

THE EVALUATION OF THE BACTERICIDAL ACTIVITY OF ETHYLENE GLYCOL AND SOME OF ITS MONOALKYL ETHERS AGAINST *BACTERIUM COLI*

PART VII

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IN the previous paper¹, disinfection data from the reaction between *Bact. coli* and the monoalkyl ethers were analysed statistically. Mean probit-log. time regressions were calculated for each substance and confidence limits for the estimation determined. This present communication is devoted to the analysis of the disinfectant data of experiments conducted at 30°C.; the statistical methods used follow exactly those in Part VI of this series of papers¹.

DISINFECTION STUDIES OF ETHYLENE GLYCOL AND ITS MONOALKYL ETHERS AT 30°C.

Probit-log. time regressions at 30°C.

EXPERIMENTAL

Concentrations of ethylene glycol and the ethers were prepared and their disinfectant activity tested against *Bact. coli* at 30°C. by means of the standardised technique². In most instances four tests were carried out on each concentration.

RESULTS AND CALCULATIONS

Probit-log. time regressions were calculated for each test. Summaries of the terms necessary to calculate the mean slopes and the error mean square at each concentration are presented in Tables IA to VID.

TABLE IA

SUMMARY OF TERMS FROM CALCULATIONS OF PROBIT-LOG. TIME REGRESSIONS OF DISINFECTION OF *BACT. COLI* BY CONCENTRATIONS OF ETHYLENE GLYCOL AT 30°C.

Observation	Concentrations of ethylene glycol			
	62.5 per cent.	65.0 per cent.	67.5 per cent.	70.0 per cent.
$S[(x-\bar{x})(y-\bar{y})]$	1.591879	5.869394	2.657648	4.573893
$S(x-\bar{x})^2$	1.003779	4.035156	2.876413	3.440898
$S(y-\bar{y})^2$	3.229122	9.206112	3.206060	6.590027
N	5	13	13	12
SS for individual regressions... ..	3.199891	8.641415	3.008845	6.298689
b	1.588894	1.454565	0.923945	1.329273
SS pool... ..	2.524539	8.537411	2.488896	6.079953

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TABLE Ib

CALCULATION OF THE ERROR MEAN SQUARE OF REGRESSIONS FROM CONCENTRATIONS OF ETHYLENE GLYCOL AT 30°C.

Concentration	Item	Sum of squares	N	Mean square
62.5 per cent.	Common regression ...	2.524539	1	2.524539
	Variation in regression ...	0.675352	2	0.337676
	Total ...	3.199891	3	
	Residual in y ...	0.029231	5	0.005846
65.0 per cent.	Common regression ...	8.537411	1	8.537411
	Variation in regression ...	0.104004	3	0.034668
	Total ...	8.641415	4	
	Residual in y ...	0.564697	13	0.043438
67.5 per cent.	Common regression ...	2.488896	1	2.488896
	Variation in regression ...	0.519949	5	0.103889
	Total ...	3.008845	6	
	Residual in y ...	0.197215	12	0.016434
70.0 per cent.	Common regression ...	6.079953	1	6.079953
	Variation in regression ...	0.218736	3	0.072912
	Total ...	6.298689	4	
	Residual in y ...	0.291338	12	0.024278

TABLE Ic

SUMMARY OF STATISTICAL DATA FROM CALCULATIONS OF PROBIT-LOG. TIME REGRESSIONS OF CONCENTRATIONS OF ETHYLENE GLYCOL AT 30°C.

Concentration	Residual in y		Variation in b		SS pooled b	S[(x- \bar{x})(y- \bar{y})]	S(x- \bar{x}) ²
	SS	N	SS	N			
62.5 per cent.	0.029231	5	0.675352	2	2.524539	1.591879	1.003879
65.0 per cent.	0.564697	13	0.104004	3	8.537411	5.869394	4.035156
67.5 per cent.	0.197215	12	0.519949	5	2.488896	2.657648	2.876413
70.0 per cent.	0.291338	12	0.218736	3	6.079953	4.573893	3.440898
Totals ...	1.082481	42	1.518041	13	19.630799	14.692814	11.356346

$$\bar{b} = \frac{14.692814}{11.356346} = 1.293798$$

$$SS \text{ for joint regression} = \frac{(14.692814)^2}{11.356346} = 19.009529$$

TABLE Id

MEAN SQUARES OF THE VARIATIONS IN THE PROBIT-LOG. TIME REGRESSIONS FROM DISINFECTATION OF *BACT. COLI* BY CONCENTRATIONS OF ETHYLENE GLYCOL AT 30°C.

