

4-1940

Characteristics Of Spectrographic Plates In The Ultra Violet Region Between 2300-2000A

R. G. Beck
University of Minnesota

L. Lundberg
University of Minnesota

Elmer S. Miller
University of Minnesota

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Recommended Citation

Beck, R. G., Lundberg, L., & Miller, E. S. (1940). Characteristics Of Spectrographic Plates In The Ultra Violet Region Between 2300-2000A. *Journal of the Minnesota Academy of Science*, Vol. 8 No. 1, 62-65. Retrieved from <https://digitalcommons.morris.umn.edu/jmas/vol8/iss1/14>

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The apparatus involved in the biological use of isotopes is expensive and complex. Several university departments must have facilities and men engaged in a particular highly specialized field of research. The physicist or physical chemist must supply the isotopic material and make mass spectrometer abundance analyses. Organic chemists are required for syntheses of isotopic compounds. Careful analytical chemists are needed for semimicrochemical analytical procedures and physiologists are needed for the animal experimentation. The initial expenditure for apparatus and isotopic chemicals is considerable but once the projects are under way the operation becomes a routine procedure presenting only usual analytical and physiological difficulties.

The stable mass isotopes as their name implies are indefinitely stable. There is no need to finish the problem in a time period before disintegration is complete as is the case with the radioactive isotopes. Synthesized compounds can be made in relatively large quantities and used for years at one's leisure. As a result of experiences with the stable mass isotopes we would conclude that they will prove of unusual value in solving problems of intermediary metabolism and chemical reaction mechanisms.

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CHARACTERISTICS OF SPECTROGRAPHIC PLATES IN THE ULTRA VIOLET REGION BETWEEN $\lambda 2300-2000\text{\AA}^*$

R. G. BECK, L. LUNDBERG AND ELMER S. MILLER
University of Minnesota

Introduction

In the use of spectrographic methods for quantitative studies in the ultraviolet region, it is necessary to determine the characteristics of emulsions sensitized for a *certain* spectral region. To date, only a limited number of studies have been made on this topic. Harrison and Leighton¹ presented evidence to show that it was possible to increase the sensitivity of spectroscopic plates to the extreme ultraviolet region by coating them with fluorescent materials.

A report of a detailed study of photographic emulsions in the region between wavelengths 2500-2000 Å has been published by **Aided by grants from the Rockefeller Foundation and the Graduate School of University of Minnesota. Assistance in the preparation of these materials was furnished by the personnel of Works Projects Administration, Official Project No. 165-1-71-124, Sub-project No. 331 and 325.*

¹Harrison, G. R. and Leighton, P. A. *Journal of Optical Society of America*, 20, 313, 1930. *Phys. Rev.* 33, 899, 1931.

Hunter and Pearse.² These investigators point out that besides the Schumann type of plate (including Ilford Q₂ plates), an ordinary plate may be bathed in mineral oils³ greases,⁴ sodium salicylate⁵ anthracene⁶ and other commercial sensitizers, such as those employed by Eastman Kodak Company and Agfa Corporation.

Hunter and Pearse² obtained data which suggested that all plates, save Ilford Q₂, have the same threshold value. They interpret these findings to mean that the present methods of sensitization do not decrease the plate inertia but merely increase contrast and saturation density. These authors observed that an 81 second exposure was necessary to obtain an image at λ 2000 Å with 0.02 mm. slit on a Hilger E₂ medium Quartz spectrograph. The dispersion of this instrument permitted the spectral region between λ 2500–2000 Å to be photographed on a 9 cm. plate. As a light source they employed a discharge tube, with *air* at reduced pressure and operated at 5000 V. and 0.15 amp.

The purpose of this paper is to present data regarding the variability of different emulsions with reference to sensitivity, (plate inertia) reciprocity law failure, and proper Gamma and development for the spectral region between λ 2300 and 2000 Å and to discuss the importance of these factors in relation to the sources of errors in the quantitative measurements of absorption coefficients.

Experimental

The complete description of the spectrographic apparatus has been reported by Belkengren et al.⁷ The nature of the equipment necessitated that Henri's⁸ photographic method be employed. The exposure interval was determined by an electrical shutter, which could be conveniently set for exposures from 0.5 to 120. seconds.

The first problem studied concerned the relative sensitivities of different emulsions. These data are presented in Table I.

