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 Stercomring 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, $C_6 H_4$ (CH₃) (OH) = 1:2. Table XVI.

Begun May 26, 3:30 P. M.

Gram-mol. per	Length May 27.	Length May 30.	
liter.	3:15 P. M.	9:40 A. M.	Condition.
1/400	21,0 mm	20,0 mm	Dead.
	16,0 "	15,0 "	? 7
	15,0 .,	14,0 "	77
	15,0 "	14,0 "	7 7
1/800	19,0 "	41,0 "	Alive.
	21,0 "	36,0 "	77
	15,0	14,5 "	Dead.
	21,5 "	46,5 "	Alive.

Table XVII.

Ortho-cresol + 1 Na OH.

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 "	رز
1/800	16,5 "	17,0 "	**
	18 ,5 "	22,0 ,	77
	28,5	30,0 "	رز
	20,5 "	25.0 "	77

Table XVIII.

Electrical Conductivity of Ortho-cresol (Bader).

V.		uv	100 k.
19,34		0,325	0,0000042
36,64		0,46	0,0000043
/	$u\infty = 356$	К =	0,0000042.

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Meta-cres	ol, C ₆ H ₄ (CH	(OH) = 1:3	• •
	Tabl	e XIX.	
Begun Feb.	2, 4:50 P. M	[,	
Gram-mol. per	Length Feb. 3.	Length Feb. 4	ł.
liter.	11:00 A. M.	2:30 P. M.	Condition.
1/400	17,0 mm	18,5 mm	Dead.
	15,0 "		77
	14.5	17.0	27
1/800	25.0	38.0 "	Alive.
1,000	19.0 "	26.0 "	
	18,0 "	22,0 "	77 77
	23,0 "	33,0 "	22
	Tab	le XX.	
Meta-cresol	+ 1 Na OH.		
Begun Feb.	13, 12:25 P.	М.	
Gram-mol. per	Length Feb. 14	. Length Feb. 1	5.
liter.	9:35 A. M.	10:30 A. M.	Condition.
1/400	16,0 mm	19,5 mm	Alive.
	18,0 "	19,0 "	77
	20,0 "	22,0 "	77
1/800	21,0 "	33.0 "	Alive
1,000	15.0 "		Dead.
	20,5 "	30,5 "	Alive.
	23,0 "	42,0 "	77
	Tab	le XXI.	
Electrical C	onductivity of	Meta-cresol (Ba	der).
V.		$\mu \nabla$	100 k.
20		0,20	0,0000017
40		0,29	0,0 000 017
80		0,79	0,0 000 020
160	956	0,79	0,0000031
ų	$100 \equiv 550.$	K = 0,0000	017.
Para-cres	sol, C ₆ H ₄ (CH	(OH) = 1:4	4.
	Tabl	e XXII.	
Begun Feb.	15, 5:00 P.	М.	
Gram-mol. po liter.	er Lengt 2:5	h Feb. 16. 20 P. M.	Condition.
1/800	14	$,5 \mathrm{mm}$	Dead.
	15	,5 "	27
	14	ⁿ ⁿ	77
1/1600	16	,0 "	A 1770
1/1000	24 20	, 5 "	ATTIVE.
	20 24	.0	7 7
	23	,5 ⁿ	27

Table XXIII.

Para-cresol Begun Feb.	+ 1 Na OH. 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 ,,	77
	21,0 "	35,0 "	77
	17,0 "	21,0 "	77

Table XXIV.

Electrical Conductivity of Para cresol (Bader).

V.	μν	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,	0 000 011.

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 scems 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 True¹) 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 ercsols. 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-

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

³⁶³

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 twentyfour 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, C₆ H₃ (CH₃) (OH) (C₃ H₇) = 1:2:4, and thymol, C₆ H₃ (CH₃) (OH) (C₃ H₇) = 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.

Carveerol, C₆ H₃ (CH₃) (OH) (C₃ H₇) = 1:2:4.

Table XXV.

Dogun 100	·, · · · · · · · · · · · · · · · · · ·		
Gram-mol. per liter.	Length Feb. 28. 3:20 P. M.	Length Mch. 2. 4:10 P. M.	Condi t ion.
1/1600	15,0 mm		Dead.
	14,0 "	—	77
	14,5 "		77
	15,0 "		22
1/3200	19,5 "	32,5 mm	Alive.
	21,0 "	33,0 "	1 7
	18,0 "	28,0 "	27
	19,0 "	30,5 ,	77
1/6400	24,0 "	54,0 "	27
	24,0 "	52,0 "	77
	16,5	32,0 "	77
	21,5 "	48,5 .,	77