Item	N	Sum of squares	Mean square
Grand regression ...	1	19.009529	19.009529
Variation in regression between concentrations ...	3	0.621270	0.207090
Variation in regression within concentrations ...	13	1.518041	0.116772
Residual in y ...	42	1.082481	0.025773

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Combined data from the calculations of the probit-log. time regressions for ethylene glycol and its monoalkyl ethers at 30°C.

Table VII presents a summary of the massed statistical data from the calculations of probit-log. time regressions for concentrations of ethylene glycol and its monoalkyl ethers at 30°C. From it has been calculated the mean slope ($\bar{b}=1.5230$) and the sum of squares for the joint regression (121.781173).

TABLE IIA

SUMMARY OF TERMS FROM CALCULATIONS OF PROBIT-LOG. TIME REGRESSIONS OF DISINFECTION OF *BACT. COLI* BY CONCENTRATIONS OF ETHYLENE GLYCOL MONOMETHYL ETHER AT 30°C.

Observation	Concentrations of ethylene glycol monomethyl ether			
	35.0 per cent.	37.5 per cent.	40.0 per cent.	42.5 per cent.
$S[(x-\bar{x})(y-\bar{y})]$	4.661846	4.190510	2.212453	3.945919
$S(x-\bar{x})^2$	3.060121	3.194711	1.676468	3.512930
$S(y-\bar{y})^2$	7.476572	5.949571	3.278853	4.811554
N	11	13	7	14
SS for individual regressions... ..	7.255987	5.632065	3.182261	4.686665
b	1.523419	1.311702	1.319711	1.123256
SS pool... ..	7.101944	5.496702	2.919798	4.432276

The analysis of variance of the massed regressions is set out in Table VIII. The z 's for the various combinations have been calculated by the technique employed in Part VI¹ and have been presented in Table IX. The mean square for the residual in y (0.027826) has been used as

TABLE IIB

CALCULATION OF THE ERROR MEAN SQUARE OF REGRESSIONS FROM CONCENTRATIONS OF ETHYLENE GLYCOL MONOMETHYL ETHER AT 30°C.

Concentration	Item	Sum of squares	N	Mean square
35.0 per cent.	Common regression	7.101944	1	7.101944
	Variation in regression	0.154043	3	0.051348
	Total	7.255987	4	
	Residual in y	0.220585	11	0.020053
37.5 per cent.	Common regression	5.496702	1	5.496702
	Variation in regression	0.135363	3	0.044841
	Total	5.632065	4	
	Residual in y	0.317506	13	0.024431
40.0 per cent.	Common regression	2.919798	1	2.919798
	Variation in regression	0.262463	3	0.087486
	Total	3.182261	4	
	Residual in y	0.096592	7	0.013797
42.5 per cent.	Common regression	4.432276	1	4.432276
	Variation in regression	0.254389	3	0.084796
	Total	4.686665	4	
	Residual in y	0.124889	14	0.008921

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denominator to calculate the variance ratios between the different items. The probabilities of the significance between these items have been computed and included in Table IX.

TABLE IIc

SUMMARY OF STATISTICAL DATA FROM CALCULATIONS OF PROBIT-LOG. TIME REGRESSIONS OF CONCENTRATIONS OF ETHYLENE GLYCOL MONOMETHYL ETHER AT 30°C.

