THE INDUCED PHOTO-DICHROISM BY INFRA-RED RAYS. (I.)

By JITARO SHIDEI, DAIJIRO YAMAMOTO and YURIKO KUBO.

Introduction.

In 1930, one (S)[1] of the present authors studied on the induced photo-dichroism caused by visible light of 680 to 440mμ region in "Imperial Gaslight Plates, warm Tone." The results obtained may be briefly summarised as follows:

(1) The photo-dichroistic effects grew stronger with the increase of the wave length of the light by which the material under investigation was to be illuminated.

(2) The types of the curves representing the relative dichroism (the ratio of the dichroism (D) to the photographic density (S) : (D/S)), obtained by plotting D/S against the time of the illumination by polarised light, were characteristic for each spectral region of the light by which the material was illuminated, especially for three primary colours (red (680mμ), green (560mμ), and blue (480mμ)). The photo-dichroistic effect for 680mμ region was entirely of negative sign, and the D/S-curves lay in the negative side of the diagram, while those for the region of green to blue lay mainly in the positive side. Judging from the types of the curves for red light (680mμ) on the one hand and for green to blue on the other it seemed that negativation and positivation of the signs of the effect were characteristic for the light of long wave length and that of short wave length respectively.

According to the view of F. Weigert, this effect seems to be of physical, and not of chemical nature. Since, in the spectral regions in which the investigation was hitherto made, the effect was always accompanied by some photo-chemical reactions, it is necessary to study the effect in the region of infra-red rays in order to see it purely as a physical effect.

As the first step in a program for the infra-red investigations, the present authors have sought to ascertain if the photographic film would be photo-dichroistically sensitive to infra-red rays. The present paper will therefore contain an account of a few experiments made in this respect.

Experimental.

The method used was essentially the same as that used in the previous experiment.[2]

1) F. Weigert and J. Shidei, *Z. physik. Chem.*, (B) 9, 329 (1930).
2) F. Weigert and J. Shidei, *ibid.*

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MATERIALS.

As the experimental material, the "Imperial Gaslight Plates, warm Tone" was again employed. After being illuminated by the polarised infra-red light, the plates were developed with a paraphenylene diamine-silver developer of Lumière and Seywetz[1] and then fixed with an acid hypo-solution.

APPARATUS AND PROCEDURE.

The measurements of the dichroism were carried out in red light (filter: a solution of rhodamine *B* and quinine sulphate) by the differential method proposed by F. Weigert with the Lippich half-shadow polarimeter. The photographic densities (*S*) of the developed fields were measured by a densitometer.

The arrangement of the apparatus used for the illumination of the photographic plates by the polarised infra-red rays is illustrated by Fig. 1.

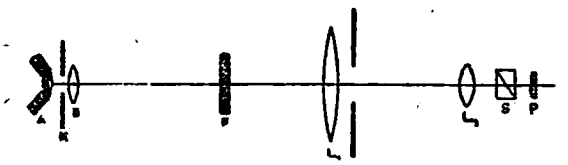

Fig. 1. Arrangement of the apparatus for illuminating the photographic plate by infra-red light.

A is a self-regulating carbon arc lamp for 10 *A*, and *B* is a quartz condenser. *K* is an asbestos diaphragm with a rectangular opening (2×2 cm), which was uniformly illuminated by the light from the arc and of which the image was to be focussed on the material under investigation. *F* is a light filter, which allows infra-red rays of 2000–900mμ region to traverse. *P* is the photographic plate under investigation. *S* is a Sénarmont-prism, which was employed to obtain double images for the purpose of measuring the dichroism by the differential method, and its position between the objective lens L_2 and the plate (*P*) was adjusted so as to allow the double images to border each other directly on the plate. By the above mentioned arrangement of the apparatus, the plates could be illuminated by the double images (each 5×5 mm) of the rectangular opening of the diaphragm sharply and uniformly.

The dichroism (*D*) was calculated by the formula:

$$D = 2 \log tg\,(45° \pm \alpha)$$

or approximately

$$D = 0{,}015 \times 2\alpha$$

1) F. Weigert and J. Shidei, *Loc. cit.*

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where, α is the angle of rotation of the analyser in the polarimeter, and 2α is shown besides by the difference between two readings in the double fields, which were illuminated by the above mentioned double images.