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

	Table XXVI		
Carvaerol + 1 Na	a OH.	•	
Begun Feb. 27. 4	1:25 P. M.		
Gram-mol. per liter. L	ength Feb. 28.	Length Mch. 2.	
P	3:30 P. M.	4:15 P. M.	Condition.
1/1600	$15,0 \mathrm{mm}$	14.5 mm	Dead.
	15,0 "	15.0 .	
	15.0	14.0	77
	15.0 "	14.5	77
1/3200	21.0	35.5	$\Delta h v o$
1.0200	17.5	35.5	7711, G.
	180 "	20.0	-7
	15,0 "	15.0	T) " 1
	10,0 "	15,0 ,,	Dead.
Thymol, C ₆ H ₃	(CH_3) (OH) $(C_3 H)$	$(1_7) = 1:3:4$	
	Table XXVI	[.	
Begun Feb. 23. 5	5:50 P. M.		
Gram-mol. per liter. L	ength Feb. 24.	Length Feb. 25.	
1	3:15 P. M.	3:30 P. M.	Condition.
1/1600	14,5 mm	14,5 mm	Dead.
	15,0 "	15,0 .,	77
	15,0 .	15,0 ,	**
	14.5 "	14.0	,,,
1/3200	17.5 "	25.0 "	Alive.
1,0200	17.0	27.0 "	
	15.0	15.0	Dead
	19.0	33.5	Alivo
1,6100	$\frac{10.0}{220}$	115 n	1111 v.C.
1/0400	22.0 "	20.5	77
	20,5 n	110 "	22
	17,0 "	44,0 "	, n ,
	15,0 ,,	15,0 "	Dead.
	Table XXVII	1.	
Thymol + 1 N	a OH.		
Begun Feb. 26, 4	::00 P. M.		
Gram-mol. per liter. L	ength Feb. 27. I	length Feb. 28.	~
111000	3:20 P. M.		Condition.
1/1600	14,0 mm		Dead.
	14,0 ,,	-Mandris - Sar	~ 7
	14,5 "	and the second se	π
	15,0 "	—	n
1/3200	17,5 "	26,0 mm	Alive.
	18,0 "	22,0 "	
	24.0	28,5 "	**
	20,0	35,0 "	,
No measurements	of the electrica	conductivity	of earwaer

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 [CHs]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, $C_6 H_4$ (OH) (OH) = 3:5, one hydrogen atom replaced by a methyl group (CH₃); or as phloroglucin, $C_6 H_3$ (OH) (OH) (OH) = 1:3:5, in which one hydroxyl group has been displaced by a methyl group.

 $Orcinol, C_6 H_3 (CH_3) (OH) (OH) = 1:3:5.$

Table XXIX.

Begun May 6,	4:20 P. M.		
Gram-mol, per liter.	Length May 7,	Length May 28.	
· •	3:45 P. M.		Condition.
1/200	$15,0 \mathrm{mm}$	14.5 mm	Dead.
	14,5	14,5 "	**
	15.0	15.0	
	15.0	15.0	77
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 "	11

The addition of the methyl group (CH_s) 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 metacresol 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 nitrogencontaining radicles.

Ortho-nitrophenol, $C_6 H_4$ (OH) (NO₂) = 1 : 2. Table XXX.

Begun Jan. 30,	3:15 P. M.		
Gram mol. per liter.	Length Jan. 31.	Length Feb. 2.	
-	10:50 P. M.	4:00 P. M.	Condition.
1/6400	14,5 mm	Dea	d, discolored.
	15,0 "	77	77
	15,0 "	17	77
	14,5 "	*7	77
1/12800	15,0 "	15,0 mm	Dead.
	20,0 "	22,0 "	Alive.
	18,5 "	21,0 "	77
	20,5 "	25,0 "	77
1/25600	28,0 "		77
	26,0 "		73
	23,0 "		23
	27,5 "		22
	/ //		11

Table XXXI.

Ortho-nitro Begun Feb. 3,	phenol + 1 N 2:35 P. M.	a OH.	
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 ,, 18,0	19,0 ,, 18,5 ,,	97 97
1/3200	17,5 , 20,5 ,	17,0 ", 23,0 "	Alive.
	20,5 " 18,0 "	22,5 ", 18,5 ", 21.0	n (?)
1/6400	18,0 ", $27,0$	21,0 " 22,0 " 30,0	77 77
	18,0 " 15.5 "	20,0 "	27 77

Table XXXII.

Electrical Conductivity of Ortho-nitrophenol (Bader). **V**. 100 k. μv 0,000043 2504,09 0,000043 500 5.147,24 0,000041 1000 10,30 0,000044 2000 K. = 0,000043. $\mu\infty = 355.$

Para-nitrophenol, $C_6 H_4$ (OH) (NO₂) = 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	—	"7
	15,5 $+$	—	**
	15,5 .,		77
1/6400	15,0 "	15,0 mm	77
	22,0 .,	27,0 "	Alive.
	19,0 .,	23,5 .,	17
	19,5 "	25,0 "	77
1/12800	22,0 "	32,5	77
	28,0	36,0 "	רק
	22,5 "	28,0 "	77
	25,0 "	31,0 "	77

Table XXXIV.

Para-nitrop	henol $+ 1$ Na(OH.	
Begun Feb. 4,	4:00 P. M.		
Gram-mol. per liter.	Length Feb. 4. 2:00 P. M.	Length Feb. 5.	Condition.
1/3200	$15,0 \mathrm{mm}$	$14,0 \mathrm{mm}$	Dead.
	15,0 ", 14,5 ", 16.0	14,5 ,, 14,5 ,, 15.5	רי רי
1/6400	15,5 16,0 18,0	22,0 " 20,5 " 27,0	Alive.
	15,0 "		Dead.

Table XXXV.

Electrical	Conductivity	of Para-nitrophenol	(B a d e r).
V.		μν	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 = 0,00001	2.

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 (NO₂) here increases to a marked degree the toxic value. (To be conclud.)

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