Concentration	Residual in y		Variation in b		SS pooled b	S[(x- \bar{x})(y- \bar{y})]	S(x- \bar{x}) ²
	SS	N	SS	N			
35.0 per cent.	0.220585	11	0.154043	3	7.101944	4.661846	3.060121
37.5 per cent.	0.317506	13	0.135363	3	5.496702	4.190510	3.194711
40.0 per cent.	0.096592	9	0.262463	3	2.919798	2.212453	1.676468
42.5 per cent.	0.124889	14	0.254389	3	4.432276	3.945919	3.512930
Totals	0.759572	45	0.806258	12	19.950720	15.010728	11.444230

$$\bar{b} = \frac{15.010728}{11.444230} = 1.311642$$

$$SS \text{ for joint regression} = \frac{(15.010728)^2}{11.444230} = 19.688695$$

TABLE IIb

MEAN SQUARES OF THE VARIATIONS IN THE PROBIT-LOG. TIME REGRESSIONS FROM DISINFECTATION OF *BACT. COLI* BY CONCENTRATIONS OF ETHYLENE GLYCOL MONOMETHYL ETHER AT 30°C.

Item	N	Sum of squares	Mean square
Grand regression	1	19.688695	19.688695
Variation in regression between concentrations ...	3	0.262025	0.087342
Variation in regression within concentrations ...	12	0.806258	0.067189
Residual in y	45	0.759572	0.016879

TABLE IIIA

SUMMARY OF TERMS FROM CALCULATIONS OF PROBIT-LOG. TIME REGRESSIONS OF DISINFECTATION OF *BACT. COLI* BY CONCENTRATIONS OF ETHYLENE GLYCOL MONOETHYL ETHER AT 30°C.

Observation	Concentrations of ethylene glycol monoethyl ether			
	12.5 per cent.	15.0 per cent.	17.5 per cent.	20.0 per cent.
S[(x- \bar{x})(y- \bar{y})]	5.204340	2.643049	2.917334	2.356392
S(x- \bar{x}) ²	3.686711	1.924663	2.346900	1.824886
S(y- \bar{y}) ²	8.478306	4.169134	3.977931	3.174931
N	13	9	11	5
SS for individual regressions... ..	7.867899	3.749695	3.755170	3.122334
b... ..	1.411649	1.373253	1.243059	1.291254
SS pool... ..	7.346699	3.629575	3.626417	3.042701

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TABLE IIIb

CALCULATION OF THE ERROR MEAN SQUARE OF REGRESSIONS FROM CONCENTRATIONS OF ETHYLENE GLYCOL MONOETHYL ETHER AT 30°C.

Concentration	Item	Sum of squares	N	Mean square
12.5 per cent.	Common regression	7.346699	1	7.346699
	Variation in regression	0.521200	3	0.173733
	Total	7.867899	11	
	Residual in y	0.610407	13	0.046950
15.0 per cent.	Common regression	3.629575	1	3.629375
	Variation in regression	0.120120	3	0.040040
	Total	3.749695	4	
	Residual in y	0.419439	9	0.046604
17.5 per cent.	Common regression	3.626417	1	3.626417
	Variation in regression	0.128753	3	0.042918
	Total	3.755170	4	
	Residual in y	0.222761	11	0.020251
20.0 per cent.	Common regression	3.042701	1	3.042701
	Variation in regression	0.079633	3	0.026544
	Total	3.122334	4	
	Residual in y	0.052597	5	0.010519

TABLE IIIc

SUMMARY OF STATISTICAL DATA FROM CALCULATIONS OF PROBIT-LOG. TIME REGRESSIONS OF CONCENTRATIONS OF ETHYLENE GLYCOL MONOETHYL ETHER AT 30°C.

Concentration	Residual in y		Variation in b		SS pooled b	S[(x- \bar{x})(y- \bar{y})]	S(x- \bar{x}) ²
	SS	N	SS	N			
12.5 per cent.	0.610407	13	0.521200	3	7.346699	5.204340	3.686711
15.0 per cent.	0.419439	9	0.120120	3	3.629575	2.643049	1.924663
17.5 per cent.	0.222761	11	0.128753	3	3.626417	2.917334	2.346900
20.0 per cent.	0.052597	5	0.079633	3	3.042701	2.356392	1.824886
Totals	1.305204	38	0.849706	12	17.645392	13.121115	9.783160

$$\bar{b} = \frac{13 \cdot 121115}{9 \cdot 783160} = 1.341194$$

$$SS \text{ for joint regression} = \frac{(13 \cdot 121115)^2}{9 \cdot 783160} = 17.597960$$

TABLE IIId

MEAN SQUARES OF THE VARIATIONS IN THE PROBIT-LOG. TIME REGRESSIONS FROM DISINFECTATION OF *BACT. COLI* BY CONCENTRATIONS OF ETHYLENE GLYCOL MONOETHYL ETHER AT 30°C.

