àre always adsorbed much more strongly than might be surmised from their influence on the surface tension [1]. I determined stalàgmometrically the σ-c figure for phenol (also given in the figure): although it appeared to lie between that of isobutyl and propyl alcohol, the influence exerted by addition of phenol is greater than that caused by isobutyl alcohol, exactly as was to be expected. This investigation is being continued, also in connection with a direct investigation as to the adsorption of the substances added.

A more extended investigation in various directions appears to me desirable all the more because the results may elucidate several other problems in the chemistry of the colloids. I will again refer to this matter in due course.

Meanwhile the results obtained are interesting when taken in connection with the researches of H. Lachs and L. Michaëlis [2], who found that surface-active non-electrolytes exert no influence on the adsorption of electrolytes: the above described investigation, however, makes us surmise that although these two kinds of substances should not be put on a par with each other without further evidence, a displacement takes place nevertheless. The effect of the displacement, however, seems to elude the direct measurement, but it may be demonstrated by measurements of the limitation values. Hence, the said investigators could find a displacement effect for isoamylalcohol only, just the very alcohol which according to our research exerts the strongest power of displacement.

Utrecht, March 1913.   van 't Hoff-*Laboratory*.

Microbiology. — "*Potassium sulfur, and magnesium in the metabolism of Aspergillus niger.*" By Dr. H. J. Waterman. (Communicated by Prof. M. W. Beijerinck).

In earlier investigations I have shown that the elements carbon, nitrogen, and fosfor occur in large quantities in young mould material, but that, when it grows older, a considerable portion is again excreted as carbonic acid, ammonia, and fosforic acid [3]. During the development the plastic aequivalent of the carbon lowers to the half; as to the nitrogen, there is a threefold accumulation, whereas the quantity of fosfor in a young mould layer is ten times as large as that

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[1] Compare for instance I. Traube, Verh. d. deutschen physik Ges **10**, 880 (1908). In the Table on p. 901, Aniline the only aromatic compound, occupies a quite special position.

[2] Zeitschr. f. Elektrochemie **17**, 1 (1911)

[3] Folia microbiologica Bd. 1 p. 422, 1912. These Proceedings 1912.

TABLE I. POTASSIUM.

a. Nutrient liquid: Distilled water, 2% glucose, 0,2% ammoniumnitrate, 0,1% magnesiumsulfate (7 Aq.), 0,1% ammonium fosfate, 0,02% calciumnitrate (free from water), 0,04% manganesechloride (MnCl$_2$. 4 Aq.). $t = 34°$ C.

Nr.	Addition of KCl milligr.	gram-mol. p. L.	1	2	3	4	5	10	30 days
1	0	0	+	+	+, few spores	+, few spores		few spores	+, hardly any spores
2	0,1	$\frac{1}{37500}$	+	+++	++, beginning sp. formation	+++, rather many sp.	rather many sp.	+++++, few spores
3	0,6	$\frac{6}{37500}$	+	+++	+++++, beg. sp. formation	+++++, many spores	many spores	+++++, rather many sp,
4	1,0	$\frac{1}{3750}$	++++++	+++++++, beg. sp. formation	++++++, many spores	" "	+++++++, many spores
5	2,0	$\frac{2}{3750}$	++++++	+++++, few spores	+++++, rather many sp.	" "	+++++, many spores

(few spores, bracketed across columns 1–2 for Nr. 2–5)

b. Nutrient liquid: Distilled water, 2% glucose, 0,15% ammoniumnitrate, 0,1% magnesiumsulfate (7 Aq.), 0,05% fosforic acid (crystallised), 0,01% MnCl$_2$. 4Aq. $t = 34°$ C.

