of the black pearlitic areas in the direction in which the punch was driven through the plate. The depth of distortion depends upon the thickness of the plate and the size (also the sharpness) of the punch; it can easily be measured, and it has been found that for a three-fourth inch hole in a three-quarter inch plate, about one-tenth inch increase of diameter of hole by reaming is necessary to remove all affected material.

Fig. 32 is a section of a steel casting cut by the oxyhydrogen blowpipe. Passing inward from the cut edge, we note the burnt or oxidized portion in the blurred part immediately adjacent; next the enlarged grain of the overheated but not burnt area; then through a graduation of grain size to the normal structure of the interior. This method seems at first sight to have a very detrimental effect, but is in reality slight, since measurement shows a depth of affected material of only four- or five-hundredths of an inch.

Numerous other instances might be cited of the usefulness of the microscope. It has materially assisted in the determination of the nature of the various zinc coatings for the protection of iron surfaces, and we are trying it out in the study of the progression of rusting on metal specimens.

But it will be necessary to conclude with a comment on the probabilities of the future. While the great field of application of metallographic study has naturally been to the metals and alloys, there is every reason to expect extension of its scope to allied lines, such as the examination of complex ores and slags, to ceramic materials and perhaps to coal and coke. In all of these instances we find good and poor materials of identical analysis; the probability is that the interrelations of the constituents are different. An interesting application along this line has just been pointed out in the use of microscopic examination to detect iron blast-furnace slags which are suitable, or otherwise, as a raw material for Portland cement. That vitrification which is essential in the proper slags is brought out very neatly.

Finally we may look to improvement in the microscope itself. We are at present restricted to the study of the heterogeneous structure revealed by ordinary reflected light. The petrographer has the advantage of being able to use transparent sections and polarized light, and in consequence can determine the crystal systems of the constituents of the rock under examination. When suitable apparatus is perfected (it is now being developed) to enable us to determine the crystal forms of the constituents of an opaque specimen by reflected light, then the metallographic microscope will have a materially enlarged scope of application and utility.

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THE SIZING OF PAPER WITH ROSIN COMPOUNDS.

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The sizing of paper, from the standpoint of the chemist, is a problem which is not uncommonly sup-

posed to be well understood and fully inquired into, but the true state of the matter is that there is as yet insufficient data available of a nature to determine definitely the actual agencies which perform the function of sizing paper, in confirmation of which be it said that the question has but to be raised to at once introduce a variety of argument and diverse opinions.

Since the publication of Dr. Wurster's treatise on rosin-alum sizing in 1878, our knowledge of chemistry, relating to paper-making, has largely increased, and it is the object of the authors of the present paper to endeavor to summarize the present position of the science, by setting out the results of recent exhaustive researches, in company with a complete criticism of data thereby accumulated, more particularly in connection with the various points concerning rosin sizing, which have long occupied the attention of paper-makers, and paper mill chemists generally.

In turning to consider the present time work and views of leading chemists dealing with the science of paper-making, the question which presents itself at the outset is the selection of a fitting subject-material, but it is obvious that in a treatise of this description the essential contents will imply so much of chemistry as is indispensable for the practical investigation, particular stress being laid upon the coöperation of the practical and theoretical issues, which in the past have remained more or less independent one of the other.

In viewing a scheme of this character it becomes clear that in the theoretical treatment of the chemical processes, which in many ways constitutes the most important part of the problem, the chief considerations are: firstly, the composition and properties of the actual sizing agents (*i. e.*, the products of interaction between rosin size and alum and auxiliary precipitants); secondly, their relationship to cellulose itself.

The present generally accepted theory of sizing action assumes that on the addition of alum the following reactions take place:

(a) (Normal action with theoretical alum.)

Since, however, the quantity used in the mill is much greater than this proportion, the excess is supposed to decompose the neutral resinate of alumina with liberation of the free acid, according to the following equation:

To proceed, Dr. Würster, from the results of his original experimental work, took exception to the then current view (which it may be remarked has till now remained unsettled) that the actual sizing agent is a resinate of alumina, formed as above represented, and asserted that the free rosin acids were the active sizing agents. He drew his conclusions from the results he obtained by extracting rosin-sized.

paper with ether and other solvents, the residue, after evaporation, being almost entirely composed of free rosin acids. He also found the alumina in the paper before and after extraction to be the same in amount.

