

Storage Factors Affecting the Deterioration Rates of Certain Chlorine Preparations of the Sodium Hypochlorite Type*

II. The Effect of Direct Sunlight

By *Elmer M. Plein and L. Wait Rising*

Although it is not customary to store chlorine preparations of the type investigated in this series of experiments where they will be exposed all day long to the direct rays of the sun, concrete knowledge concerning the hazard of the condition should nevertheless be made available. There are people who without thought of conservation of efficiency set such products in windows and other exposed places. What in specific terms are they doing to the strength of their chlorine preparations?

EXPERIMENTAL

To answer this question and also to determine the effectiveness of various colors of glass as protection against the action of light, the ten chlorine preparations examined in the first study of the series (1) were removed from their stock bottles and placed in clear, green and blue glass pint bottles. As the products were originally packaged in amber bottles by their manufacturers these containers were used as the amber bottles. These sets were then stored on the roof of the laboratory building where they were exposed to whatever sunlight was available. The

TABLE I.—NUMBER OF CLEAR, PARTLY CLOUDY AND CLOUDY DAYS DURING THE PERIOD OF INVESTIGATION (DATA TAKEN FROM THE OFFICIAL WEATHER REPORTS OF THE UNIVERSITY OF WASHINGTON DEPARTMENT OF GEOLOGY)

Month	Weather			Mean Temperatures, °F.
	No. of Clear Days	No. of Partly Cloudy Days	No. of Cloudy Days	
May 24-31	4	1	2	58.79
June	18	7	5	63.43
July	15	7	9	64.90
August	17	3	11	64.30
September	13	6	11	54.40
October	2	5	24	56.35
November	1	3	27	43.58
December	8	1	22	44.28
January	7	3	21	43.63
February	9	2	17	46.32
March 1-20	11	3	6	51.12

* From the College of Pharmacy, University of Washington, Seattle, Wash.
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weather conditions, together with the mean temperatures for each month of exposure, are shown in Table I. It is important to note that the maximum sunlight was impinging upon the bottles from the very beginning of the investigation until after the effect of sunlight was no longer so significant.

The preparations were analyzed in accordance with the procedure employed in study I (1). The data collected are given in Tables II to XI, inclusive. Table XII compares the degree of deterioration of each for the period of the study.

TABLE II.—RATE OF DETERIORATION OF C-5 UNDER THE CONDITIONS OF THE STUDY

Date of Chlorine Determination	Per Cent of Available Chlorine for Various Colors of Storage Bottles			
	Clear	Green	Blue	Amber
May 24, 1940 (Initial)	4.25	(Bottle broken)	4.49	...
June 15, 1940	0.00	...	0.00	4.60
July 1, 1940	0.01	...	0.00	4.12
July 15, 1940	0.00	...	...	3.73
Aug. 15, 1940	...	...	...	3.23
Sept. 18, 1940	...	...	...	...
Oct. 17, 1940	...	...	...	2.77
Nov. 1, 1940	...	4.18 ^a	...	...
Nov. 15, 1940	...	...	...	2.71
Nov. 29, 1940	...	1.96	...	...
Dec. 18, 1940	...	0.05	...	2.68
Jan. 15, 1941	...	...	...	2.63
Feb. 23, 1941	...	...	...	2.42
Apr. 2, 1941	...	...	...	2.25

^a A new series of determinations begun.

TABLE III.—RATE OF DETERIORATION OF C-7 UNDER THE CONDITIONS OF THE STUDY

Date of Chlorine Determination	Per Cent of Available Chlorine for Various Colors of Storage Bottles			
	Clear	Green	Blue	Amber
May 24, 1940 (Initial)	2.66	2.69	2.77	2.68
June 15, 1940	0.01	0.01	0.01	2.41
July 1, 1940	0.01	0.01	0.01	2.10
July 15, 1940	...	...	...	2.02
Aug. 15, 1940	...	0.01	0.01	1.79
Sept. 18, 1940	...	0.01	...	...
Oct. 17, 1940	...	...	...	1.59
Nov. 1, 1940	1.30 ^a	...	...	...
Nov. 15, 1940	...	...	...	1.42
Nov. 29, 1940	0.01	...	...	...
Dec. 18, 1940	...	...	...	1.34
Jan. 15, 1941	...	...	...	1.06
Feb. 24, 1941	...	...	...	0.32
Apr. 2, 1941	...	...	...	0.24

^a A new series of determinations begun.