Item	N	Sum of squares	Mean square
Grand regression	1	17.597960	17.595960
Variation in regression between concentrations	3	0.047432	0.015811
Variation in regression within concentrations	12	0.849706	0.070809
Residual in y	38	1.305204	0.034348

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Test of significance of the difference between the mean squares for variation in regression between concentrations and variations in regression between individual tests.

The same formulas as have been used in Part VI¹ are again used here.

$N_1=19$ and $N_2=73$, therefore $h=30.1522$.

$$\text{Hence } z_{(5 \text{ per cent.})} = \sqrt{\frac{1.6449}{30.1522-1}} - 0.7843 \left(\frac{1}{19} - \frac{1}{73} \right) = 0.27416$$

The observed value of $z(\bar{1}.99119)$ is less than that calculated at the 5 per cent. level, hence $P > 0.05$.

TABLE IVA

SUMMARY OF TERMS FROM CALCULATIONS OF PROBIT-LOG. TIME REGRESSIONS OF DISINFECTION OF *BACT. COLI* BY CONCENTRATIONS OF ETHYLENE GLYCOL MONOPROPYL ETHER AT 30°C.

Observation	Concentration of ethylene glycol monopropyl ether			
	3 per cent.	4 per cent.	5 per cent.	6 per cent.
$S[(x-\bar{x})(y-\bar{y})]$	1.890377	1.439740	2.695830	4.639438
$S(x-\bar{x})^2$	0.897739	0.599865	1.445619	2.113064
$S(y-\bar{y})^2$	4.421353	4.197453	5.949648	11.016602
N	5	5	6	11
SS for individual regressions... ..	4.274127	4.093332	5.760662	10.876641
b	2.105709	2.400107	1.864827	2.195597
SS pool... ..	3.980584	3.455530	5.027254	10.186338

TABLE IVB

CALCULATION OF THE ERROR MEAN SQUARE OF REGRESSIONS FROM CONCENTRATIONS OF ETHYLENE GLYCOL MONOPROPYL ETHER AT 30°C.

Concentration	Item	Sum of squares	N	Mean square
3.0 per cent.	Common regression	3.980584	1	3.980584
	Variation in regression	0.293543	2	0.146772
	Total	4.274127	3	
4.0 per cent.	Residual in y	0.147226	5	0.029445
	Common regression	3.455530	1	3.455530
	Variation in regression	0.637802	3	0.212601
5.0 per cent.	Total	4.093332	4	
	Residual in y	0.104121	5	0.020824
	Common regression	5.027254	1	5.027254
6.0 per cent.	Variation in regression	0.733408	3	0.244469
	Total	5.760662	4	
	Residual in y	0.188986	6	0.031498
6.0 per cent.	Common regression	10.186338	1	10.186338
	Variation in regression	0.690303	3	0.230101
	Total	10.876641	4	
	Residual in y	0.139961	11	0.012724

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Since there was no significant difference between the two items, the sums of squares have been combined and divided by the appropriate number of degrees of freedom to give an error mean square of 0.094755 (Table VIII).

TABLE IVc

SUMMARY OF STATISTICAL DATA FROM CALCULATIONS OF PROBIT-LOG. TIME REGRESSIONS OF CONCENTRATIONS OF ETHYLENE GLYCOL MONOPROPYL ETHER AT 30°C.

