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LECTURES ON VEGETABLE CHEMISTRY,

BY

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LECTURE XLVIII.

On Fermentation and its Products.

I BELIEVE we may define *fermentation* as implying a series of changes which certain fluids undergo when submitted to certain agencies and terminating in the formation of an intoxicating liquid, or, in other words, of a vinous or spirituous liquor. Fermentation is carried on in various ways, in order to produce different fluids, such as beer, cider, and wine, and occasionally a peculiar form of fermentation is employed to produce spirituous liquors, and for the distillation of alcohol. It would seem, that in all cases of vegetable fermentation, sugar is the essential ingredient. When sugar is combined with a certain quantity of starch, and dissolved in water, you have a liquid which, under certain circumstances, will undergo fermentation, and it appears that the sugar, and the other substances, re-act upon each other, and the sugar disappears, its elements entering into the formation of alcohol or spirit.

I cannot give you a better view of the general subject of fermentation, than the manner in which it is pursued in our large breweries in the production of beer, where it is carried on upon an enormous scale, and the outline of the process is this:—

A quantity of malt is ground, and of this an infusion is made, technically called the *mash*, which is usually prepared in a large vat, called the *mash-tun*. Now, as I stated to you the other day, in consequence of the large quantity of starch contained in the malt, it is necessary that the water should be let in upon the malt at a proper tempera-

ture, that is to say, between 160° and 180°, and thus, by steeping, the *wort* is made. From the relative composition of barley and malt, it is evident that a change has taken place in the composition of the barley, and that the starch which it contained is converted into sugar. Here is a table which shows you the nature of the change effected, when barley is made into malt.

	Barley.	Malt.
Gum	5	14
Sugar	4	16
Gluten	3	1
Starch	88	69

You see how much sugar and gum the malt has gained, and how much starch and gluten the barley has lost.

The wort, which is an infusion of malt, contains the soluble matter of the malt, that is to say, it contains a quantity of gum and starch in solution, and that it has sugar, you may learn from its sweet taste. It is a matter of the utmost importance to the process, to ascertain accurately the quantity of soluble matter contained in a given quantity of the water, to determine with accuracy the strength of the wort, and this is done by means of an instrument used for this purpose, called the *saccharometer*, or hydrometer, which, floating in the liquid, gives you its specific gravity. This is the instrument: it is composed of a brass globe, from the upper surface of which a graduated stem arises, which is marked off in 100 parts from the 0, the point to which it sinks in distilled water at 70°. The specific gravity of the wort for ale is about 1.090; in general, however, the brewers allow so many pounds to the barrel, and a very convenient instrument it is for them. The term *saccharometer* is not altogether correct, as the instrument merely denotes the specific gravity of the liquor, and not the quantity of saccharine matter which it contains. The specific gravity having been determined, the next thing is, that it is boiled with a quantity of hops, amounting, on an average, to above one-twentieth of the weight of the malt used; and they are added, not merely to give the beer an agreeable bitter flavour, but to preserve it from a sub-

sequent fermentation. The wort having been boiled with the hops, it is rapidly drawn out from the boiler by means of a pump, and conveyed into shallow vessels called *coolers*, which are built in the most cool part of the brewery, and then the wort is cooled down to about the temperature of 50°. There are two objects in view in thus rapidly cooling the wort, the one of which is, the precipitation of a glutinous matter, which would be injurious to it if allowed to remain; and another object is to retain the liquor at the temperature which is most convenient for fermentation. It is then drawn off into the *fermenting squares*, where yeast is added to it, and where, after a time, intestine motion begins; it hisses, air is extricated, a scum collects upon the surface, a whitish matter is precipitated to the bottom of the vessel, and an immense extrication of carbonic acid gas takes place; at length the evolution of gas ceases; the liquor becomes quiet and clear, losing much of its sweetness, and a certain quantity of alcohol is formed in it. When the fermentation has gone on to a certain extent, and begins to fall, the operation is put a stop to, by running the liquid out into smaller vessels, where a quantity of scum is again deposited, and at length it is conveyed into very large vats, for keeping. It is found, that as the fermentation proceeds, the liquor loses its density, and acquires intoxicating properties.