Again, as recently as February, 1907, in *The World's Paper Trade Review*, Mr. Edward F. Moody made the following statement in an article on the same subject—"the free rosin being absolutely insoluble in water is a much better sizing agent than the precipitated and more or less soluble alumine resinate." From a large number of experiments we have found that alumina resinate is very slightly soluble in water at ordinary working temperatures. Mr. Moody further states that "there is no doubt that a pound of free rosin is as effective as two pounds of alumina resinate." Our results do not coincide with this.

Thus we rapidly reach a fundamental stage in the principles of sizing with rosin soaps. To take the simplest case, What is the best form in which rosin can be applied? One school teaches us that the free rosin is the most valuable constituent of the size—in other words, the more free rosin the size contains, the better the results obtained, upon which theory the custom has developed of making sizes very rich in free rosin, sometimes in the form of an emulsion, containing an exceedingly high percentage of finely divided free rosin particles. On the other hand, some well-known experts maintain that the alum precipitates the size from its solution, producing a complex mixture consisting of alumina resinate and free rosin emulsion. Again, the use of a considerable excess of alum—often more than four times the necessary quantity—is usually recommended. Beyond this important stage, except for the suggestion that the requisite excess has been determined rather by experience than by theoretical calculations based upon scientific grounds, nothing more appears to be known.

Having duly considered the various aspects of this extremely important inquiry, we next approach the details of our work and conclusions on the subject. Any attempt to investigate this problem by experiments conducted on finished sized paper alone is to endeavor to do, at least at this early stage, what is almost impossible. Consequently, we have divided the work of this investigation into three entirely distinct sections, *viz.*: (a) the theory of the constitution and general properties of the active sizing agents; (b) their reactions under the influence of varying conditions in the beating engines, more especially with regard to their ultimate sizing efficiency; (c) the behavior of cellulose towards such substances, with observations on the deviations from simple additive relations. In the first place, therefore, we will consider the question of the composition and activity of alumina resinate.

In order to isolate the resins of alumina, the neutral brown size is dissolved in luke-warm water, diluted to a convenient bulk, and the molecular proportion of pure alum, previously dissolved in water, is gradually added to the solution. The compound resins of alumina, which soon separate, are collected

and rapidly washed with water, until the washings no longer contain salts of sulphuric acid.

The air-dried substance has the approximate composition (mean result of twenty-five determinations),

1.000 grams of anhydrous alumina resinate gave 0.0456 gram alumina, Al_2O_3 .

$$\text{Al}_2\text{O}_3 = 4.56 \text{ per cent.}$$

The aluminum derivative of abietic acid, $\text{Al}_2(\text{C}_{44}\text{H}_{62}\text{O}_5)_3$, requires $\text{Al}_2\text{O}_3 = 4.94$ per cent.

It will be seen from the above results that the figure for the equivalent of alumina in aluminum resinate is rather lower than that which theory requires for aluminum abietate. Although as a general statement " Al_2H_3 " holds good for aluminum resinate, it must be borne in mind that commercial rosin itself is a mixture of rosin acids and certain other substances, which are not present in constant proportions and have been found on experiment to possess equivalents varying in a greater degree than that which has hitherto been supposed. Consequently, the composition of the mixture of aluminum resins produced during the reaction with alum and neutral rosin differs with the type of size used.

The anhydrous compound aluminum resinate consists of an amorphous powder: it is of a light buff color, resembling rosin, but usually much softer. It dissolves very readily in cold benzene and chloroform, and it is also readily soluble in hot acetic anhydride, but it is only moderately and sometimes partially soluble in oil of turpentine, petroleum, ether, acetone, ether and alcohol. The solvent effects of the two latter bodies we have dealt with fully, later.

The alumina resinate melts at $135\text{--}140^\circ\text{C.}$, and yields on ignition a mineral ash consisting of alumina, only traces of foreign bases being present.

