A Spectral Investigation of Glucose Glass

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A Spectral Investigation of Glucose Glass

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The spectral transmission of glucose glasses has been investigated over the wave-length region from 3600 to 8000A. Glasses of different thermal history were tested, ranging from white to dark brown in color. The glasses show different transmission values, and shifts of the transmission maximum and the absorption limit at small wave-lengths with increasing caramelization.

I. INTRODUCTION

THE thermal properties of glucose glass have been investigated by Parks and co-workers.[1] The color of these glasses varies, depending on the thermal history, from white to dark brown indicating the formation of decomposition products during caramelization. (It is generally assumed that small amounts of colloidal carbon are finally liberated.) An investigation seemed of interest to determine the effect of caramelization on the spectral transmission of glucose glass.

II. METHOD

Spectra were obtained with my Hilger grating spectrograph, dispersion 49.4A/mm. The range from 3600 to 8000A was investigated using Wratten and Wainwright hypersensitive panchromatic plates and Eastman Kodak I-N plates. The first-order spectrum was used, the overlapping ultraviolet of the second order being eliminated by a No. 12 Wratten gelatin filter. A straight filament 8.5-volt lamp with rheostat control was used as a light source. A condenser lens projected the light on the slit. The slit width was 0.1 mm. A very fine neutral wedge from Hilger was placed in front of the slit. (A separate investigation showed that this wedge

[1] G. S. Parks and H. M. Huffman, J. Phys. Chem. **31**, 1842–55 (1927); G. S. Parks, H. M. Huffman and F. R. Cattoir, J. Phys. Chem. **32**, 1366–79 (1928); F. R. Cattoir and G. S. Parks, J. Phys. Chem. **33**, 879–882 (1929); G. S. Parks and W. A. Gilkey, J. Phys. Chem. **33**, 1428–37 (1929); G. S. Parks and S. B. Thomas, J. Am. Chem. Soc. **56**, 1423 (1934); G. S. Parks, L. E. Barton, M. E. Spaght and J. W. Richardson, Physics **5**, 193–199 (1934); G. S. Parks, L. J. Snyder and F. R. Cattoir, J. Chem. Phys. **2**, 595–598 (1934); J. C. Lyman and G. S. Parks, J. Chem. Phys. **4**, 218–219 (1936); G. S. Parks and J. D. Reagh, J. Chem. Phys. **5**, 364–367 (1937).

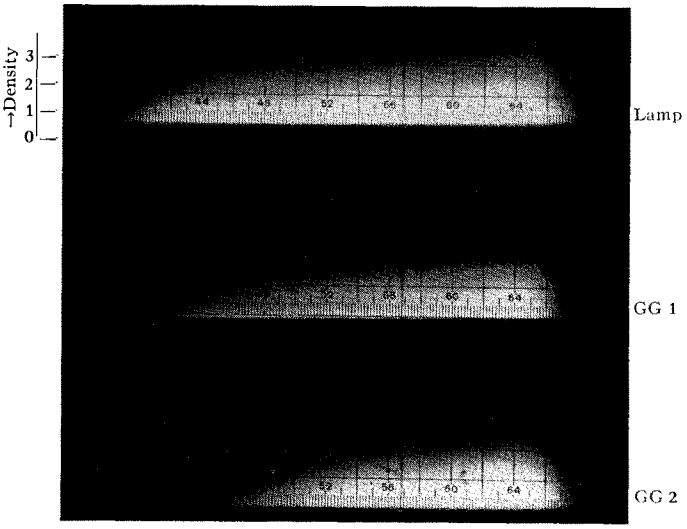

FIG. 1. Plate No. BL 401. Hyperpan plate. Wedge spectra for lamp alone, and glucose glasses GG 1 and GG 2. Time of exposure 2 minutes.

FIG. 2. Plate No. BL 410. I-N plate. Wedge spectra for lamp alone, and glucose glass GG 1. Time of exposure 10 minutes.

is neutral over the entire wave-length region investigated.) The density of the wedge was such that the light end transmits 10,000 times the light transmitted by the dark end.[2] A wave-length and density scale was printed on the plate, together with the spectrum. (The wave-length scale needs a slight correction which was determined from line spectra.)

The glucose glass samples were contained in metal cells of 23.5 mm inside diameter with silica glass windows, the length of cells GG 1 and 2 was 24.0 and that of all other cells was 25.0 mm. The samples were placed in front of the wedge. Several spectra were taken from each sample. The difference in density of the lamp and glass spectra on a plate was small enough to permit the photometric reduction.

The photometric reduction was carried out as follows: A wedge spectrum of the lamp alone was printed on each plate, together with one or two glucose glass spectra. All spectra on a plate were taken with the same time of exposure and the same voltage of the lamp. Fig. 1 shows the panchromatic plate BL 401 with wedge spectra of the lamp alone and glasses GG 1 and 2, and Fig. 2 shows the I-N plate BL 410 with wedge spectra of the lamp and glass GG 1.

The density of the glass and lamp spectra was measured every 20 mμ. A simple computation gave then the light transmission values. Considering the values for the lamp alone as unity the transmission of the glass could be computed in percent. The steep decrease in sensitivity of the panchromatic plates makes values around 660 mμ less accurate than the remaining values. (All values of less weight are given in parentheses in Table II.) The probable error of the measurements amounts to ±2 percent.

[2] C. E. K. Mees and S. H. Wratten, Brit. J. Phot. **54**, 384–385 (1907).