In regard to *grape juice*, the process is very similar, but there is no occasion to add yeast to it, as it ferments spontaneously at temperatures between 60° and 80°, and the result of the operation is, that the mawkish sugar of the grape becomes changed; it acquires a pungent flavour, and an agreeable odour derived from the presence of alcohol. It has been found, that a small quantity of sugar will contribute to convert a large quantity of a starchy fluid into alcohol, and it is upon this principle that *washes*, as they are called, are prepared by distillers; so that if a small quantity of malted grain be mixed with a large quantity of unmalted, the product of the fermentation of the mixture is alcohol, which is separated by distillation. The active principle in yeast appears to be gluten, and if we do not add yeast to wort and similar compounds, they are apt to run into the acetous fermentation. The result of this fermentation, supposing things to have gone on favourably, is the product, among other things, of a peculiar fluid, to which the term spirit has been given.

If you distil wine in this way you gain an acrid, pungent, highly-intoxicating liquid, well known under the name of *spirits of wine*; but the fact is, that all these fer-

mented liquids owe their intoxicating effect to the presence of alcohol, which is the product of fermentation.

Here is a table, showing you the proportion per cent. of alcohol contained in different fermented liquors; and alcohol, as you are aware, is composed of carbon, oxygen, and hydrogen.

	per cent.
Port wine.....	25.83
Ordinary port	23.71
Madeira	24.42
Sherry	19.81
Lisbon	18.94
Bucellas	18.49
Cape Madeira	22.94
Vidonia.....	19.25
Hermitage	17.43
Claret	17.11
Burgundy.....	16.60
Sauterne	14.22
Hock	14.37
Champagne	13.80
Champagne (sparkling) ..	12.80
Vin de Grave	13.94
Cider from 5.50 to	9.87
Perry (average)	7.26
Burton ale	8.88
Edinburgh	6.20
Dorchester	5.56
Brown stout.....	6.80
London porter (average) ..	4.20
Brandy.....	53.39
Rum.....	53.68
Gin	51.60

The figures set down opposite each liquor, exhibit the quantity of alcohol per cent., by measure in each at the temperature of 60°. You see that port, sherry, and Madeira, contain a large quantity of alcohol; that claret, Burgundy, and Sauterne, contain less; and that brandy contains as much as 53 per cent. of alcohol. In a general way, we may say, that the strong wines in common use, contain as much as a fourth per cent. of alcohol.

In the process of distillation, some water is brought over with the alcohol, which must be separated, if you wish to obtain the alcohol pure; hence it follows, that its specific gravity varies with its strength. When alcohol is poured upon the hand, it produces considerable cold, in consequence of its rapid evaporation; and its boiling point naturally varies with its specific gravity, but it boils at about 176°, when its specific gravity is .820. Now the specific gravity of the vapour of alcohol at 60°, is shown in this table; 100 cubic inches weigh 47.712 grains; and, compared to hydrogen, it is as 21.65 to 1.

We come now to a very important point in the chemical history of alcohol, namely, what happens when it is mixed with water. First, then, the temperature of the mixture

is increased considerably; and, in the next place, there is a corresponding diminution in bulk, which may be easily shown, by mixing the two fluids in a long glass tube. Alcohol being of a less specific gravity than water, being only .820, whilst water is 1.000, you can pour the alcohol upon the water without mixing; but if you invert the tube, the fluids will mix, the vessel will become warm, and there will be a considerable diminution in bulk, and, of course, an increase in its specific gravity; so that the specific gravity of a mixture of alcohol and water is not the mean of the two, but considerably above it. The empty space in the tube is the consequence of the admixture, or the mutual penetration, as it is sometimes called, of the two fluids. It will be many hours before this admixture will have acquired its extreme density, so that it is necessary to afford it time, if we wish to arrive at an accurate knowledge of the result of the mixture. This experiment is important, as connected with the specific gravity of different spirituous liquors; and it shows us, I think, why mere mixtures of spirit and water are more pernicious than when alcohol constitutes an essential part of the fermented beverage, as in wine, perry, and so on. Looking then at the fact, that spirit and water, of the same strength as the alcohol in an equal measure of wine, are more intoxicating than the wine, we may say that the alcohol is more united with the essential components of the wine, and therefore does not act so readily upon the nerves of the stomach, as is well known by experience to be the case. Alcohol exists in some liquids in large quantities, forming irritating, intoxicating, fluids, as brandy, rum, and gin; sometimes you have it combined with certain acids, as with wine; and, in some cases, as in beer, porter, and so on, you have it combined with some nutritious matter, as gum, and so on; and although we are accustomed to speak of wine as strengthening, it is not absolutely so; whereas beer and porter are certainly deserving of that title, a certain part of the nutritious matter remaining behind undecomposed.