Concentration	Residual in y		Variation in b		SS pooled b	$S[(x-\bar{x})(y-\bar{y})]$	$S(x-\bar{x})^2$
	SS	N	SS	N			
3.0 per cent.	0.147226	5	0.293543	2	3.980584	1.890377	0.897739
4.0 per cent.	0.104121	5	0.637802	3	3.455530	1.439740	0.599865
5.0 per cent.	0.188986	6	0.733408	3	5.027254	2.695830	1.445619
6.0 per cent.	0.139961	11	0.690303	3	10.186338	4.639438	2.113064
Totals ...	0.580294	27	2.355056	11	22.649706	10.665385	5.056287

$$\bar{b} = \frac{10 \cdot 665385}{5 \cdot 056287} = 2.109331$$

$$SS \text{ for joint regression} = \frac{(10 \cdot 665385)^2}{5 \cdot 056287} = 22.496832$$

TABLE IVd

MEAN SQUARES OF THE VARIATIONS IN THE PROBIT-LOG. TIME REGRESSIONS FROM DISINFECTON OF *BACT. COLI* BY CONCENTRATIONS OF ETHYLENE GLYCOL MONOPROPYL ETHER AT 30°C.

Item	N	Sum of squares	Mean square
Grand regression ...	1	22.496832	22.496832
Variation in regression between concentrations ...	3	0.152874	0.050958
Variation in regression within concentrations ...	11	2.355056	0.214369
Residual in y ...	27	0.580294	0.021492

TABLE Va

SUMMARY OF TERMS FROM CALCULATIONS OF PROBIT-LOG. TIME REGRESSIONS OF DISINFECTON OF *BACT. COLI* BY CONCENTRATIONS OF ETHYLENE GLYCOL MONOBUTYL ETHER AT 30°C.

Observation	Concentration of ethylene glycol monobutyl ether			
	1.5 per cent.	2.0 per cent.	2.5 per cent.	3.0 per cent.
$S[(x-\bar{x})(y-\bar{y})]$...	3.109591	3.810624	4.120585	4.262868
$S(x-\bar{x})^2$...	1.924012	2.589282	2.602655	2.416612
$S(y-\bar{y})^2$...	5.471177	6.077422	6.713748	7.853541
N ...	11	11	10	9
SS for individual regressions... ..	5.048367	5.806799	6.591779	7.523255
b	1.616202	1.471691	1.583224	1.763985
SS pool	5.025726	5.608063	6.523808	7.519636

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TABLE V_B

CALCULATION OF THE ERROR MEAN SQUARE OF REGRESSIONS FROM CONCENTRATIONS OF ETHYLENE GLYCOL MONOBUTYL ETHER AT 30°C.

Concentration	Item	Sum of squares	N	Mean square
1.5 per cent.	Common regression	5.025726	1	5.025726
	Variation in regression	0.022641	3	0.007547
	Total	5.048367	4	
	Residual in y	0.422810	11	0.038437
2.0 per cent.	Common regression	5.608063	1	5.608063
	Variation in regression	0.198736	3	0.066268
	Total	5.806799	4	
	Residual in y	0.270623	11	0.024602
2.5 per cent.	Common regression	6.523808	1	6.523808
	Variation in regression	0.067971	3	0.022986
	Total	6.591779	4	
	Residual in y	0.121969	10	0.012197
3.0 per cent.	Common regression	7.519636	1	7.519636
	Variation in regression	0.003619	3	0.001206
	Total	7.523255	4	
	Residual in y	0.330286	9	0.036699

TABLE V_C

SUMMARY OF STATISTICAL DATA FROM CALCULATIONS OF PROBIT-LOG. TIME REGRESSIONS OF CONCENTRATIONS OF ETHYLENE GLYCOL MONOBUTYL ETHER AT 30°C.

Concentration	Residual in y		Variation in b		SS pooled b	S[(x- \bar{x})(y- \bar{y})]	S(x- \bar{x}) ²
	SS	N	SS	N			
1.5 per cent.	0.422810	11	0.022641	3	5.025726	3.109591	1.924012
2.0 per cent.	0.270623	11	0.198736	3	5.608063	3.810624	2.589282
2.5 per cent.	0.121969	10	0.067971	3	6.523808	4.120585	2.602655
3.0 per cent.	0.330286	9	0.003619	3	7.519636	4.262868	2.416612
Totals	1.145688	41	0.292967	12	24.677233	15.303668	9.532561

$$\bar{b} = \frac{15.303668}{9.532561} = 1.605410$$

$$SS \text{ for joint regression} = \frac{(15.303668)^2}{9.532561} = 24.568660$$

TABLE V_D

MEAN SQUARES OF THE VARIATIONS IN THE PROBIT-LOG. TIME REGRESSIONS FROM DISINFECTATION OF *BACT. COLI* BY CONCENTRATIONS OF ETHYLENE GLYCOL MONOBUTYL ETHER AT 30°C.