III. SAMPLES

The samples were prepared by Dr. Parks and co-workers at different times, samples GG 1 and 2 were, approximately, four years old. These samples had been prepared from "C. P. Pfanstiehl" anhydrous glucose with a subsequent purification by the method of Hudson and Dale[3] with glacial acetic acid. The remaining samples were made directly from Pfanstiehl glucose without this special purification. The samples were, with the exception of GG 4 and 6, remarkably free of bubbles. No striae appeared in any glass. GG 4 and 7 showed the beginning of crystallization starting from the edge of one front end. GG 1 was practically colorless, the remaining samples extended from light yellow to dark brown in color, see Table I. This table presents also colorimetric values obtained by means of a Lovibond tintometer, series No. 52.[4] Glucose glasses GG 3 and 5, GG 4 and 6, and GG 7 and 8,

TABLE I. *Color and Lovibond values for glucose glasses.*

GLASS NO.	COLOR	LOVIBOND VALUE
GG 1	White	3.0
GG 2	Light yellow	11.0
GG 7	Yellow	12.0
GG 8	Yellow	10.7
GG 9	Yellow	12.0
GG 4	Yellow-brown	15.3
GG 6	Yellow-brown	14.7
GG 3	Dark brown	37.3
GG 5	Dark brown	36.7

[3] C. S. Hudson and J. K. Dale, J. Am. Chem. Soc. **39**, 324–328 (1917).

[4] K. S. Gibson and F. K. Harris, Sci. Papers, Nat. Bur. Stand. No. 547, 1927.

respectively, show only small differences in color, each of these pairs having been prepared at about the same time.

IV. Results

Table II contains the results of the individual measurements of the glucose glasses (reduced to a thickness of 25 mm). Fig. 3 shows the transmission curves including averages for glasses GG 3 and 5, GG 4 and 6, and GG 7 and 8. The difference in transmission values of GG 4 and 6 is due to the larger number of bubbles and the beginning of crystallization in GG 4. The following remarks refer to the results obtained.

(1) A careful study under varying conditions showed the absence of narrow absorption bands in the entire wave-length region investigated.

(2) The spectral energy distribution shows flat maxima for all glasses. The maxima occur in the range from 580 to 640 mμ. The maxima of transmission are shifted toward greater wave-lengths with increasing caramelization.

(3) The absorption limits at small wave-lengths are shifted toward the red with increasing caramelization. Table III gives the absorption limits for small wave-lengths.

(4) None of the glasses shows a limit of transmission toward great wave-lengths within the range investigated (up to 800 mμ). The transmission curves become, at great wave-lengths, approximately parallel to the abscissa for several glasses; a small increase in transmission is indicated for GG 8.

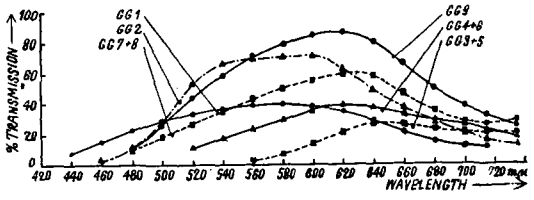

FIG. 3. Spectral transmission of glucose glasses.

(5) The transmission values of GG 1 are lower than those of the remaining glasses. This is probably due to the age of GG 1 as against the recent glass batches GG 3 to 9. It seems likely that crystallization has started already in GG 1 and 2, although it is not visible. Another cause of this difference may lie in the different purification process of the two groups of samples. A recrystallization would tend to decrease the transmission values over the entire spectrum.

TABLE II. *Transmission of glucose glasses in percent as a function of the wave-length; thickness of layer 25 mm.*

Wave-length in mμ	GG 1 %	GG 2 %	GG 7 %	GG 8 %	GG 9 %	GG 4 %	GG 6 %	GG 3 %	GG 5 %
440	8.4								
460	15.2	2.1							
480	22.9	11.8	9.6	9.2	11.6				
500	29.1	29.3	20.4	17.0	26.2				
520	33.6	53.3	29.6	25.4	44.4	13.2	10.2		
540	36.9	66.9	37.8	33.6	59.2	15.0	19.4		
560	39.0	69.0	44.8	41.8	70.6	17.2	29.8	3.0	(3.2)
580	40.1	70.6	49.6	49.6	78.6	21.6	37.8	7.6	6.6
600	38.6	71.3	55.2	56.2	84.6	26.8	45.8	13.6	14.4
620	34.6	62.9	59.2	60.0	86.4	27.2	50.8	22.2	21.8
640	28.2	48.7	58.4	57.2	80.2	25.6	49.2	28.0	25.4
660	(20.4)	(37.1)	(44.8)	(46.6)	(65.4)	(24.2)	(40.2)	(28.0)	(24.4)
680	14.5	28.2		34.6	49.6	23.4	36.8	27.0	19.4
700	11.0	20.7		27.8	37.2	18.6	33.8	25.6	16.6
715	10.4	15.2		27.0	31.2	13.3	31.2	24.8	16.9
735		13.2		28.3	24.6	11.6	26.9	24.7	15.7

TABLE III. *Absorption limits in mμ at short wave-lengths for glucose glasses.*

Glass No.	GG1, mμ	GG2, mμ	GG7, mμ	GG8, mμ	GG9, mμ	GG4, mμ	GG6, mμ	GG3, mμ	GG5, mμ
Absorption Limit	397	426	447	441	441	479	481	539	539

The results indicate that the spectral transmission of glucose glass depends on the thermal history of the glass, in a similar manner as do the thermal properties. A spectral investigation presents, if carried out under standardized conditions, a quick and sensitive method for a classification of samples, and a checking of the thermal history of the samples.

V. Summary

The spectral transmission of glucose glasses of different thermal history has been investigated between 3600 and 8000A. All glasses show flat transmission maxima which are shifted toward greater wave-lengths with increasing caramelization. The absorption limits at small wave-lengths are shifted toward the red with increasing caramelization.

In conclusion I should like to express my thanks to Dr. George S. Parks of Stanford University for preparing the samples and for helpful discussions I have had with him.