To determine the *strength* of spirituous liquors, which is a matter of some importance, we must take their mutual penetration into account; and, in examining them, it is necessary to determine their specific gravity; and from that specific gravity, we are led to infer the quantity of alcohol that may be contained in the liquor in question. Now, with regard to the mode of determining the specific gravity of a spirit, this is generally done by an instrument called the hydrometer; and I think that these hydrometers are to be preferred which give you at once the specific gravity

of the fluid, without any reference to its being above proof, or below it. If you learn that the specific gravity of a fluid is .930, you know that that is the specific gravity of a mixture of equal weights of alcohol and water; and this will give you a proof spirit, that is, spirit of a specific gravity of .930; the specific gravity of the spirit being .820, and that of water 1.000. There have been published in the Philosophical Transactions, tables made by the late Mr. Gilpin, which are invaluable to persons concerned in experiments of this kind; these tables show, in the first place, the specific gravity of any mixture of spirit and water, the spirit being taken by weight, and the water by weight. They tell you also the quantity of spirit by measure contained in any mixture with water, and the quantity of water by measure, thus showing the diminution in bulk, by the mutual penetration of the fluids. Now, in determining the value of spirits in that way, namely, by their specific gravity, the excise are liable to be deceived, because the imported or manufactured spirit may contain a quantity of sugar, and hence the specific gravity of the fluid would be found greater, and it would be supposed that the spirit was weaker. A better way of determining the strength of spirits, and to prevent the occurrence of this fallacy, is to take a bottle containing a certain quantity of distilled water, and weigh it accurately, we will say that it contains 1000 grains of water, or only 970; you then pour away the water, and weigh the same bulk of spirit; and if you then divide the weight of the spirit by the former weight of water, the product gives you the specific gravity of the spirit. Thus we find that the bottle filled with distilled water weighs 970 grains, and that the weight of the bottle of spirituous liquor, is only 853.6; you divide the 853.6 by 970, which gives you 0.880, the specific gravity of the fluid. So that, in a mixture of 100 parts of spirit and water of that specific gravity, you would have 34 parts by weight of water, and 79.65 per cent. by measure of alcohol; and these have been decided to be correct proportions by actual experiment, and are set down in Mr. Gilpin's tables.

As you see, in the common spirit lamp, alcohol burns with a pale bluish flame, without giving out any smoke, and, although a costly kind of fuel, it is important and valuable to the chemist. During the combustion of alcohol, under a glass tube, we find that there is a quantity of water collected, which far exceeds the quantity of alcohol burned; and whenever you hold a bell glass over a lamp, it becomes immediately coated with moisture, and drops of water fall down. Lavoisier found, by ex-

periment, that the combustion of 100 parts of alcohol produce 136 parts of water.

When alcohol is passed through a red hot tube, it is entirely decomposed, separating into hydrogen, and carbon, and oxygen, its elements; a portion of charcoal is deposited, and carburetted hydrogen gas evolved. The experiment can be easily made, by putting a portion of a tube into the fire, and through the tube some wire should be bent, so as to afford a greater surface, and the gaseous results may be collected; but if alcohol be decomposed with caution, we learn the quantity of carbon, of oxygen, and hydrogen which it contains. Here is a gaseous compound, containing hydrogen, oxygen, carbon, the vapour of water, and other substances; but, if the experiment be performed with due caution, we come to the result, that alcohol is composed of carbon, hydrogen, and oxygen, in such proportions as may be stated to be a compound of two parts, by weight, of olefiant gas, and one of water; and you will remember that olefiant gas is a compound of 1 proportional of carbon and 1 proportional of hydrogen. Therefore, as you see on this table, twice 7 make 14 of olefiant gas, and one proportional of water 9, make 23, as the equivalent number of alcohol; or, in other words, its elements are 2 of carbon, 3 of hydrogen, and 1 of oxygen, making its number 23, as derived from its decomposition, and the one volume of carburetted hydrogen, and one volume of steam, become condensed into one volume, as far, that is, as the ultimate elements are concerned.