Nr.	Addition of KCl milligr.	gram-mol. p. L.	1	2	3	4	8 days
1	0	0		+-++, no spores	++, no spores	++, few spores	++, hardly any spores
2	0,001	$\frac{1}{3750000}$		" "	" "	" "	" " "
3	0,01	$\frac{1}{375000}$		" "	" "	" "	+++, no spores
4	0,1	$\frac{1}{37500}$		++, beginning spore formation	+++, beg. sp. formation	+++, rather many spores	+++++, beginning spore formation
5	1 ·	$\frac{1}{3750}$		+++, very few spores	+++++++, few spores	+++++++, beg. spore formation	+++++, rather many spores
6	2	$\frac{2}{3750}$	+	+++++, very few spores	" "	+++++++, few spores	+++++++, many spores
7	5	$\frac{5}{3750}$		" "	" "	" "	" ♩
8	12	$\frac{12}{3750}$		" "	" "	" "	" "
9	15,5	$\frac{15,5}{3750}$		" "	" "	" "	" "
10	35,5	$\frac{35,5}{3750}$		" "	" "	" "	" "
11	85,5	$\frac{85,5}{3750}$		" "	" "	" "	" "

contained in a similar old one. Various influences on the metabolism, such as temperature, concentration, hydrogenions, boric acid, manganese, rubidium, etc., were studied, in which only changes of velocity were observed.

I have now continued these experiments, more qualitatively, with potassium sulfur, and magnesium and obtained the following results.

a. Potassium. I used a nutrient liquid of the composition given in Table I. The constituents of the solution in the series of experiments *b* were the same as those of *a*, only no calcium had been added, because, as I have shown before, the non-adding of this element under the mentioned circumstances, has no influence on the velocity or the nature of the metabolism. This was also the case with chlorine.

The cultivation was always effected in ERLENMEYER flasks of Jena glass and of 200 cm³. capacity, the volume of the medium being 50 cm³. The distilled water was once more purified in an apparatus of Jena glass. These experiments prove that the quantity of produced mould, even in the Nrs. *a* 1 and *b* 1, where no potassium was added, is not inconsiderable. This may be ascribed to the difficulties accompanying the exclusion of traces of this element. Further we see that by excess of potassium the spore formation is temporarily inhibited. Compare Nr. 5 with Nr. 4, after 4 and 5 days (Table *a*), and Nr. 6 and following Nrs. with 5, after 4 days (Table *b*). This inhibition of spore formation by an excess of a necessary element finds its cause in the cells being able to accumulate reserve food. [1]).

Finally Table I shows that deficiency of potassium does provoke production of mycelium but no spore formation (Nrs. 1—3, Table I *b*).

Only at $\dfrac{1}{37500}$ gr. mol. KCl. p. L. spore forming begins after 8 days.

Formerly [2]) I have shown that potassium can but partly be replaced by rubidium. Whereas the production of mycelium is possible as well with· potassium as with rubidium, spore formation takes only place with a certain percentage of potassium and not at all with rubidium. It was likewise proved that manganese is necessary for the latter process. The results given in Table I prove that at very low concentrations the action of potassium is quite analogous to that of rubidium : mycelium is formed, but hardly any spores, and this in spite of the presence of large quantities of manganese.

In the physiological action of potassium thus, two functions are to be distinguished, one corresponding with that of rubidium, the other with that of manganese.

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[1]) These Proceedings, 1912.

[2]) These Proceedings, 1912.

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b. Sulfur. The results of the experiments on the action of different sulfate concentrations are found in Table II.

Here we see that in the culture tubes (N° 1), where no sulfur was added, development takes place, just as had before been observed for the nitrogen, the fosfor, and the potassium. A considerable spore formation took place after 2 days already in Nrs. 1—7, which had a deficiency of sulfur, whilst in the experiments with more sulfur the production of spores was at first slackened. Nrs. 8—20 had only few spores. After 3 days Nrs. 14—20 had hardly any, whilst in all other culture tubes an important spore formation had already occurred. After 4 days these differences were less marked; after 40 days all the mould layers were covered with a considerable number of spores. The explanation of this temporary inhibition of the spore production is the same as for the elements treated before. In other respects, too, the sulfur quite corresponds with the other elements. *Like the carbon, nitrogen, and fosfor, the sulfur accumulates in the cells and is afterwards partly excreted.*

Indirectly this could already be shown by the following consider ations.

