verdickungen durch Resorption aufgelöst worden sind, auch wenn sie lebenden Inhalt führen, wie *Aristolochia brasiliensis*, das neue Theilungsgewebe hervorgegangen sein kann.

7. Das Eindringen der den Stereomring begrenzenden Parenchymzellen erfolgt sowohl vom Aussenrande des Ringes, als auch von dessen innerer Seite.

The Poisonous Effect Exerted on Living Plants by Phenols.

By

Rodney H. True, Ph. D., and Carl G. Hunkel, B. S.1)

(Continued.)

Ortho-cresol, $C_6H_4(CH_3)(OH) = 1:2$.

Table XVI.

Begun May 26, 3 : 30 P. M.

Gram-mol. per liter.	Length May 27. 3 : 15 P. M.	Length May 30. 9 : 40 A. M.	Condition.
1/400	21,0 mm	20,0 mm	Dead.
	16,0 „	15,0 „	„
	15,0 „	14,0 „	„
	15,0 „	14,0 „	„
1/800	19,0 „	41,0 „	Alive.
	21,0 „	36,0 „	„
	15,0 „	14,5 „	Dead.
	21,5 „	46,5 „	Alive.

Table XVII.

Ortho-cresol + 1 NaOH.

Begun Feb. 13, 12 : 30 P. M.

Gram-mol. per liter.	Length Feb. 14. 9 : 50 A. M.	Length Feb. 15. 11 : 00 A. M.	Condition.
1/400	18,0 mm	20,5 mm	Alive.
	17,8 „	—	Injured.
	21,5 „	24,0 „	Alive.
	18,5 „	21,5 „	„
1/800	16,5 „	17,0 „	„
	18,5 „	22,0 „	„
	28,5 „	30,0 „	„
	20,5 „	25,0 „	„

Table XVIII.

Electrical Conductivity of Ortho-cresol (Bader).

V.	μv	100 k.
19,34	0,325	0,0000042
36,64	0,46	0,0000043

$\mu\infty = 356$ K = 0,0000042.

Meta-cresol, $C_6H_4(CH_3)(OH) = 1:3$.

Table XIX.

Begun Feb. 2, 4:50 P. M.

Gram-mol. per liter.	Length Feb. 3. 11:00 A. M.	Length Feb. 4. 2:30 P. M.	Condition.
1/400	17,0 mm	18,5 mm	Dead.
	15,0 „	—	„
	17,0 „	—	„
	14,5 „	17,0 „	„
1/800	25,0 „	38,0 „	Alive.
	19,0 „	26,0 „	„
	18,0 „	22,0 „	„
	23,0 „	33,0 „	„

Table XX.

Meta-cresol + 1 NaOH.
Begun Feb. 13, 12:25 P. M.

Gram-mol. per liter.	Length Feb. 14. 9:35 A. M.	Length Feb. 15. 10:30 A. M.	Condition.
1/400	16,0 mm	19,5 mm	Alive.
	18,0 „	19,0 „	„
	20,0 „	22,0 „	„
	21,0 „	25,5 „	„
1/800	22,0 „	33,0 „	Alive.
	15,0 „	—	Dead.
	20,5 „	30,5 „	Alive.
	23,0 „	42,0 „	„

Table XXI.

Electrical Conductivity of Meta-cresol (Bader).

V.	μv	100 k.
20	0,20	0,0 000 017
40	0,29	0,0 000 017
80	0,79	0,0 000 020
160	0,79	0,0 000 031

$\mu\infty = 356$. K = 0,0 000 017.

Para-cresol, $C_6H_4(CH_3)(OH) = 1:4$.

Table XXII.

Begun Feb. 15, 5:00 P. M.

Gram-mol. per liter.	Length Feb. 16. 2:20 P. M.	Condition.
1/800	14,5 mm	Dead.
	15,5 „	„
	14,5 „	„
	16,0 „	„
1/1600	24,5 „	Alive.
	20,5 „	„
	24,0 „	„
	23,5 „	„

Table XXIII.

Para-cresol + 1 NaOH.
Begun Feb. 16, 2:25 P. M.

Gram-mol. per liter.	Length Feb. 17. 2:35 P. M.	Length Feb. 18, 5:00 P. M.	Condition.
1/800	18,5 mm	—	—
	19,9 „	24,0 mm	Dead.
	15,0 „	15,0 „	Alive.
	17,0 „	17,5 „	Dead. (?)
1/1600	23,0 „	29,5 „	Alive.
	30,0 „	50,0 „	„
	21,0 „	35,0 „	„
	17,0 „	21,0 „	„

Table XXIV.