The uses of alcohol are exceedingly numerous in the arts and chemistry; its principal consumption is, unfortunately, in the form of gin, and other liquids which are used by the lower orders, patronised by the government in consequence of the large revenue afforded by their sale.

Ether.—When alcohol is mixed with certain acids, and submitted to distillation, a peculiar compound is formed, called *ether*, and these are distinguished by the names of the different acids employed in their formation. We have only time now to mention one, and shall therefore take *sulphuric ether*. The manufacture of this is very simple; it is made by distilling together equal parts, by measure, of alcohol and sulphuric acid; and the distillation may be carried on in a small scale, in a glass retort, and using a vessel, as you see here; but it would be dangerous to make large quantities of it in an apparatus of this kind, and therefore they put the retort in sand, and have recourse to a leaden still for the distillation of the liquid; and they heat it with high pressure steam, so that no fire shall come near the liquor. I believe I said, by mistake, *equal measures* of sulphuric acid and alcohol, but it

is, in fact, *equal weights*; the mixture is, a pound of sulphuric acid and a pound of alcohol, and, in mixing these two liquids, it is necessary that you should be cautious, in consequence of the heat that is evolved. When we are manufacturing ether on a large scale, it is convenient to have a dropping apparatus to mix the two fluids, and a person should stir them at the same time, and thus the evolution of heat is prevented. In distilling this mixture, you will find that there will come over, first, a certain quantity of alcohol, a little changed; then a quantity of ether; and then a peculiar compound, to which the name of *oil of wine* has been given; and, lastly, a quantity of sulphurous acid. If you continue to apply the heat, there is a black matter formed, and a good deal of carbon deposited; but you should put a stop to the process before this change takes place. The ether procured at the first distillation is not pure, but a second distillation renders it sufficiently pure for all the common purposes of experiment. It ought to be afterwards washed with a little water, and re-distilled with a little chloride of calcium, the dry muriate of lime.

The specific gravity of ether is 720, in its pure state, and about 730, and from that to 760, as it is found in commerce. It is highly volatile, so that you cannot pour it from one vessel to another, without losing a portion of it; and, during its evaporation, it produces a great degree of cold, so that if you drop a little ether upon the bulb of a thermometer, you will see the fluid gradually sinking in the tube; and there is a pretty experiment of allowing ether to dribble over a tube containing water; the water freezes readily, and this freezing of water by evaporation of ether may be made under the receiver of the air pump. If you introduce a small quantity of ether beneath the receiver, and allow the vessel containing it to float in water. As you exhaust the air, the ether boils, and by continuing to diminish the pressure, the ether evaporates so rapidly as to cause the water immediately surrounding it to freeze. This depends upon the abstraction of the heat from the water, until it being all carried off by the conversion of the ether into vapour, the water freezes. There are some other properties of sulphuric ether to be pointed out; and these, with the changes which the acids and alcohol undergo when mixed together, will be adverted to in the next lecture.

LECTURE XLIX.

On the production of Ether; on the acetous fermentation, and the manufacture of Vinegar.

At the conclusion of the last lecture, we were examining what happened when equal weights of alcohol and sulphuric acid

were distilled together; one of the results of that distillation was *sulphuric ether*, and I mentioned some of its general properties; its low specific gravity, its volatility, its great inflammability, and so forth. In addition to the properties mentioned, we may observe, that it is the solvent of certain bodies, of certain vegetable bodies, as the resins and oils; it dissolves sulphur and phosphorus, but does not dissolve the fixed alkalies, although it combines with ammonia. It dissolves the oxides of gold and platinum, and this solution of gold was called, by the old chemists, *aurum potabile*.