Item	N	Sum of squares	Mean square
Grand regression	1	24.568660	24.568660
Variation in regression between concentrations	3	0.108573	0.036191
Variation in regression within concentrations	12	0.292967	0.024414
Residual in y	41	1.145688	0.027944

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Test of significance of the difference between the mean squares for the variation in regression between the different compounds and the residual in y .

Here $N_1=5$ and $N_2=232$; from the statistical tables it is seen that the observed value of z (0.894322) is larger than the theoretical value even at the 0.1 per cent. level, (about 0.7), hence $P < 0.001$.

TABLE VIA

SUMMARY OF TERMS FROM CALCULATIONS OF PROBIT-LOG. TIME REGRESSIONS OF DISINFECTATION OF *BACT. COLI* BY CONCENTRATIONS OF ETHYLENE GLYCOL MONOHEXYL ETHER AT 30°C.

Observation	Concentration of ethylene glycol monohexyl ether				
	0.325 per cent.	0.350 per cent.	0.375 per cent.	0.400 per cent.	0.425 per cent.
$S[(x-\bar{x})(y-\bar{y})]$	2.915882	1.959550	1.374006	2.103304	2.816573
$S(x-\bar{x})^2$	1.219958	0.753519	0.751145	0.987800	1.619699
$S(y-\bar{y})^2$	7.555418	5.700525	3.132374	4.970084	5.323962
N	11	7	8	7	6
SS for individual regressions ...	7.147758	5.402183	2.776206	4.656061	5.117676
b	2.390150	2.600532	1.829215	2.129281	1.738948
SS pool	6.969394	5.095872	2.513353	4.478526	4.897875

TABLE VIb

CALCULATION OF THE ERROR MEAN SQUARE OF REGRESSIONS FROM CONCENTRATIONS OF ETHYLENE GLYCOL MONOHEXYL ETHER AT 30°C.

Concentration	Item	Sum of squares	N	Mean square
0.325 per cent.	Common regression	6.969394	1	6.969394
	Variation in regression	0.178364	3	0.059455
	Total Residual in y	7.147758 0.407660	4 11	0.037060
0.350 per cent.	Common regression	5.095872	1	5.095872
	Variation in regression	0.306311	3	0.102104
	Total Residual in y	5.402183 0.298342	4 7	0.042622
0.375 per cent.	Common regression	2.513353	1	2.513353
	Variation in regression	0.262853	3	0.087618
	Total Residual in y	2.776206 0.356168	4 8	0.044521
0.400 per cent.	Common regression	4.478526	1	4.478526
	Variation in regression	0.177535	2	0.088767
	Total Residual in y	4.656061 0.314023	3 7	0.04486
0.425 per cent.	Common regression	4.897875	1	4.897875
	Variation in regression	0.219801	2	0.109901
	Total Residual in y	5.117676 0.206286	3 6	0.034361

TABLE VIC

SUMMARY OF STATISTICAL DATA FROM CALCULATIONS OF PROBIT-LOG. TIME REGRESSIONS OF CONCENTRATIONS OF ETHYLENE GLYCOL MONOHEXYL ETHER AT 30°C.

Concentration	Residual in y		Variation in b		SS pooled b	$S[(x-\bar{x})(y-\bar{y})]$	$S(x-\bar{x})^2$
	SS	N	SS	N			
0.325 per cent.	0.407660	11	0.178364	3	6.969394	2.915882	1.219958
0.350 per cent.	0.298342	7	0.306311	3	5.095872	1.959550	0.753519
0.375 per cent.	0.356168	8	0.262853	3	2.513353	1.374006	0.751148
0.400 per cent.	0.314023	7	0.177535	2	4.478526	2.103304	0.987800
0.425 per cent.	0.206286	6	0.219801	2	4.897875	2.816573	1.619699

$$\bar{b} = \frac{11 \cdot 169315}{5 \cdot 332121} = 2.094723$$

$$SS \text{ for joint regression} = \frac{(11 \cdot 169315)^2}{5 \cdot 332121} = 23.396618$$

TABLE VID

MEAN SQUARES OF THE VARIATIONS IN THE PROBIT-LOG. TIME REGRESSIONS FROM DISINFECTATION OF *BACT. COLI* BY CONCENTRATIONS OF ETHYLENE GLYCOL MONOHEXYL ETHER AT 30°C.