We propose to show in the following discussion that the absence of alumina in the "ether-extract" of a rosin-sized paper is not direct evidence in support of the claims brought forward by the exponents of the "free-rosin acid" sizing theory. According to Würster's well-known treatise, to which reference has already been made, it is the free rosin acids which are the effective sizing agents. Würster's observations with regard to the extraction and composition of the size obtained from paper with various solvents are perfectly true, and have been repeatedly confirmed during the course of this investigation. The conclusions arrived at, however, are not at all in accordance with the outcome of our present and more expanded inquiry. As far as Würster's experimental determinations go, the conclusions arrived at are natural and in order, but a new factor must now be taken into consideration, which is—that both ether and alcohol readily cause the decomposition of alumina resins to take place, even in the bone-dry condition, the solvents removing some of the products of dissociation formed during the rearrangement of radicals, which occurs during what is known as sizing. Moreover, it is to be remembered that in practice the free rosin already contained in the size used will naturally

be found in the contents of the preliminary ethereal extract.

The results of some experimental determinations concerning the action of solvents on anhydrous alumina resinate are given in the following table:

TABLE I.

	Ether.		Alcohol.	
	Per cent. of alumina, Al_2O_3 , in residue.	Per cent. of alumina, Al_2O_3 , in extract.	Per cent. of alumina, Al_2O_3 , in residue.	Per cent. of alumina, Al_2O_3 , in extract.
1.....	6.01	1.38	5.40	1.71
2.....	6.51	1.28	6.92	1.52
3.....	6.78	1.25	6.40	1.68
4.....	7.40	1.33	8.72	1.41
5.....	6.66	1.30	6.62	1.51

Alumina resinate was shaken up in the cold with excess of ether and allowed to stand for about half an hour. The filtrate was then decanted off and the residue dried. The filtrate was in turn evaporated to dryness and both extract substances analyzed for alumina.

The above preliminary tests led to the quantitative investigation of the amounts in which the two extracts are present, with the results given below:

TABLE II.

Exp.	Percentage of residue.	Percentage of extract.	Percentage of Al_2O_3 in residue.	Percentage of ash in filtrate extract.
1.....	40.10	59.90	10.40	1.20
2.....	39.40	60.60	9.05	0.67
3.....	33.50	66.50	8.41	1.30
4.....	40.00	60.00	7.41	1.01
5.....	34.15	65.85	6.16	1.27
6.....	37.10	62.90	9.22	1.10
7.....	37.35	62.65	8.30	1.41
8.....	30.00	70.00	9.16	1.06
9.....	33.3	66.70	10.64	0.30
10.....	32.00	68.00	8.80	1.10
11.....	30.50	69.50	9.53	1.02
12.....	35.10	64.90	9.02	0.86

In dealing with the question of the reaction which really does take place between alums and rosin size, it cannot be denied that much confusion is liable to arise, inasmuch as it is a matter of great significance, and of an intricate and complicated nature, such as is rarely encountered in technical investigation. It has been found during the course of the present investigation, that contrary to the general belief, practically no free rosin acids are liberated during interaction with both neutral and excess of alum; that is, provided that there are no active foreign bodies present, such as other metallic salts, and more especially free acid. The last named is an essential consideration, seeing that many technical difficulties, for instance the discoloration and the deterioration of the strength of paper, can primarily be traced to the unfavorable conditions under which it was sized. Up to this point we have assumed that all the alumina molecules attaching themselves to resin acids are held in the ratio of alumina resinate. It is equally conceivable, however, that two units of affinity are united with the resin acids in some cases, and that the alumina resinate may not only be formulated on the basis of the simplest attachment, but that, in others, where a higher alumina equivalent in proportion to the resin acids, is contained a firmer union of these acids with

basic alumina is involved. From the results of a large number of experiments conducted on the precipitation of alumina resinate with neutral alum, and also of excess of alum in various proportions, and further, the influence of acids and alkalies, salts and other alums in these same reactions we have invariably found that aluminum resinate exists in more than one form or condition, and also in conjunction with cellulose itself: hence the observations which we have advanced above, concerning these precipitated mixtures. Reference has already been made to the condition of the anhydrous alumina resinate which remains when the substance dissolved in ether or alcohol is separated. It is evident that some of the sodium resinate contained in neutral size are too weak to react with equivalent dilute solutions of alum, but certain unstable compounds are formed in the presence of the slightest excess of this precipitant. It is in the capacity of these two kinds of substances for uniting to form an active homogeneous compound, or rather, the opportune and consequent effective transformation of the sodium resinate present into certain modifications of resinous compounds, that the real secret of the efficient and perfect sizing of paper lies.