Now, the ether which we have procured by the distillation of sulphuric acid and alcohol, may be purified by a second distillation with bodies that contain water; ether being soluble in water to a certain extent, one part of ether requiring ten of water for its solution, and you will observe, that you are sometimes directed to purify ether by washing it to abstract the alcohol; but whenever you do that, you must recollect that you give the ether about one-tenth of water, and therefore it is necessary to have recourse to some process to get rid of the water, and this may be done by lime, by caustic, potash, and chloride of calcium, substances which readily abstract the water, but which the ether does not dissolve. With alcohol, it combines and forms the *spiritus ætheris sulphurici* of the Pharmacopœia, 100 cubic inches of which weigh 78.36 grains, and hence, when we are using ether, we should be very careful not to bring a candle near it, as its vapour is very inflammable. You may easily show the inflammability of ether, by introducing a small portion of it into a bladder containing common air; you will find that a kind of inflammable gas is formed; and if there were a sufficient quantity of air present, a detonating compound would be produced.

When ether is subjected to the process of decomposition before pointed out, we arrive at a knowledge of its ultimate composition; and it is worth our while to compare it with alcohol, in order to have an idea of the nature of the process which has been here going on, referring to the distillation of the alcohol and acid. We find that ether, compared to alcohol, is composed of four proportionals of olefiant gas and one of water, or, if we put these into numbers, of 28 olefiant gas and 9 of water; here, then, you have one volume of steam, or the vapour of water, combined with two volumes of carburetted hydrogen, or 9 parts of water, 4 times 7, making 28 of olefiant gas; and you will remark, that these three volumes are condensed into one, which will satisfactorily account for its little specific gravity. Now, here we have found, in converting alcohol into ether, that there is an abstrac-

tion of a quantity of water, or, to speak more correctly, of the elements of water, because, if you take away half of the water of the alcohol, you convert it into ether; so that, it would seem, that all that the sulphuric acid has done in this distillation, is to abstract half of the elements of water that the alcohol contains. In this experiment, the sulphuric acid itself undergoes a curious change, and it is found to have entered into combination with a certain portion of the elements of the alcohol.

Ether combines with carbon and hydrogen, and you have, produced with these elements, a certain compound to which the name of *sulpho-vinous acid* has been given. A peculiar fluid is obtained by mixing ether with its bulk of sulphuric acid, and distilling it, and this has long been known under the name of *oil of wine*; it is composed of two proportionals of sulphuric acid, eight of carbon, and eight of hydrogen; and, when oil of wine is heated, its nature becomes evident. In the *sulpho-vinous acid*, you have two proportionals of sulphuric acid combined with four of carbon, and four of hydrogen; or, in other words, you have abstracted one-half of the carburetted hydrogen of the oil of wine. This acid enters into combination with certain bodies, and forms *sulpho-vinates*; for example, the *sulpho-vinate of baryta* is composed of two proportionals of sulphur, four of carbon, four of hydrogen, and one of baryta; and the whole forms a triple saline compound, composed of sulphuric acid, carbon, hydrogen, and baryta. These experiments are very interesting, as associated with the statement made to you by Mr. Faraday, namely, that he had discovered a similarly neutralising power with naphthaline and sulphuric acid, which he called *sulpho-naphthalic acid*, composed of two proportionals of sulphuric acid, twenty of carbon, and eight of hydrogen. Then, again, the *sulpho-naphthalite of baryta* is composed of the same elements and one proportional of baryta. These are a very curious and interesting set of bodies, and the prosecution of their chemical history will, no doubt, lead us to some new views on this interesting subject. In the alcohol there is an excess of carburetted hydrogen, and you convert the alcohol into ether by abstracting one-half of the elements of water which the alcohol contains. I should mention to you, that when ether is kept for a long time it undergoes a change, and more especially if it be exposed to the light of the sun, and a small portion of air is formed in it.

When you mix together alcohol and nitric acid, and more especially nitrous acid, there is, unless you are very careful, an intense and sudden action, attended with great evolution of heat, so that it becomes neces-