These data show that for short exposures, only the Eastman I-O (UV.) plates are sufficiently sensitive at λ 2000 Å to be satisfactory for quantitative spectrographic photography. In these studies, the exposures and plate development were made so as to give a gamma of $0.8 \pm .05$ at isodensities. Because the intensity of the hydrogen discharge tube and the transmission of the quartz optics varied with wavelength, only a relative comparison of emulsion sensitivities can be presented, as shown in Fig. 1. Curve number 4 in Fig. 1 begins to flatten at λ 2200 Å, but the slope approaches infinite at λ 2000

² Hunter, A. and Pearse, R. W. B. *Physical Soc.* 50, 257, 1938.

³ Harrison, Geo. R. *Jour. Opt. Soc. of Am.* 11, 113, 1925.

⁴ Beach, *Nature*, London, 123, 166, 1929.

⁵ Tien Kin, *C. R. Acad. Sci. Paris*, 201, 1348, 1935.

⁶ Helmich, *Jour. Opt. Soc. of Am.* 9, 521, 1924.

⁷ Belkengren, Richard, J. P. Kass, Elmer S. Miller, and Geo. O. Burr. *The Far Ultraviolet Absorption Studies of Conjugated and Non-Conjugated Alcohols and Fatty Acids.* (In Press).

⁸ Henri, Victor, *Etudes de Photochimie* 1919. Gauthier-Villars et Cie, Paris.

TABLE I. SENSITIVITIES OF SIX PLATE EMULSIONS

| Emulsion | Log of exposure to give density of 1.35 | | |
|------------------|---|------------------|----------------------------|
| | Sensitizer | λ 2300 Å | Lowest wavelength recorded |
| Cramer contrast | Mineral Oil | 2.035 | 3.495 at λ 2100 Å |
| Eastman I-F | Mineral Oil | 1.68 | 3.7 at λ 2050 Å |
| Eastman I-O | Mineral Oil | 1.395 | 4.2 at λ 2020 Å |
| Eastman I-O (UV) | Trade Secret | 0.93 | 4.04 at λ 2000 Å |
| Eastman 103-O | Mineral Oil | 1.38 | 3.295 at λ 2050 Å |
| Ilford Q-3 | Mineral Oil | 1.65 | 4.25 at λ 2050 Å |

Å. This enormous gamma wavelength effect, (Fig. 3) necessitates taking several exposures for quantitative measurements. In covering the spectral region between λ 2200 and 2000 Å, three questions arise, why three different plates, why not three different series of exposures, one for λ 2200, 2100, and 2000 Å, respectively. The latter, would be possible on a plate 4 to 6 inches wide, but in this study, the plate holder would accommodate a maximum width of 2.5 inches. The maximum error between the respective densities on two different plates taken under similar conditions is 10 per cent because of variations in plate emulsions and calibration procedures.

Fig. 2 presents data regarding the relative sensitivities of spectroscopic plates between λ 2300 and 2000 Å.

In determining absorption coefficients by spectrographic methods, an important source of error is introduced by failure of photographic receivers to integrate properly due to the failure of the reciprocity law. This phenomenon is not adequately described by the Schwarzschild Equation:

$$E = IT^P$$

where P = Schwarzschild constant.

Recent work by Kron⁹ and Holm¹⁰ indicates that the relationship between time (T) and intensity can be expressed by the following equation:

$$I \cdot T = \frac{I_0 \cdot T_0}{2} \left\{ \frac{(I_x)^n}{I_0} + \frac{(I_x)^{-n}}{I_0} \right\}$$

The failure of the reciprocity law, in part, summarizes, this failure of the emulsion to integrate linearly, i.e. for intensities either above or below the optimal, requires a greater exposure to produce a unit density. Depending upon the type of emulsion and the method of recording the latent image, according to the method of keeping intensity (I) constant and varying time (T), or keeping T constant and varying I by the use of a sector, this source of error necessitates the correction of the observed density by a factor of $0.86 \pm .04$ or less. This value was obtained by the use of calibrated

⁹ Kron Veber das Schwarzungsgesetz "Eder's Jahrbuck," 26, 1914.

¹⁰ Holm, J. Roy. Astron. Soc. Mon. Not., p. 43, June 1922.

screens. These studies suggest that further studies must be made to make available better emulsions suitable for quantitative spectrographic photography in the far ultraviolet region, and to further calibrate the present spectrographic procedures for recording and developing the latent image, in order to reduce this source of error from 10 to 2 per cent; which is now permissible in the near ultraviolet and visible spectral region.

Summary:

1. Characteristics of emulsions suitable for spectral studies between λ 2300 and 2000 Å have been developed.
2. Sources of error due to emulsion heterogeneity and failure of photographic receivers to integrate in a linear manner according to the failure of the reciprocity law, have been discussed.