When anhydrous alumina resinate is treated with cold ether (the same applies in a lesser degree to alcohol) for a considerable time, or even extracted in the ordinary way in a Soxhlet separator for about half an hour, it appears to have undergone an unusual process (possibly pre-existent) of dissociation which may be regarded as caused by an uncertain distribution in the first place of the aluminum base between the various resin acids present, especially since the total quantity of the latter is greater than that required for neutralization (see Table II). As regards the properties of the residual compound (aluminum resinate) X: the substance is a hard amorphous body. It has no definite melting point, but shrinks and darkens at a temperature above 300°C . This derivative does not give the (Liebermann-Storch) reaction, acetic anhydride H_2SO_4 , nor is it attacked by any of the usual solvents. Further, it is but little affected by mineral acids. Hot chloroform, however, has the peculiar property of causing this new compound to take the form of a characteristic jelly-like substance.

It seems plain that all available evidence points to the necessity of recognizing the important part played by aluminum resinate during the process of sizing paper. With a view to further justifying a new position, in advocating the value of aluminum resinate as the real sizing agent, the influence on paper of all the existing sizing materials used in connection with engine-sizing have been investigated, and the results obtained are in complete harmony with those previously arrived at.

Before turning to the data derived from the various paper trials some explanation must be forthcoming to account for the behavior of solvents during the estimation of rosin in paper by the ordinary methods. It has long been known that ether alone does not extract all the resin from paper, and the course invariably recommended is to acidulate the ether with

either acetic or hydrochloric acid, in order to permit of complete extraction. It has also been noted by many observers that the partially extracted paper is not altogether absorbent; in other words, not entirely desized. The experimental data collected and summarized in the following table goes to show that the free rosin in paper is not the most important sizing agent. The sample papers used for this research were manufactured from specially prepared stock, with a view to distinguishing between the added rosin and resinous bodies pre-existing in the pulp furnish of the paper. Moreover, the papers were sized with known quantities of certain market brands of rosin soaps.

TABLE III.—TABLE OF EXTRACTS. SOLVENT ETHER.

Exp.	Description of papers (all unloaded).	Time, Hrs.	Preliminary rosin extract.	Further extract after decomposition.	Acid used.	Total extracted rosin.	Percentage of ether extract under neutral conditions.
1	Imitation parchment	3	1.66	0.47	HCl	2.13	77.93
2	"	3	1.96	0.36	Acetic	2.32	84.40
3	"	3	1.86	0.35	"	2.21	84.10
4	"	3	1.77	0.41	"	2.18	81.20
5	"	3½	1.87	0.22	"	2.09	90.00
6	"	4	1.85	0.23	HCl	2.08	88.90
7	Manila insulating	3	1.92	0.27	Acetic	2.19	89.60
8	"	3	1.89	0.28	HCl	2.17	87.10
9	Brown wrapper sized	5	0.22	0.08	"	0.30	73.30
10	"	3½	0.21	0.08	Acetic	0.29	72.40
11	"	7	0.18	0.07	"	0.27	66.60
12	"	4	0.20	0.09	"	0.29	69.00
13	"	3	0.22	0.09	"	0.31	72.90
14	"	2	0.19	0.04	HCl	0.23	82.60
15	"	3	0.20	0.10	"	0.30	66.60

In all cases the papers extracted according to the column showing results with ether alone were only partially desized and still ink-resisting. Furthermore, according to the existing methods of analysis, a certain proportion of the remaining alumina resins, though their functions are destroyed, are left behind.

It has been shown in the preceding sections, on the basis of many experimental results, that alumina resinate exists in more than one form and much information has been collected towards the solution of these sizing problems from the behavior of the alumina resinate in the nascent state. A careful consideration of the facts pointed out in the following discussion will show that these influences may be regarded from two different standpoints, *viz.*, that of the stable form alumina resinate, and that involving the formation of still more complicated compounds.