TABLE IV.—RATE OF DETERIORATION OF C-6 UNDER THE CONDITIONS OF THE STUDY

Date of Chlorine Determination	Per Cent of Available Chlorine for Various Colors of Storage Bottles			
	Clear	Green	Blue	Amber
May 24, 1940 (Initial)	5.13	5.20	5.00	...
June 15, 1940	...	0.41	0.32	5.22
July 1, 1940	0.02	0.01	0.01	3.46
July 15, 1940	...	0.01	0.01	2.67
Aug. 15, 1940	0.01	0.01	0.01	1.54
Sept. 18, 1940	0.01	0.01	0.01	0.98
Oct. 17, 1940	0.01	0.01	0.01	0.88
Nov. 15, 1940	...	...	...	0.79
Dec. 18, 1940	...	...	...	0.75
Jan. 15, 1941	...	...	...	0.74
Feb. 24, 1941	...	...	...	0.64
Apr. 2, 1941	...	...	...	0.52

TABLE V.—RATE OF DETERIORATION OF C-8 UNDER THE CONDITIONS OF THE STUDY

Date of Chlorine Determination	Per Cent of Available Chlorine for Various Colors of Storage Bottles			
	Clear	Green	Blue	Amber
May 24, 1940 (Initial)	4.45	4.68	4.48	4.45
June 15, 1940	0.01	0.00	0.00	4.32
July 1, 1940	0.01	...	...	3.79
July 15, 1940	0.00	...	...	3.55
Aug. 15, 1940	...	...	...	3.06
Sept. 18, 1940	...	...	...	...
Oct. 17, 1940	...	...	...	2.46
Nov. 15, 1940	...	...	...	2.30
Dec. 18, 1940	...	...	...	2.27
Jan. 15, 1941	...	...	...	2.17
Feb. 24, 1941	...	...	...	2.06
Apr. 2, 1941	...	...	...	1.84

TABLE VI.—RATE OF DETERIORATION OF C-9 UNDER THE CONDITIONS OF THE STUDY

Date of Chlorine Determination	Per Cent of Available Chlorine for Various Colors of Storage Bottles			
	Clear	Green	Blue	Amber
May 24, 1940 (Initial)	5.07	5.12	4.70	4.72
June 15, 1940	0.00	0.01	0.00	4.72
July 1, 1940	...	0.00	...	4.45
July 15, 1940	4.30
Aug. 15, 1940	4.04
Sept. 18, 1940	3.89
Oct. 17, 1940	3.75
Nov. 15, 1940	3.75
Dec. 18, 1940	3.73
Jan. 15, 1941	3.62
Feb. 24, 1941	3.48
Apr. 2, 1941	3.48

TABLE VII.—RATE OF DETERIORATION OF C-10 UNDER THE CONDITIONS OF THE STUDY

Date of Chlorine Determination	Per Cent of Available Chlorine for Various Colors of Storage Bottles			
	Clear	Green	Blue	Amber
May 24, 1940 (Initial)	4.71	4.67	...	4.79
June 15, 1940	0.01	0.03	...	4.67
July 1, 1940	0.01	0.01	...	4.19
July 15, 1940	0.00	0.01	...	4.06
Aug. 15, 1940	...	0.00	...	3.71
Sept. 18, 1940	...	...	...	3.48
Oct. 17, 1940	...	...	...	3.41

(Table VII continued in next column)

Date of Chlorine Determination	Per Cent of Available Chlorine for Various Colors of Storage Bottles			
	Clear	Green	Blue	Amber
Nov. 1, 1940	4.35 ^a	...
Nov. 15, 1940
Nov. 29, 1940	1.24	...
Dec. 18, 1940	0.05	3.19
Jan. 15, 1941	0.00	...
Feb. 24, 1941	2.88
Apr. 2, 1941	2.93

^a Initial determination.

TABLE VIII.—RATE OF DETERIORATION OF C-2 UNDER THE CONDITIONS OF THE STUDY

Date of Chlorine Determination	Per Cent of Available Chlorine for Various Colors of Storage Bottles			
	Clear	Green	Blue	Amber
May 24, 1940 (Initial)	4.50	...	4.57	4.87
June 15, 1940	0.01	...	0.01	4.72
July 1, 1940	0.01	...	0.01	4.37
July 15, 1940	0.00	...	0.00	4.27
Aug. 15, 1940	...	...	...	3.86
Sept. 18, 1940	...	...	...	...
Oct. 17, 1940	...	...	...	...
Nov. 1, 1940	...	4.27 ^a	...	...
Nov. 15, 1940	...	...	...	3.83
Dec. 18, 1940	...	1.10	...	3.71
Jan. 15, 1941	...	0.00	...	...
Feb. 24, 1941	...	...	...	3.43
Apr. 2, 1941	...	...	...	3.46

^a Initial determination.