Electrical Conductivity of Para-cresol (Bader).

V.	μv	100 k.
14,4	0,14	0,0000011
28,8	0,28	0,0000011
57,6	0,30	0,0000012
115,2	0,48	0,0000016

$\mu\infty = 356$. K = 0,0000011.

As will be seen in the preceding tables of electrical conductivity, Bader was able to give a constant for the cresols. From his results, it appears that the ortho compound is more dissociated than the meta form, and this again more than the para isomer. The results observed in working with the lupines presented in the preceding tables indicate that a greater toxic activity is possessed by the para-cresol than by its isomers. It seems probable, however, that the difference in dissociation does not account for the difference in toxic activity seen.

This agrees in a general way with an observation by Kahlenberg and True[1]) on the ortho-, meta- and para-nitrobenzoic acids. The boundary-concentrations determined for lupines were 1/6400, 1/12800 and 1/12800 respectively; the degree of dissociation at a dilution of 1/1024 for these acids was 87,9 per cent, 44,4 per cent and 46,4 per cent respectively. Unpublished results by the same authors on the toxic activity of the sodium salts of these acids show the same toxic value, 1/400, for all three isomers.

Tables XVII, XX and XXIII present the results observed on adding NaOH to the cresols. The poisonous effect is somewhat diminished in all except para-cresol, the situation here being unchanged.

Filaments of Spirogyra placed in a solution of ortho-cresol containing 1/400 gram-molecule per liter, were found after twenty-

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[1]) Kahlenberg and True, Bot. Gaz. XXII. p. 122.

four hours to be little affected, nearly all responding to a plasmolysing solution promptly and in the normal manner. Filaments of the same alga placed in a solution of para-cresol containing 1/200 gram-molecule per liter were found after twenty-four hours to be dead, no surviving cell being seen. The protoplast had shrunken away from the wall, the chlorophyll band had broken up, and aggregated into several masses, and the protoplasm contained large numbers of highly refractive granules. In a solution containing 1/400 gram-molecule per liter, the chlorophyll band seemed somewhat disturbed, but the cells were not seriously injured and appeared to recover; those placed in a solution of half this concentration seemed to be unaffected.

Experiment seems to indicate that the toxic action of the cresols is chiefly due to the undissociated molecules in the ortho and meta compounds, the effect in part being due to $\overset{+}{H}$ ions and perhaps also in some degree to the anions.

From these results, it appears that the displacement of one of the hydroxyl groups of a di-atomic phenol by a methyl group may result in a compound of greater toxicity, and this toxic action will depend for its intensity somewhat on the position which this radicle occupies in the molecule, the strongest action here characterizing the para compound.

By introducing an isopropyl group $(-CH[CH_3]_2)$ into the para position to the methyl group in ortho- and meta-cresols, we obtain carvacrol and thymol respectively with the formulae: carvacrol, $C_6H_3\ (CH_3)\ (OH)\ (C_3H_7) = 1 : 2 : 4$, and thymol, $C_6H_3\ (CH_3)\ (OH)\ (C_3H_7) = 1 : 3 : 4$. Since no study of the electrical conductivity of these compounds has been made as far as the writers are aware, evidence of this nature could not be here cited.

Carvacrol, $C_6H_3\ (CH_3)\ (OH)\ (C_3H_7) = 1 : 2 : 4$.

Table XXV.

Begun Feb. 27, 4 : 30 P. M.

Gram-mol. per liter.	Length Feb. 28. 3 : 20 P. M.	Length Mch. 2. 4 : 10 P. M.	Condition.
1/1600	15,0 mm	—	Dead.
	14,0 „	—	„
	14,5 „	—	„
	15,0 „	—	„
1/3200	19,5 „	32,5 mm	Alive.
	21,0 „	33,0 „	„
	18,0 „	28,0 „	„
	19,0 „	30,5 „	„
1/6400	24,0 „	54,0 „	„
	24,0 „	52,0 „	„
	16,5 „	32,0 „	„
	21,5 „	48,5 „	„

Table XXVI.

Carvacrol + 1 NaOH.
Begun Feb. 27, 4 : 25 P. M.

