the mucous

membrane. A slow evolution of spontaneously inflammable gas, burning with a splendid green flame, was also noticed ; and this evolution of gas became more rapid when the warmth of the hand was applied to the flask containing the ingredients. Purified and submitted to analysis, the gas exhibited a composition agreeing with the formula



Boric methide is produced from boracic ether and zinmethyll by the following reaction :—



The formation of boric methide under these circumstances proves conclusively that the corresponding ethyl compound is formed, not by the removal of the whole of the oxygen from boracic ether, but by the actual substitution of the three atoms of oxygen in boracic acid by three atoms of ethyl ; whilst boric methide is in like manner produced by the similar substitution of methyl for oxygen, which is quite in harmony with the mode of formation of very numerous compounds in the organo-metallic family.

Boric methide exists at ordinary temperatures as a colourless and transparent gas possessing a peculiar and intolerably pungent odour, irritating the mucous membrane and provoking a copious flow of tears. Its specific gravity is 1.93137. It retains its gaseous condition when exposed to a cold of  $-16^{\circ}$  Cent. ; but at  $10^{\circ}$  Cent., and under a pressure of three atmospheres, it condenses to a colourless, transparent, and very mobile liquid. It is very sparingly soluble in water, but very soluble in alcohol and in ether. In contact with atmospheric air, it takes fire spontaneously, burning with a bright green flame, which is very fuliginous if the volume of the flame be considerable. If the gas issue into the air through a tube  $\frac{1}{10}$ th of an inch in diameter, the amount of smoke is surprisingly great ; 2 or 3 cubic inches of gas, when consumed in this way, filling the atmosphere of a large room with large comet-like flocks of carbonaceous matter. This curious phenomenon is probably due, in part at least, to the forma-

tion of a superficial coating of boracic acid, which envelopes the particles of carbon and prevents their combustion. Suddenly mixed with atmospheric air or oxygen, boric methide explodes with great violence. In contact with atmospheric air, both boric methide and the vapour of boric ethide exhibit two distinct kinds of spontaneous combustion. Thus when these bodies issue very slowly from a glass tube into the air, they burn with a lambent blue flame invisible in daylight, and the temperature of which is so low that a finger may be held in it for some time without much inconvenience. Under these circumstances partial oxidation only takes place, and it is to the products thus formed that the peculiar pungent odour of boric ethide and boric methide is due. When, on the other hand, these bodies issue into the air more rapidly, the lambent blue and nearly cold flame changes to the green and hot flame above mentioned. I have not examined the spectra of the two differently-coloured flames from the same compound; but they doubtless present a widely different appearance, thus affording another instance of the dependence of the spectra of bodies upon temperature,—a phenomenon to which I recently called attention in the case of lithium\*.

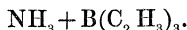
Boric methide is not acted upon by binoxide of nitrogen or by iodine. Solution of bichromate of potash scarcely affects it, but the addition of concentrated sulphuric acid at once determines the reduction of the chromic acid. When boric methide is allowed to bubble through water into chlorine, each bubble burns explosively with a bright flash of light and the separation of carbon: it has no tendency to unite with acids. Concentrated sulphuric acid has no action upon it; when mixed with hydriodic acid gas, it suffers no change; but, on the other hand, it is freely absorbed by solutions of the fixed alkalies and by ammonia. If a very rapid current of the gas mixed with half its volume of marsh-gas be passed through a stratum of strong solution of ammonia only half an inch deep, not a trace of boric methide escapes absorption.

#### *Ammonia Boric Methide.*

When dry ammoniacal gas is mixed with an equal volume of dry boric methide, both gases instantly disappear, with the evolution of a considerable amount of heat and the production of a white, volatile,

\* Phil. Mag. Dec. 1861, p. 472.

crystalline compound. The latter is also formed when boric methide is passed into solution of ammonia. The colourless liquid stratum which forms upon the surface soon solidifies when it is placed over sulphuric acid *in vacuo*. A quantity of the compound obtained by this latter process was purified by solution in ether and subsequent recrystallization : on being submitted to analysis, it yielded numbers corresponding to the formula



Ammonia boric methide is deposited from its ethereal solution in magnificent arborescent crystals, which rapidly volatilize without residue when exposed to the air. They possess a caustic and bitter taste and a very peculiar odour, in which both the smell of ammonia and that of boric methide can be recognized. Ammonia boric methide fuses at  $56^\circ$  Cent., and boils at about  $110^\circ$  Cent. In a current of air, or better of carbonic acid, it sublimes at a very gentle heat and condenses in arborescent crystals. Several determinations of the specific gravity of the vapour of ammonia boric methide gave the mean number 1.253, which indicates that the vapour of ammonia boric methide consists of equal volumes of boric methide and ammonia united without condensation. Thus the formula of ammonia boric methide is a four-volume formula\*—a state of condensation which is usually considered to be abnormal, and which, where it occurs, is generally explained by the assumption of a decomposition of the body at the moment of conversion into vapour. The proof of the disunion or integrity of the vaporous molecule of ammonia boric methide would be interesting in connexion with these so-called anomalous vapour-densities, but the author regrets his inability to offer any sufficiently decisive solution of this problem ; for although fused chloride of copper absorbs ammonia from the vapour, yet it does so under circumstances which admit of the assumption that the vapour of ammonia boric methide is *decomposed* by the chloride of copper.