TABLE IX.—RATE OF DETERIORATION OF C-3 UNDER THE CONDITIONS OF THE STUDY

Date of Chlorine Determination	Per Cent of Available Chlorine for Various Colors of Storage Bottles			
	Clear	Green	Blue	Bottles Amber
May 24, 1940 (Initial)	4.72	4.75	4.84	4.89
June 15, 1940	0.00	0.00	0.01	4.10
July 1, 1940	0.00	2.94
July 15, 1940	2.31
Aug. 15, 1940	1.41
Sept. 18, 1940	0.88
Oct. 17, 1940	0.81
Nov. 15, 1940	0.73
Dec. 18, 1940	0.69
Jan. 15, 1941	0.68
Feb. 24, 1941	0.57
Apr. 2, 1941	0.46

TABLE X.—RATE OF DETERIORATION OF C-4 UNDER THE CONDITIONS OF THE STUDY

Date of Chlorine Determination	Per Cent of Available Chlorine for Various Colors of Storage Bottles			
	Clear	Green	Blue	Amber
May 24, 1940 (Initial)	2.98	3.58	3.58	3.55
June 15, 1940	0.00	0.00	0.00	3.34
July 1, 1940	2.98
July 15, 1940	2.67
Aug. 15, 1940	2.41
Sept. 18, 1940
Oct. 17, 1940	2.13
Nov. 15, 1940	1.94
Dec. 18, 1940	1.70
Jan. 15, 1941	0.45
Feb. 24, 1941	0.07
Apr. 2, 1941	0.04

TABLE XI.—RATE OF DETERIORATION OF C-1 UNDER THE CONDITIONS OF THE STUDY

Date of Chlorine Determination	Per Cent of Available Chlorine for Various Colors of Storage Bottles			
	Clear	Green	Blue	Amber
May 24, 1940 (Initial)	0.96	1.01	1.01	1.06
June 15, 1940	0.00	0.00	0.00	0.98
July 1, 1940	0.94
July 15, 1940	0.89
Aug. 15, 1940	0.85
Sept. 18, 1940
Oct. 17, 1940	0.82
Nov. 15, 1940	0.78
Dec. 18, 1940	0.78
Jan. 15, 1941	0.72
Feb. 23, 1941	0.70
Apr. 2, 1941	0.67

TABLE XII.—A COMPARISON OF THE DEGREE OF TOTAL DETERIORATION OF SAMPLES STUDIED

Preparation	Per Cent Total Deterioration during Study			
	Clear Bottles	Green Bottles	Blue Bottles	Amber Bottles
C-5	100.00	98.80	100.00	46.68
C-7	99.63	100.00	99.64	91.05
C-6	99.81	99.81	99.80	90.04
C-8	100.00	100.00	100.00	58.65
C-9	100.00	100.00	100.00	31.02
C-10	100.00	100.00	98.85	38.83

(Table XII continued in next column)

Preparation	Per Cent Total Deterioration during Study			
	Clear Bottles	Green Bottles	Blue Bottles	Amber Bottles
C-2	100.00	74.24 ^a	100.00	28.95
C-3	100.00	100.00	100.00	90.59
C-4	100.00	100.00	100.00	98.87
C-1	100.00	100.00	100.00	36.79

^a Forty-eight days.

TABLE XIII.—COMPARISON OF DEGREE OF TOTAL DETERIORATION OF THE SAMPLES IN AMBER BOTTLES UNDER THE INFLUENCE OF DIRECT SUNLIGHT AND DIFFUSED SUNLIGHT

Preparation	Per Cent Deterioration under Direct Sunlight	Per Cent Deterioration under Diffused Sunlight
	C-2	28.95	14.38
C-9	31.02	18.19
C-1	36.79	6.93
C-10	38.83	21.82
C-5	46.68	17.91
C-8	58.65	57.75
C-6	90.04	41.52
C-3	90.59	11.62
C-7	91.05	98.48
C-4	98.87	24.78

REFERENCES

- (1) Plein, E. M., and Rising, L. W., *JOUR. A. PH. A.*, 31 (1942), 183.

Storage Factors Affecting the Deterioration Rates of Certain Chlorine Preparations of the Sodium Hypochlorite Type*

III. (A) The Effect of Constant Moderate Heat, (B) The Effect of Storage in a Dark Room and (C) The Effect of Refrigeration

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(A) The Effect of Constant Moderate Heat

Many of the chlorine preparations used routinely in the home for hygienic purposes on the person and in the laundry, also those used in hotels, taverns, hospitals and elsewhere to protect the public against the spread of contagious diseases, are stored in warmer-than-average places. This is not intentional. It is pure coincidence that so frequently the out-of-the-way corners and cabinets convenient for storage are near steam pipes, heating units or hot water pipes. That this heat can be damaging to the activity of the chlorine preparations no one can successfully deny without previously having measured its effect. Published ac-

counts showing adequate measurements of its effect are lacking, so the work reported in this paper was undertaken to help answer the question on the basis of data collected under controlled conditions.

EXPERIMENTAL

Standard commercial packages of the ten preparations used in the previous phases (1) of this study were used. Since light was not to be considered as a deterioration factor, the products were left in their original containers. These were stored in a covered box placed over a copper chest in which small steam pipes were coiled. The temperature of the liquids in the box, without considering the few fluctuations when the steam was cut off, averaged about 42° C. The samples were analyzed according to the time intervals and method of the previous studies (1). Table I shows the results of the determinations. Table II shows the total deterioration of each over the period of investigation.

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