We see that in Nr. 8, after 3 days only 34,5 %, after 3 days in Nr. 9, 36 %, after 40 days already 48 % of the glucose has been assimilated, notwithstanding after 3 days no sulfate was left in the solution. Evidently during the development of the organism by the dissimilation of an intermediary product, sulfate is set free in the liquid so that the assimilation of the glucose can go on. This is still more obvious in Nrs. 11—13. After 3 days the assimilation of the glucose was 49 %, after 4 days it mounted to 61 %, and after 40 days already 82 % of the glucose had been used, whereas, here too, after 3 days already, all the sulfate had disappeared from the solution. By direct analysis was shown that an old, mature mould layer indeed contains less sulfur than a young one obtained in quite the same way and under the same conditions.

To this end the mould was, after frequent washing with distilled water, destroyed by fuming nitric acid, in a closed tube at 300° C. The sulfate was precipitated in the usual way.

It was here proved that of 4 mature mould layers (70 and 40 days old), treated in this way, after 3 to 4 hours' heating on a low flame, no precipitate was formed, whereas 4 young moulds (3 and 4 days old) [1]), likewise treated, did give a precipitate after heating. In what condition the sulfur, temporarily withdrawn from the liquid, exists in the organism, must for the moment be left undiscussed.

·) These were the mould layers of Nrs. 14, 18, 15, 16 (Table II).

T A.B L E IV. *Activation of magnesium by zinc.*

Nutrient liquid: 50 cm³ of distilled water in a Jena glass apparatus, in which dissolved 2 % glucose, 0,15 % ammoniumnitrate, 0,1 % potassiumsulfate, 0,05 % potassiumchloride, 0,05 % fosforic acid (crystallised), 0,01 % manganese sulfate.

No.	Added	Development after			
		1	3	4	12 days
1	—		—	—	?
2	—		—	—	—
3	—		—	—	—
4	0 001 mgr. ZnSO₄.7 Aq		Germination	+	+—++
5	0,01 „ „ „		?	+	+
6	0,001 „ MgSO₄ 7 Aq		—	—	—
7	0,001 „ MgSO₄.7 Aq + 0,001 mgr. ZnSO₄ 7 Aq		—	—	Germination
8	0,001 „ MgSO₄.7 Aq + 0,001 mgr. Cadmiumsulfate		—	—	—
9	0,001 „ MgSO₄.7 Aq + 0,01 mgr. strontiumnitrate		—	.—	?
10	0,001 „ MgSO₄.7 Aq + 0,001 mgr. HgCl₂		—	—	—.
11	0,005 „ MgSO₄.7 Aq		—	—	—
12	0,005 „ MgSO₄.7 Aq + 0,001 mgr. ZnSO₄.7 Aq		—	+ (slight)	+
13	0,005 „ MgSO₄.7 Aq + 0,01 mgr. ZnSO₄.7 Aq		—	?	Germination
14	0,01 „ MgSO₄.7 Aq		?	+ (slight)	+
15	0,05 „ „ „		Germination	+	++, no spores
16	0,1 „ „ „		+	++, no spores	++, no spores
17	0,3 „ „ „	+	++, beginning sp. formation	+++, beg. sp. formation	++++, beg. sp. formation
18	0,5 „ „ „	+	+++, beg. sp. formation	++++, beg. sp. formation	+++++, rather many sp.
19	1 „ „ „	+	++++, no spores	++++++, beg. sp. form	+++++++, many spores
20	5 „ „ „	+	++++++, few spores	++++++, rather many sp.	++++++ many spores

It may finally be called to mind that with deficiency of a necessary element the metabolism of *Aspergillus niger* remains unchanged. This follows from the amounts found for the plastic aequivalent of the carbon. The table shows, namely, that only trifling differences are found for all the simultaneous determinations. We see, moreover, that those mould layers, which are more developed, possess a correspondingly lower plastic aequivalent.