sary to mix them together in small quantities and with great care. Now, when you consider what the elements here used are, namely, nitrogen, oxygen, hydrogen, and carbon, it is manifest that you may have a great variety of secondary compounds produced, and some of them are very remarkable. In the first place, in regard to *nitric ether*; this is also very volatile; it has a penetrating fragrant odour, and it soon decomposes, and, combined with spirits of wine, it is well known to you under the name of *spirit of nitric ether*. If, during this action of the nitric acid on the alcohol, there should be present the oxide of silver or mercury, a compound is produced called fulminating silver, or fulminating mercury. The process by which it is procured is simple: the metal is dissolved in the acid, and, during this effervescence, a powder is precipitated, which is the powder in question; but, in making it, you must be careful to use only small quantities of the materials, as it will detonate with great violence, even in its moist state. The fulminating silver is the most violent of the two, and it will explode with the slightest friction. In exploding a portion of this substance, you must be careful that there is no more near it, as the mere vibration of the air will often explode it. Now, then, we have obtained these compounds by acting the nitric solutions of the two metals by alcohol; but what is their nature? I believe that, until lately, the general opinion was, that they were oxalates, containing, according to Thenard's calculation, a great deal of oxide of silver in them. Some recent experiments of Guy-Lussac, and Leubeck have given another view of the subject, and I think that they contain cyanogen. Now, I formerly mentioned to you, that cyanogen combined with oxygen to form cyanic acid, and it would seem that this cyanic acid enters into combination with the oxides of the metals mentioned, and thus constitutes the fulminating compounds described. Cyanogen, you know, is a compound of two proportionals of carbon and twelve of nitrogen, and this cyanogen, when combined with half its volume of oxygen, gives cyanic acid, represented by the number 34; and one proportion of this acid combines with one of the oxide of silver, or mercury, and forms this fulminating powder.

The other ethers we know very little about. When *chlorine* is passed through alcohol, a liquid is obtained, called *muric ether*, but what its composition is, or the exact nature of the change which takes place, we are ignorant of; and another difficulty, common to the correct examination of all the ethers, is, that they are remarkably prone to change.

Acetous fermentation.—This brings us to the subject of *vinegar*, or acetic acid, which we have left thus distinct from the other vegetable acids, because it is, generally speaking, the product of a distinct fermentation, called the acetous fermentation. You very well know, that by keeping wine, or beer, out of the contact of air, they may be preserved a long time without undergoing any change; but, by exposure to the air, under a due temperature, they will soon become sour; a fermentation goes on, and the liquid, originally vinous, is converted into an acid.

Vinegar is made, in this country, chiefly from *malt*; a wort is obtained, as for the manufacture of beer, and this wort is converted into vinegar; but it is manifest that, besides the vinegar, the fluid must contain other bodies usually present in the malt, such as starch, gum, and gluten. Vinegar is, therefore, a very impure acetous acid, and is, in the common way, mixed with other acids diluted with water. If you distil this vinegar, you have an acetic acid and water, and a small quantity of alcohol formed, usually containing, also, a minute portion of vegetable matter. When chemists began to ascertain that the vegetable acids might be obtained in a concentrated form, they applied this knowledge to the production of vinegar, and with great success. One of the oldest methods of obtaining a strong vinegar was to freeze it; the water frozen, the vinegar was obtained much stronger than before; but this was a very wasteful practice, because the acetous acid itself freezes without much difficulty. Then, the next procedure resorted to, was the decomposition of the acetates, and this is the plan now resorted to in order to obtain vinegar in its pure form. If you put some acetate of lead into a retort, and pour upon it sulphuric acid, and carefully distil it, there will presently come off from it a quantity of a highly volatile and intensely acid vapour, which may be condensed by the usual process; but, even obtained in this way, the acid is not perfectly pure. Here is a specimen of distilled vinegar; you see it is a colourless liquid; it is very sour, highly pungent, and its specific gravity is 1,080; it is very volatile and excoriating, and it congeals at a temperature of 40°. Here you see it in its congealed state, constituting what is called *glacial acetic acid*. Its equivalent number is somewhat between 48 and 50, but we will take it as the same as the carbonate of lime, and call it 50.

