

## COAGULATION OF THE PRUSSIAN BLUE-GUM GHATTI SOL BY PHENOL AND HYDROCHLORIC ACID

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**Introduction**

This paper is a continuation of the work presented to the South Dakota Academy of Science by Carhart and Shaw<sup>1, 2</sup>, to which the reader is referred for historical survey, experimental procedure, and a sample of the detailed data. Since the death of micro-organisms undoubtedly involves colloidal coagulation<sup>3</sup>, it seemed desirable to determine the kinetics of coagulation of a colloid by phenol, in order to compare it with the kinetics of toxic action. In the case of the toxic action of phenol, Watson<sup>4</sup> pointed out that the expression

$$C^n t = k$$

where C is the concentration of disinfectant  
t is the time required for disinfection  
n and k are constants

fitted the data of Chick<sup>5</sup>.

The Ishizaka<sup>6</sup> equation, which Carhart and Shaw<sup>2</sup> found to hold for the coagulation of the Prussian Blue-gum ghatti sol by KCl, can be converted to this form if we replace t by t<sub>s</sub>, the time to a given degree of coagulation.

**Experimental**

The coagulation experiments were carried out at 30±0.5°C., in 15 ml. centrifuge tubes, which were centrifuged continuously except during the short intervals when colorimetric comparisons of the uncoagulated residues were made. At each concentration of HCl, the colloidal samples containing varying amounts of phenol were made from the same batch of Prussian Blue-gum ghatti sol. Phenol alone did not produce coagulation of Prussian Blue or of the Prus-

<sup>1</sup> H. W. Carhart and E. H. Shaw, Jr., *Proc. So. Dak. Acad. Sci.*, **15**, 46-50 (1935).

<sup>2</sup> H. W. Carhart and E. H. Shaw, Jr., *Proc. So. Dak. Acad. Sci.*, **16**, 34-43 (1936).

<sup>3</sup> W. D. Bancroft and G. H. Richter, *J. Phys. Chem.*, **35**, 511-530 (1931).

<sup>4</sup> H. Watson, *J. Hyg.*, **8**, 537 (1908).

<sup>5</sup> H. Chick, *J. Hyg.*, **8**, 92-158 (1908).

<sup>6</sup> N. Ishizaka, *Z. physik. Chem.*, **83**, 87-125.

sian Blue-gum ghatti sol, but merely accelerated the coagulation that was already taking place. The influence of phenol on the rate of coagulation of the Prussian Blue gum-ghatti sol could be expressed by the formula:

$$k = m + bc$$

where  $k$  is the velocity constant for a second order reaction (the coagulation followed a bimolecular curve in each case).

$m$  is the value of  $k$  when no phenol is present.

$C$  is the concentration of phenol

$b$  is a constant

Values for  $k$ ,  $m$ , and  $b$  were obtained graphically. In the case of each individual coagulation, there was a lag time, the period of time before any appreciable coagulation occurred. When the results of each coagulation were plotted with  $\frac{x}{1-x}$  as the ordinate and  $t$  (time in minutes) as the abscissa, the slope of the straight line, ordinate divided by abscissa, was taken as the numerical value of  $k$ , and the intercept on the  $t$ -axis was taken as the lag time. For any given concentration of HCl, when  $k$  was plotted as ordinate and  $C$  (the concentration of phenol) as abscissa, a straight line was obtained. The slope of this line, ordinate divided by abscissa, was taken as the numerical value of  $b$ , and the intercept on the  $k$ -axis was taken as the numerical value of  $m$ . The results of the experimental work are given in the tables.

Table I

0.000167 M Prussian Blue 0.01% Gum Ghatti 0.004136 M HCl  
 $k = 0.021 + 0.022C$

C Concn. of Phenol Mols per l.	pH		k	k calc. from m and b	lag time minutes
	Initial	Final			
0	2.57	2.60	0.0258	(0.021)	53
0.2286	2.60	2.57	0.0260	0.0260	49
0.3429	2.60	2.59	0.0285	0.0285	46
0.4571	2.57	2.60	0.0310	0.0311	40

Table II

0.000167 M Prussian Blue 0.01% Gum Ghatti 0.003102 M HCl  
 $K = 0.015 + 0.0385C$

C Concn. of Phenol Mols per l.	pH		k	k calc. from m and b	lag time minutes
	Initial	Final			
0	2.79	2.79	0.0150	0.0150	109
0.2286	2.76	2.74	0.0243	0.0238	82
0.3429	2.77	2.77	0.0282	0.0282	57
0.4571	2.76	2.76	0.0321	0.0326	38

Table III

0.000167 M Prussian Blue 0.01% Gum Ghatti 0.002068 M HCl  
 $k = 0.0017 + 0.0082C$

C Concn. of Phenol Mols per l.	pH		k	k calc. from m and b	lag time minutes
	Initial	Final			
0	2.91	2.91	*		more than 1620
0.2286	2.88	2.91	0.0037	0.0036	375
0.3429	2.88	2.91	0.0042	0.0045	364
0.4571	2.88	2.88	0.0056	0.0055	322

\* No coagulation in 25 hrs., but 69% complete in 54 hours.

### Summary

Phenol alone cannot initiate the coagulation of colloidal Prussian Blue or of the Prussian Blue-gum ghatti sol. In the case of the Prussian Blue-gum ghatti sol, when coagulation is already taking place, definite acceleration of coagulation is observed.

tion is produced by phenol. The influence of the concentration of phenol upon the velocity constant of the coagulation is linear, in accordance with the formula:

$$k=m+bC$$

The formula governing the influence of phenol on the coagulation of the Prussian Blue-gum ghatti sol does not conform to the Watson equation for the kinetics of the toxic action of phenol.