Ammonia boric methide scarcely absorbs a perceptible amount of oxygen at ordinary temperatures, even after several days' exposure to the gas ; but it takes fire below  $100^\circ$  Cent. when heated in contact with the air. Its vapour is also very inflammable ; thus when ammonia boric methide is placed under the receiver of an air-pump, and

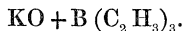
\*  $\text{H}_2\text{O}_2 = 2$  vols.

the air is being withdrawn, the explosion of the mixture of air and vapour in the cylinders of the pump is frequently determined by the rise of temperature consequent upon the depression of the pistons when the rarefaction has become considerable.

Boric methide is also absorbed by aniline with great avidity. Acids expel the gas from this compound unchanged.

Terhydride of phosphorus has no action upon boric methide. A mixture of equal volumes of the two gases is spontaneously inflammable, burning with a yellowish-white flame, in which the characteristic green tinge attending the combustion of boric methide is no longer perceptible.

*Compounds of Boric Methide with Potash, Soda, Lime, and Baryta.*—Solution of caustic potash absorbs boric methide with great energy. The saturated solution, exposed over sulphuric acid *in vacuo*, dries down to a gummy mass, which scarcely exhibits signs of crystallization. The same body may be more conveniently formed by decomposing ammonia boric methide with alcoholic solution of potash, taking care to employ an excess of the former. On evaporation over sulphuric acid *in vacuo*, the excess of the ammonia compound volatilizes and is decomposed by the sulphuric acid, with the elimination of boric methide; thus the solution of the potash compound evaporates in an atmosphere of boric methide. Nevertheless, even by this method the potash compound could not be obtained in a state of perfect purity, the numbers obtained on analysis indicating only remotely the formula



Boric methide is also readily absorbed by solution of neutral carbonate of potash, bicarbonate of potash and potash boric methide being apparently formed. Although boric methide and potash unite with remarkable energy, they are separated by acids with the greatest readiness; even carbonic acid in the presence of water can expel boric methide from its potash compound; thus if an aqueous solution of potash boric methide be passed into carbonic acid standing over mercury, the acid gas soon becomes replaced by pure boric methide.

Soda boric methide, baryta boric methide, and lime boric methide are similar bodies produced by the absorption of boric methide gas by caustic solutions of soda, baryta, and lime; they are all readily soluble in water and react alkaline.

Boric methide in combination with the alkalies and alkaline earths has almost entirely lost its powerful affinity for oxygen; nevertheless, when these bodies are placed in contact with a known quantity of oxygen over mercury for several days, the volume of the gas perceptibly diminishes.

The great difficulty, not to say danger, attending the gradual oxidation of considerable quantities of a gaseous and spontaneously inflammable body like boric methide has prevented the author from following this compound into its products of oxidation, as was done in the case of boric ethide. With a graduated supply of oxygen, however, boric methide appears to comport itself like boric ethide, and the compounds formed are probably homologous with diethylate and dihydrate of boric dioxyethide.

In conclusion, it can scarcely be doubted that the action upon boracic ether of the zinc compounds of the remaining alcohol radicals would produce the homologues of the bodies described in the foregoing pages. It may also be remarked that the existence of bodies like boric dioxyethide, in which one-third of the oxygen in boracic anhydride is replaced by ethyl, altogether abolishes any supposed analogy between carbonic and boracic acids, whilst it proves that the composition of the latter acid is expressed by the formula  $\text{BO}_3$ , or some multiple of that formula.

V. "On the Constitution of Sea-Water, at different Depths, and in different Latitudes." By GEORGE FORCHHAMMER, Ph.D., Professor of Mineralogy in the University of Copenhagen. Communicated by the President.

Professor Forchhammer was present at the Meeting, and, by request of the President, gave a statement of the principal results of his researches. He first, however, took occasion to express his great satisfaction in being allowed the opportunity of personally and gratefully acknowledging the liberality with which men of science in this country had entered into his views and supplied him with specimens requisite for carrying on his inquiries; and he particularly mentioned the name of a late distinguished Fellow of this Society, Sir James Clark Ross, who had kindly furnished various samples of sea-water procured in his Antarctic voyage.