The freshly precipitated or hydrated neutral resinate of alumina is readily soluble to a clear solution in the usual solvents. On continued digestion with ether and alcohol, an extremely interesting and important reaction takes place. In the cold, no essential change is noticeable but, on warming, a white flocculent precipitate gradually settles out, which substance, on analysis, is found to be identical in composition with the residue previously obtained by extraction of the anhydrous alumina resinate, already described. It contains a higher molecular proportion of alumina, and the resinous components appear to have under-

gone a change. The substance itself possesses entirely different physical and chemical properties from those of the normal alumina resinate, which at once confirms our previous impression, that either a process of condensation has taken place, or that the molecular relations of the alumina and rosin acids have been submitted to a rearrangement. The fact that the change is accompanied by a kind of dissociation of the resin acids is very significant, and is the opening of an entirely new field of research, on and around the constitution of resin acids.

To resume: we believe that the explanation of many of the vagaries of sizing lies here, and the essential sequence is, therefore, to make plain, by means of data derived from practical experiments and observations, the full effect of sizing agents under all known conditions. The details of the sizing of trial sheets are given in the following table, in condensed form, in order to render results convenient for the purposes of comparison.

NOTES AND OBSERVATIONS.

The trials are numbered approximately in the order of importance which they occupy in this scheme of classification. The majority of the papers of this series were made from bleached sulphite and soda pulp, and subjected, as nearly as possible, to similar treatment in the beaters. "Neutral size" (column 2) refers to a solution of sodium resins, containing no free rosin, while the term "ordinary size" indicates that a stock size, containing about 6-8 per cent. of free rosin, was used.

An explanation of the signs employed in the preceding table are herewith given:

(⊙) = Extra free beater pulp.

(⊗) = Extra wet pulp.

The following is a brief summary of the chief deductions made from the results of this investigation.

It is obvious that in making a relative comparison of the respective merits of the two sizing agents which have in the past been considered of primary importance, the part played by "free rosin" can lay no claim to any particular scientific value. The most general conclusion to be drawn is that nascent alumina resinate already fulfils the essential conditions of a true size, and that, both theoretically and practically speaking, the neutral resinate is a highly effective sizing agent. In actual practice the reaction is in accordance with the general rule above stated, the excess of alum required being only slight, in order to counteract the hardness of the water, and any large excess unnecessary. Further, the excess alum has no effect whatever upon the alumina resinate first formed, and the idea that alumina is precipitated by the soda of the rosin soap, when reaction with alum takes place, has nothing to recommend it. It is true that papers made from moderately wet beater stuff possess a natural resistance to water, and when sized with free rosin in sufficiently large quantity they become hard-sized, solely by virtue of a mechanical surface action on the basis of the fact that the heat of the drying cylinders serves to melt together the small particles

TABLE IV.—PAPER TRIALS.