Now, either by the fermentation of malt liquor, or by the acetous fermentation of wine, you obtain vinegar contaminated with various substances, and such is the vinegar used in the general way for the table. Now this leads me to speak of a me-

thod of obtaining vinegar, largely practised, and which is a very curious and important chemical operation. It was discovered long ago by Glauber, and described in his works, which you will find to contain much interesting chemical information, that vinegar might be obtained from wood, and it has been lately procured in considerable quantities from this source. In the distillation of wood, in the process of making charcoal for the manufacture of gunpowder, a large quantity of gaseous and empyreumatic matter are given out, and this gaseous matter is found to be formed principally of acetous acid; but, unfortunately for the manufacturer, there is a strong affinity between the acid and this matter, so that he is at some trouble to separate them. The method of obtaining pure vinegar from this acid, is to saturate the vinegar of wood with slaked lime; the other liquids are poured off, or evaporated, and we then obtain a *pyrolignate of lime*, commonly combined with some empyreumatic oil, and having a strong empyreumatic odour. Then the next step in the operation for obtaining vinegar from this product, consists in decomposing the pyrolignate of lime by sulphate of soda; a double decomposition takes place, and you have an acetate of soda and a sulphate of lime formed; the acetate of soda is a crystallisable salt, and by dissolving and recrystallising it two or three times, you obtain it quite pure; you then place the acetate of soda in a retort, and pour sulphuric acid upon it, by which the acetic acid is set free, and a sulphate of soda is formed, which does for the future preparation of the acid in the way already mentioned. A pure acetic acid is thus obtained, which you may reduce to any strength you please, by mixing it with water; but as people do not generally like colourless vinegar, the manufacturers are in the habit of colouring it with a little burnt sugar; and in this way an important branch of manufacture is prosecuted. Vinegar, when diluted with water, is used for a great variety of purposes; but, in its concentrated state, it is very acrid, and blisters the skin, and might produce great irritation.

The acetates are all of them soluble in water, and some of them are principally confined to medical purposes. The *acetate of ammonia* is obtained by saturating distilled vinegar with carbonate of ammonia, and this fluid was formerly known under the name of *Mindererus' spirit*, because it was first exhibited by Mindererus; it is readily made, but the acetate of ammonia is crystallisable with difficulty. The acetate of potash is chiefly manufactured for pharmaceutical purposes, and is called the *diuretic salt*, a salt which is generally obtained in flaky masses; it is very deliquescent, containing a large quantity of the water of crys-

tallisation. The *acetate of soda* has an agreeable taste, but its principal importance is as a sourer of acetic acid in the manufactory to which I have adverted. The *acetate of lime* is chiefly important, as being one of the products in the operation for making pure acetic acid. The *acetate of iron* is an article of importance to the calico printer, as a mordant for black dyes; but it is a salt difficultly crystallisable. The acetate of *zinc* is employed occasionally in medicine. The acetate of *copper*, of which there are two kinds met with in commerce, one a pulverulent substance, generally a great mass of impurities, from being made by exposing copper plates to the action of vinegar, produced by the fermentation of the refuse of grape stalks, grape skins, and so on, is an article of some importance in commerce, being known under the name of *verdigris*. What is sold, however, as *verdigris*, is nothing more than a mixture of whitening and sulphate of copper; you should, therefore, always use the crystallised acetate. The *acetate of lead* is used in large quantities by the calico printer as a mordant. Now as all these salts are of great use in the arts, and are manufactured on a large scale, you may imagine how very importantly the manufacture of acetic acid from wood bears upon these, and instead of being, as formerly, obliged to have recourse to France for our supplies, we now manufacture them here in abundance with the acid obtained from wood. The acetate of lead in its dry state, has the number 162 for its equivalent, but in its crystallisable state it contains three proportionals of water, three times 9 being 27; we therefore have to add the 27 to the 162, and then it is represented by 189. When acetate of lead is dissolved in water, and boiled upon oxide of lead, it takes up a portion of the acid, you then get what is called a *subacetate of lead*, which is curious in many respects; it is easily decomposable by exposure to air, is not crystallisable, and its solution takes up carbonic acid from the air, and becomes converted into a carbonate of lead, which is insoluble. The subacetate of lead, obtained by boiling litharge in vinegar, used to be called *Goulard's extract of lead*, and it is the *liquor plumbi subacetatis* of the Pharmacopœia. The other acetates are of no importance.

There are some curious facts connected with the acetates generally, namely, that under decomposition, during particular circumstances, there is a substance generated similar, in some respects, to naphthaline, or ether, and was used formerly burned in lamps.

This, then, Gentlemen, concludes the chemical history of the vegetable substances; the three next Lectures will be occupied with the consideration of animal chemistry, and we shall finish the course with an outline of the science of geology.