Item	N	Sum of squares	Mean square
Grand regression	1	23.396618	23.396618
Variation in regression between concentrations ...	4	0.558402	0.139605
Variation in regression within concentrations ...	13	1.144864	0.088066
Residual in y	39	1.582479	0.040576

Test of significance of the difference between the mean squares for the variation in regression between concentrations and the residual in y .

Here $N_1=19$ and $N_2=232$, therefore $h=35.1235$; from this $z_{(5 \text{ per cent.})} = 0.24366$.

The observed value of $z(0.299278)$ is greater than that calculated at the 5 per cent. level, hence $P < 0.05$.

Test of significance of the difference between the mean squares for the variation in regression between tests and the residual in y .

Here $N_1=73$ and $N_2=232$, therefore $h=111.056$; from this $z_{(5 \text{ per cent.})} = 0.1497$.

The observed value of $z(0.308143)$ is greater than that calculated at the 5 per cent. level, hence $P < 0.05$.

Test of significance of the difference between the mean squares for the variation in the pooled regression (i.e. between concentrations between tests and residual in y .)

Here $N_1=92$ and $N_2=232$, hence $h=131.7531$; from this $z_{(5 \text{ per cent.})} = 0.1387$.

The observed value of $z(0.3063)$ is greater than that calculated at the 5 per cent. level, hence $P < 0.05$.

TABLE VII
 SUMMARY OF MASSES STATISTICAL DATA FROM CALCULATIONS OF PROBIT-LOG, TIME REGRESSIONS FOR CONCENTRATIONS OF ETHYLENE GLYCOL AND ITS MONOALKYL ETHERS AT 30°C.

Compound	Range of concentrations investigated	Residual in y						Variation in b						$S[(x-\bar{x})(y-\bar{y})]$	$S(x-\bar{x})^2$
		SS		N		Between tests		Between concentrations		SS		N			
		SS	N	SS	N	SS	N	SS	N	SS	N	SS	N		
Ethylene glycol	62.5 to 70.0 per cent.	1.082481	42	1.518041	13	0.621270	3	19.009529	14.692814	11.356346					
Monomethyl ether	35.0 to 42.5	0.759572	45	0.806258	12	0.262025	3	19.688695	15.010728	11.444230					
Monethyl ether	12.5 to 20.0	1.305204	38	0.849706	12	0.047432	3	17.597960	13.121115	9.783160					
Monopropyl ether	3.0 to 6.0	0.580294	27	2.355056	11	0.152874	3	22.496832	10.665385	5.056287					
Monobutyl ether	1.5 to 3.0	1.145688	41	0.292967	12	0.108573	3	24.568660	15.303668	9.532561					
Monohexyl ether	0.325 to 0.425	1.582479	39	1.144864	13	0.558402	4	23.396618	11.169315	5.332121					
Totals	...	6.455718	232	6.966892	73	1.750576	19	126.758294	79.963025	52.504705					

$$\bar{b} = \frac{79.963025}{52.504705} = 1.522969$$

$$SS \text{ for joint regression} = \frac{(79.963025)^2}{52.504705} = 121.781173$$

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Calculation of the standard errors of the probit-log. time regression coefficients at 30°C.

The variance of b is given by the formula $V_b = \frac{V_y}{S(x-\bar{x})^2}$ where V_y is the variance of y (the probit), i.e. the error mean square (0.094755, Table VIII) and $S(x-\bar{x})^2$ is the corrected sum of squares of x (the log.