Exp. No.	Material used.		Precipitant.	Quantity.	Size precipitant.	Sizing agent.	Ink-resisting properties.		Effect of the various chemicals on the paper. Remarks, etc.
	Pulp.	Size.					How sized trade terms.	Standard test seconds. ¹	
1	Unbleached soda	Neutral size	Alum	3%	Chemical equivalent	Alumina resinate	Very hard	410	
2	"	"	"	4½%	"	"	"	450	Excellent surface
3	Bleached soda ²	"	"	5%	"	"	Extra hard	Over 1000	"
4	"	"	"	5%	"	"	Hard	205	
5	Unbleached sulphite ¹	"	"	3%	"	"	Medium	45	
6	"	"	"	5%	"	"	"	55	
7	Bleached soda	"	"	5%	Slight excess	"	Hard	200	
8	Unbleached sulphite	"	"	5%	"	"	Medium to hard	120	Loaded with kaolin
9	"	"	"	6%	"	"	Hard	220	Excellent surface
10	"	"	"	3%	Large excess	"	Medium	35	
11	" ¹	"	"	5%	"	"	"	45	
12	"	Ordinary size	"	3%	Chemical equivalent	Alumina resin and free rosin	"	30	
13	Unbleached sulphite	"	"	5%	Slight excess	Alumina resinate and free rosin	Hard	110	Good surface
14	"	"	"	12%	Large excess	"	"	165	Sizing properties are not entirely relative to quantity
15	"	Neutral	Aluminum hydrate	3%	Chemical equivalent	"	Not sized	2	
16	"	"	"	5%	"	"	"	2	
17	"	"	"	5%	Excess	"	"	3	
18	"	"	Nil	3%	Nil	"	"	1	
19	"	Ordinary size	"	6%	"	"	"	4	
20	"	Neutral	Sulphuric acid	3%	3%	Free rosin	"	2	Causes weakening of the pulp
21	"	Ordinary size	"	6%	6%	"	"	7	Brittle and speckled
22	"	Nil	"	Nil	6%	"	Slightly	10	Parchmentized and brittle
23	"	"	"	"	Large excess	"	Not sized	4	General rotting effect
24	Unbleached sulphite	Nil	Alum	"	10%	"	"	2	Hardened
25	"	"	"	"	20%	"	"	3	Hardened
26	"	"	Caustic soda	"	10%	"	"	1	Softened
27	"	Free rosin	Nil	3%	Nil	"	"	4	
28	"	"	"	5%	"	"	"	4	
29	"	"	"	8%	"	"	"	5	Speckled
30	"	Soln. of free rosin in alcohol	"	4%	"	"	"	1	
31	"	"	"	12%	"	Free rosin	Slightly	10	Heavily speckled
32	"	Free rosin	Alum	3%	3%	"	Not sized	5	
33	"	Rosin in alcohol	"	6%	10%	Free rosin	Slightly	15	Speckled
34	"	"	"	12½%	15%	"	Hard	100	Varnished, unevenly sized, and brittle
35	"	"	Sulphuric acid	6%	3%	"	Not sized	5	Speckled
36	"	"	"	12½%	3%	"	Hard	180	Varnished, unevenly sized, and brittle
37	Unbleached sulphite	Free rosin	"	5%	3%	"	Not sized	1	
38	"	Nil	Aluminum hydrate	Nil	4%	"	"	1	
39	"	Free rosin	"	3%	Chemical equivalent one-half	"	"	1	
40	"	"	"	5%	1%	"	"	1	
41	"	Nil	Nil	Nil	Nil	"	"	1	
42	"	"	Froth oil	"	"	"	"	1	
43	Unbleached soda	"	Nil	"	"	"	"	1	
44	"	"	Froth oil	"	"	"	"	1	
45	"	Free rosin	Nil	3%	"	"	"	1	
46	"	"	"	5%	"	"	"	3	Speckled
47	Unbleached sulphite	Alumina resinate (anhydr.) ¹	"	3%	"	"	"	2	
48	"	Alumina resinate (hydrated) ¹	"	5%	"	"	"	3	
49	Unbleached sulphite	Alkaline soln. of alumina resinate	Nil	5%	Nil	"	Not sized	1	Softened
50	"	Alumina resinate (anhydr.) ¹	Alum	5%	3%	Alumina resinate	Slightly	7	Hardened

¹ The aluminum resinate was applied under ordinary conditions. The papers were run off on a model Fourdiner machine, all being of equal thickness, but not glazed or calendered.

of free rosin, forming what may be best described as a varnish, continuously, though unevenly distributed. Moreover, it has been repeatedly stated by a number of observers that free rosin particles are the effective "sizing agents;" consequently, it occurred to us to try the effect of dispensing with the double operation as carried out in our modern beating engines, and going one step further, to use an all free-rosin emulsion in place of the usual high free-rosin sizes. The results of many attempts, however, were unsatisfactory and conclusive.

Under ordinary circumstances, using normal quantities of size, rich in or entirely composed of free rosin, however intimately the free rosin may have penetrated into the fiber, it will not hard-size it.