c. Magnesium. Whilst in the study of the other required elements it was found that even the slightest quantities cause a perceptible growth, magnesium behaves quite otherwise. Relatively great quantities $\left(\dfrac{1}{2470000}\ \text{gr. mol. Mg SO}_4\ 7\ \text{Aq. per L.}\right)$ did not, even after a prolonged cultivation, produce any macroscopically perceptible mycelium, whereas stronger concentrations $\left(\dfrac{2}{247000}\ \text{gr.mol. Mg SO}_4\ 7\ \text{Aq. p. L.}\right)$, only after some days caused a considerable growth.

This result warns us to be cautious in the computation of a production in a way as suggested by MITSCHERLICH [2]) even in a relatively simple case such as the present. The results of the referring experiments are found in Table III.

The explanation of the above fact has not yet been found. It might be supposed that the metabolism of the magnesium is extremely slow; whereas for each individual cell much magnesium should be wanted. More acceptable, however, is the supposition that by absence or deficiency of magnesium some unknown factor in the medium is allowed to exert its noxious influence which may be counteracted by addition of more magnesium. Beryllium, lithium, manganese, and calcium cannot replace magnesium. (See Table III). Zinc can replace it, as is shown by the experiments, whose results are exposed in Table IV.

For cadmium, strontium, and mercury I have not as yet been able to find an action analogous to that of zinc. Nrs. 12 and 13 are in particular convincing as they show *that even the slightest quantities of zinc are sufficient to activate magnesium* (0,02 mgr. ZnSO$_4$. 7 Aq. p. L.).

The abundant growth in Nrs. 4 and 5 is also remarkable as not any magnesium was added there. This does not, however, prove that the magnesium is here replaced by zinc, as it is always possible that slight quantities of magnesium are present in the solution, so that in this case, too, the influence of the zinc may be only an

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[2]) MITSCHERLICH, Bodenkunde für Land- und Forstwirte, 2te Aufl. Berlin 1913.

activating one. This effect is the more important as hitherto I have not succeeded in the usual way to demonstrate a favourable influence of zinc.

Laboratories for Microbiology and Organical Chemistry
of the Technical University

Delft, March 1913.

Physics. — *"On the law of partition of energy"*. II. By J. D. VAN DER WAALS Jr. (Communicated by Prof. J. D. VAN DER WAALS).

§ 6. It is obvious that the chance that the value of one of the variables p or q lies between specified limits cannot be represented by a normal frequency curve. If however we investigate a region of the spectrum, which is very narrow, but yet contains many elementary vibrations, then we find another probability curve than for one single elementary vibration. If the region is sufficiently small, then the radiation will appear to us to be homogeneous. Only an observation during a long time (i.e. very long compared with one period) will reveal the want of homogeneity by the increase and decrease of the amplitude in consequence of beats. In order to describe the momentaneous condition we can represent one elementary vibration by :

$$a \sin \frac{2\pi t}{T} + b \cos \frac{2\pi t}{T}$$

and the total vibration of the spectral region by :

$$(\Sigma a) \sin \frac{2\pi t}{T} + (\Sigma b) \cos \frac{2\pi t}{T}.$$

In this expression the separate a's and b's may have all kinds of values. The chance that they lie between specified limits is not represented by a normal frequency curve. But this does not detract from the fact that the chance for a specified value of $(\Sigma a) = A$, is represented by a normal curve, at least if the sum contains a sufficiently great number of terms.

Let us imagine that the decrease of the amplitude of the vibrators in consequence of the radiation has such a value, that they are perceptibly set vibrating by a great number of elementary vibrations whose period does not differ too much from the fundamental period of the vibrators, then MAXWELL's law will hold for the chance that the velocity of a vibrating particle lies between specified limits. The mean energy of a linear vibrator is probably rightly represented by