TABLE VIII

ANALYSIS OF VARIANCE OF MASED REGRESSIONS FOR DISINFECTION OF *BACT. COLI* BY CONCENTRATIONS OF ETHYLENE GLYCOL AND ITS MONALKYL ETHERS AT 30°C.

Item	N	SS	Mean square	Variance ratio	Probability
Massed regression	1	121.781173	121.781173		
Variation in regression between compounds	5	4.977121	0.995424		
Variation in regression between concentrations	19	1.750576	0.092136	see Table IX	
Variation in regression between tests	73	6.966892	0.095437		
Residual in y	232	6.455718	0.027826		
Pooled error	92	8.717468	0.094755		

TABLE IX

CALCULATION OF z 'S FOR THE ITEMS IN THE ANALYSIS OF VARIANCE OF THE MASED REGRESSIONS IN TABLE VIII

N_1/N_2	Variance ratio (V.R.)	$\log_{10} V.R.$	$\frac{\log_e V.R.}{\log_{10} V.R. \times 1.15129}$	$z = \frac{1}{2} \log_e V.R.$	Probability
19/73	0.965412	1.9847	1.98238	1.99119	> 0.05
5/232	35.773162	1.5536	1.78864	0.89432	< 0.001
19/232	3.311148	0.5199	0.59856	0.29928	< 0.05
73/232	3.429774	0.5353	0.61629	0.30814	< 0.05
92/232	3.405000	0.5321	0.6126	0.3063	< 0.05

TABLE X

THE PROBIT-LOG. TIME REGRESSION COEFFICIENTS WITH THEIR STANDARD ERRORS, OF THE REACTION BETWEEN *BACT. COLI* AND ETHYLENE GLYCOL AND ITS MONOALKYL ETHERS AT 30°C.

Compound	b	N	$S(x-\bar{x})^2$	V_y	$s_b = \frac{V_y}{S(x-\bar{x})^2}$	Ratio of b to s_b
Ethylene glycol	1.293798	13	11.356346	0.094755	0.09135	14
Monomethyl ether	1.311642	12	11.444230		0.09099	14
Monoethyl ether	1.341194	12	9.783160		0.09842	14
Monopropyl ether	2.109331	11	5.056287		0.01369	15
Monobutyl ether	1.605410	12	9.532561		0.09978	16
Monohexyl ether	2.094723	13	5.332121		0.13330	16

time) for the regression lines of each compound. The standard error of the regression coefficients (V_b) have been computed and set out in Table X. As in the experiments at 20°C., the ratio of the regression coefficients to their slopes is large, thereby indicating that b has been satisfactorily estimated. Comparison with the results in Part VI, Table IX, indicates that the values of b are higher at 30°C. than at 20°C.

CONCLUSIONS

As with the results from the experiments at 20°C. (Part VI), the analysis of variance indicates that there is a significant variation in regressions between the different compounds, i.e. each substance has its characteristic regression coefficient which differs significantly from the average of the series.

The analysis also shows that the variations in the regressions between the concentrations of the substances are of the same order as the variation between the individual tests at a particular concentration. Hence the regressions of different concentrations of the same substance may be taken as parallel.

SUMMARY

1. The course of the disinfection (at 30°C.) between *Bact. coli* and several concentrations of ethylene glycol and the following ethers: monomethyl, monoethyl, monopropyl, monobutyl and monohexyl has been investigated. Several experiments were conducted at every concentration and probit-log. time regressions calculated for all experiments.

2. For every concentration of a substance the sum of squares for the common regression and for the variation in regression were calculated; the error mean square of the regression was also computed.

3. The data for every concentration of each compound have been pooled and a mean regression has been calculated for each compound.

4. The statistical data from all the calculations for the terms of the regressions for every concentration of the compounds (at 30°C.) have been massed and an analysis of variance carried out.

5. The probabilities for the differences between the mean squares of the items in the analysis of variance have been deduced by means of the z distribution.

6. No significant difference could be shown between the variation in regression between concentrations and between tests; these two errors have been pooled in order to establish the error mean square for all the estimations performed.

7. The probit-log. time regression coefficient for every compound has been compared with its standard error; in all cases the ratio was large, thereby indicating that b had been estimated satisfactorily.

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