Gram-mol. per liter.	Length Feb. 28. 3 : 30 P. M.	Length Mch. 2. 4 : 15 P. M.	Condition.
1/1600	15,0 mm	14,5 mm	Dead.
	15,0 „	15,0 „	„
	15,0 „	14,0 „	„
	15,0 „	14,5 „	„
1/3200	21,0 „	35,5 „	Alive.
	17,5 „	35,5 „	„
	18,0 „	20,0 „	„
	15,0 „	15,0 „	Dead.

Thymol, $C_6H_3(CH_3)(OH)(C_3H_7) = 1:3:4$.

Table XXVII.

Begun Feb. 23, 5 : 50 P. M.

Gram-mol. per liter.	Length Feb. 24. 3 : 15 P. M.	Length Feb. 25. 3 : 30 P. M.	Condition.
1/1600	14,5 mm	14,5 mm	Dead.
	15,0 „	15,0 „	„
	15,0 „	15,0 „	„
	14,5 „	14,0 „	„
1/3200	17,5 „	25,0 „	Alive.
	17,0 „	27,0 „	„
	15,0 „	15,0 „	Dead.
	19.0 „	33,5 „	Alive.
1/6400	22,0 „	44,5 „	„
	20,5 „	30,5 „	„
	17,0 „	44,0 „	„
	15,0 „	15,0 „	Dead.

Table XXVIII.

Thymol + 1 NaOH.
Begun Feb. 26, 4 : 00 P. M.

Gram-mol. per liter.	Length Feb. 27. 3 : 20 P. M.	Length Feb. 28.	Condition.
1/1600	14,5 mm	—	Dead.
	14,0 „	—	„
	14,5 „	—	„
	15,0 „	—	„
1/3200	17,5 „	26,0 mm	Alive.
	18,0 „	22,0 „	„
	24,0 „	28,5 „	„
	20,0 „	35,0 „	„

No measurements of the electrical conductivity of carvacrol or thymol are known to the authors, but probably no appreciable dissociation takes place, since the toxic action seems to be unchanged by the addition of NaOH, indicating the absence of H ions. The entire molecule in both of these substances is, therefore, to be regarded as responsible for the poisonous effect here seen.

The introduction of the isopropyl group ($CH[CH_3]_2$) is here seen to very materially increase the toxic properties of the molecule; no difference is, however, to be detected between the effectiveness of the ortho and the meta derivatives.

Orcinol may be regarded as resorcinol, C_6H_4 (OH) (OH) = 3 : 5, one hydrogen atom replaced by a methyl group (CH_3); or as phloroglucin, C_6H_3 (OH) (OH) (OH) = 1 : 3 : 5, in which one hydroxyl group has been displaced by a methyl group.

Orcinol, C_6H_3 (CH_3) (OH) (OH) = 1 : 3 : 5.

Table XXIX.

Begun May 6, 4 : 25 P. M.

Gram-mol, per liter.	Length May 7, 3 : 45 P. M.	Length May 28.	Condition.
1/200	15,0 mm	14,5 mm	Dead.
	14,5 „	14,5 „	„
	15,0 „	15,0 „	„
	15,0 „	15,0 „	„
1/400	25,0 „	48,0 „	Alive.
	15,5 „	17,0 „	„
	15,5 „	15,5 „	Dead (?).
	16,0 „	20,0 „	Alive.
	23.5 „	38,0 „	„

The addition of the methyl group (CH_3) increases appreciably the toxic value of the compound, as we have seen in the cresols. Comparing orcinol with resorcinol, we see that here again we have an increase of toxic activity, resorcinol 1/200 as against orcinol, 1/400. It might, however, be possible to regard orcinol as meta-cresol in which one H atom is replaced by an OH group. A comparison of the toxic value of meta-cresol (1/800) with that of orcinol (1/400) might point to the conclusion that in this case the addition of the OH group has diminished the toxic effect. Compared with phloroglucin, we see an increase of toxic action, this increase being in the ratio already seen when orcin is compared with resorcinol.

In the tables immediately following, we see the effect on plants resulting from the introduction into the molecule of nitrogen-containing radicles.

Ortho-nitrophenol, C_6H_4 (OH) (NO_2) = 1 : 2.

Table XXX.

Begun Jan. 30, 3 : 15 P. M.