The conclusions which have been arrived at by the sizing tests on a practical scale, and also those based upon entirely different considerations, *i. e.*, the behavior of alumina resinate itself, seem to be in striking opposition to much of the doctrine hitherto formulated, and we are brought now to the question of the part played by cellulose in the order of reactions in relation to sizing. Now, Messrs. Cross and Bevan (see work 1900, etc.) suggest that cellulose would decompose the neutral resinate by combining with alumina, and also simultaneously with the rosin acids. From this, one may presume that compounds of "cellulose-alumina resinate" may possibly exist, which would conveniently explain away some of the previous difficulties. Experimental work goes to prove to us that, although such compounds undoubtedly exist, they are only formed under certain circumstances, or, one might say, special conditions, which, under the existing "modus operandi" of paper mills, are liable to be overlooked. As a general statement, it is admitted that when the condition of the pulp in the beater is basic the alumina resinate is partially broken up, and the cellulose, when in the right state, displays a strong affinity towards it, the evolved compound becoming more active by virtue of the union of the cellulose with the resins of alumina. This subject we propose to treat with in detail in a later publication. It is worthy of note that this type of reaction cannot be said to be constant for all varieties of cellulose, as it has been frequently observed that the completeness of the interactions vary considerably with different kinds and conditions of cellulose. The study of the compound celluloses (so far as this investigation has taken us) regarding their reactions with alumina resinate has led to their division into two classes. For example, according to the previous "conditioning" one can obtain two very dissimilar sizing effects on the same pulp, though using exactly the same proportions of size. In one, predominating, the distinctive properties of alumina resinate may be easily recognized. In the other mixture, many of the properties of the chief components are changed, which can beyond all doubt be affirmed to be due to the formation of a new chemical compound. We are thus disposed to consider the distinction between the various mixtures and chemical compounds, produced during the course of engine-sizing, as being only relative to the primary condition of the cellulose.

In conclusion, it can be anticipated from the foregoing remarks that the hope of a speedy and definite settlement of this question will be justified when the chemical changes which take place between cellulose and alumina resinate are more widely known and that the importance of righting these doubtful issues will be recognized.

AYNSOME TECHNICAL LABORATORIES,
LANCASHIRE, ENGLAND.
March 29, 1911.

THE CHEMISTRY OF ANAESTHETICS, II: EXAMINATION OF COMMERCIAL OXYGEN.¹

By CHARLES BASKERVILLE AND RESTON STEVENSON.

A critical study of the many chemicals used for anaesthetic purposes and the modern methods of administration involves the use of oxygen. This paper records the results of the examination of commercial "C. P." oxygen of the various kinds procurable on the market, for its strength and medicinal and chemical purity.

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A. BIBLIOGRAPHY.

1. *The Methods of Preparation of Oxygen.*

The alchemists² were probably acquainted with oxygen, perhaps also the Greeks³ in the fourth century, and the Chinese,⁴ long before Priestley's experiments. In 1630, Jean Rey⁵ knew that certain metals, when heated, fix a portion of the air, and in 1674 Mayow prepared oxygen from niter. In 1771, Scheele⁷ prepared a gas by heating several oxides, including the black oxide of manganese, and, at about the same time, Cavendish⁸ studied oxygen. To Priestley,⁹ however, has been given the honor of discovering oxygen as a constituent of the air. Davy¹⁰ and Lavoisier¹¹ later studied the preparation and nature of this gas.

¹ Read at the regular March meeting of the New York Section of the American Chemical Society, 1911.

² Bolton, *Am. Chem.*, **4**, 170.

³ Hoefer, *Histoire de la Chimie*, **2**, 271.

⁴ Duckwood, *Chem. News*, **53**, 250.

⁵ Jean Rey, *Essai sur la recherche de la cause pour laquelle l'estain et le plomb augmentent de poids quand on les calcine*. Bazas, 1630.

⁶ Mayow, Rodwell, *Chem. News*, **8**, 113.

⁷ Scheele, *Chemische Abhandlung von der Luft und dem Feuer*. Upsala u. Leipzig, 1777.

⁸ Cavendish, *Trans. Roy. Soc.*, **56**, 432; **74**, 119, 170; **75**, 372.

⁹ Priestley, *Ibid.*, **62**, 147; **65**, 384; **73**, 398; **75**, 279; **78**, 147, 313; **79**, 7, 289; *Experiments and Observations on Different Kinds of Air*, London, **2**, 29 (1775-1777); **3**, 1; *Experiments and Observations Relating to Various Branches of Natural Philosophy*, London, **1**, 192 (1779).

¹⁰ *Trans. Roy. Soc.*, **101**, 1.

¹¹ *Chem. J.* (Crell), **4**, 440; **5**, 125; *Chem. Ann.* (Crell), **1**, 33, 136 (1786); **1**, 354, 441, 528, 550, 552 (1788); **2**, 55, 262, 431, 433 (1788); **1**, 145, 162, 260, 323 (1789); **2**, 68, 145, 433 (1789); **1**, 69, 518 (1790); **1**, 71 (1791); **1**, 29 (1803).