Gram-mol. per liter.	Length Jan. 31. 10 : 50 P. M.	Length Feb. 2. 4 : 00 P. M.	Condition.
1/6400	14,5 mm		Dead, discolored.
	15,0 „		„ „
	15,0 „		„ „
	14,5 „		„ „
1/12800	15,0 „	15,0 mm	Dead.
	20,0 „	22,0 „	Alive.
	18,5 „	21,0 „	„
	20,5 „	25,0 „	„
1/25600	28,0 „		„
	26,0 „		„
	23,0 „		„
	27,5 „		„

Table XXXI.

Ortho-nitrophenol + 1 NaOH.
Begun Feb. 3, 2 : 35 P. M.

Gram-mol. per liter.	Length Feb. 4. 2 : 40 P. M.	Length Feb. 5. 2 : 00 P. M.	Condition.
1/1600	18,5 mm	18,0 mm	Dead. translucent.
	19,0 „	19,0 „	„
	18,0 „	18,5 „	„
	17,5 „	17,0 „	„
1/3200	20,5 „	23,0 „	Alive.
	20,5 „	22,5 „	„
	18,0 „	18,5 „	„ (?)
	20,0 „	21,0 „	„
1/6400	18,0 „	22,0 „	„
	27,0 „	30,0 „	„
	18,0 „	20,0 „	„
	15,5 „	—	—

Table XXXII.

Electrical Conductivity of Ortho-nitrophenol (Bader).

V.	μv	100 k.
250	4,09	0,000043
500	5,14	0,000043
1000	7,24	0,000041
2000	10,30	0,000044

$\mu\infty = 355$. K. = 0,000043.

Para-nitrophenol, $C_6H_4(OH)(NO_2) = 1 : 4$.

Table XXXIII.

Begun Feb. 14 : 15 P. M.

Gram-mol. per liter.	Length Feb. 2. 4 : 15 P. M.	Length Feb. 3. 11 : 00 A. M.	Condition.
1/3200	15,0 mm	—	Dead.
	15,5 „	—	„
	15,5 „	—	„
	15,5 „	—	„
1/6400	15,0 „	15,0 mm	„
	22,0 „	27,0 „	Alive.
	19,0 „	23,5 „	„
	19,5 „	25,0 „	„
1/12800	22,0 „	32,5 „	„
	28,0 „	36,0 „	„
	22,5 „	28,0 „	„
	25,0 „	31,0 „	„

Table XXXIV.

Paranitrophenol + 1 NaOH.

Begun Feb. 4, 4 : 00 P. M.

Gram-mol. per liter.	Length Feb. 4. 2 : 00 P. M.	Length Feb. 5.	Condition.
1/3200	15,0 mm	14,0 mm	Dead.
	15,0 „	14,5 „	„
	14,5 „	14,5 „	„
	16,0 „	15,5 „	
1/6400	15,5 „	22,0 „	Alive.
	16,0 „	20,5 „	„
	18,0 „	27,0 „	„
	15,0 „	—	Dead.

Table XXXV.

Electrical Conductivity of Para-nitrophenol (Bader).

V.	μv	100 k.
35,5	0,75	0,000012
71,2	1,04	0,000012
142,4	1,45	0,000012
284,8	2,13	0,000013
569,6	3,01	0,000013

$\mu\infty = 355$ K = 0,000012.

From Bader's tables we can calculate the degree of dissociation of ortho-nitrophenol to be 2,9 per cent at 2000 liters; 1,43 per cent at 500 liters. The para compound dissociates 0,9 per cent at 569,6 liters. At the dilution first permitting the lupines to survive, dissociation would seem to have advanced to some considerable extent, judging by the marked reduction of the toxic action in adding NaOH. The sum of the action of the anions and of the undissociated molecules seems, however to be still a strong factor in determining the toxic value of this compound.

The para compound seems to owe its effectiveness chiefly to the undissociated molecules. This is indicated by the absence of difference between the toxic values of the compound itself and of its Na compound. It schould be pointed out, however, in this connection that the comparatively small difference between the results obtained with these two isomers by Bader seems to indicate that the explanation may be hardly sufficient to account for the difference in physiological action noted.

Unfortunately, meta-nitrophenol was not available at the time these experiments were performed. This as well as reasons already suggested make a further study of the action of these isomers desirable.

It seems, however, clear that the introduction of a nitro group (NO_2) here increases to a marked degree the toxic value.

(To be conclud.)

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