EXPERIMENTAL RESULTS.

The experiments were made under several conditions of different light intensities, times of the excitation and the development, on which the dichroistic effect for visible light depended markedly as was shown previously.

The results obtained preliminary are tabulated in Table 1 and 2 and illustrated diagrammatically in Fig. 2 and 3.

From this, it will be seen that the dichroistic effect was produced evidently by the infra-red rays though not so strongly as that by red light. The type of the curves showing D/S was similar to that for red light (680mμ), in which case the curves used to descend first with the time of the excitation, falling to a

Table I. Relative Dichroism (D/S) in Infra-red Rays under Different Times of Development. Temp. of Developer. 24°C. Light Intensity. 72×10^{-3} cal. cm.$^{-2}$ sec.$^{-1}$

Time of Developing		Time of Illumination					
		1′	2′	4′	8′	15′	30′
40″	2α	0	0	0	0	−0.04	−0.05
	S	0	0	0	0	0.02	0.05
	D/S	0	0	0	0	−3.00	−1.50
80″	2α	0	0	−0.02	−0.08	−0.10	−0.15
	S	0	0	0.02	0.04	0.08	0.10
	D/S	0	0	−1.50	−3.00	−1.87	−2.25
240″	2α	0	0	?	?	−0.16	−0.30
	S	0	0	0.15	0.18	0.30	0.30
	D/S	0	0	0	0	−0.80	−1.50
480″	2α	0	−0.03	−0.10	−0.12	−0.12	−0.26
	S	0	0.10	0.10	0.09	0.11	0.12
	D/S	0	−0.45	−1.50	−2.00	−1.64	−3.24
900″	2α	0	−0.04	−0.39	−0.70	−1.04	−1.39
	S	0	0.30	0.32	0.41	0.39	0.50
	D/S	0	−0.20	−1.83	−2.67	−4.00	−4.17

Table 2. Influence of Light Intensity upon Relative Dichroism (D/S) Temp. of developer. 24°C. Time of Developing. 900″

Relative intensity	Time of Illumination					
	1′	2′	4′	8′	15′	30′
1 (72×10^{-3}cal. cm.$^{-2}$sec.$^{-1}$)	0	−0.20	−1.83	−2.67	−4.00	−4.17
0.79	0	−0.13	−1.57	−2.94	−4.00	−3.68
0.51	0	−0.07	−0.74	−1.20	−1.44	−1.68
0.37	0	−0.06	−0.21	−0.94	−2.73	−2.49

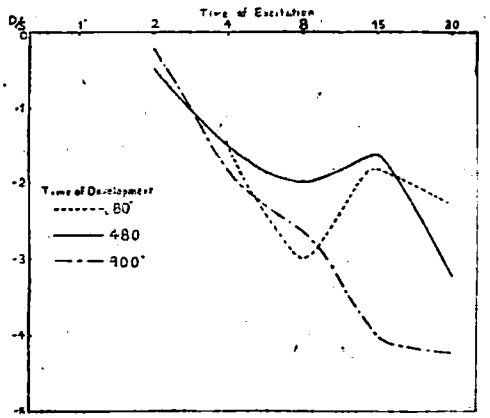

Fig. 2. Influence of the time of development upon the relative dichroism.

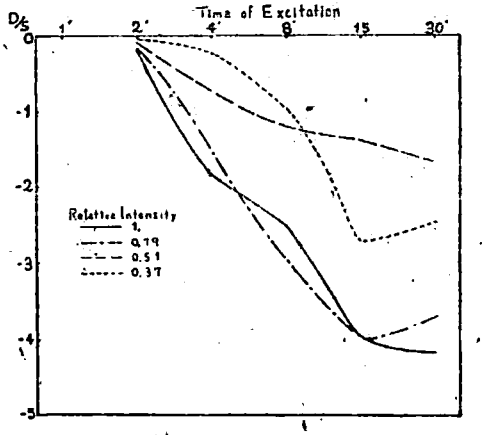

Fig. 3. Influence of light intensity upon the relative dichroism *D*/*S*.

minimum, then to ascend to reach a maximum again to descend. The photo-dichroistic effect grew stronger with the intensity of light and also with the time of development, so that the relative dichroistic curves were displaced in the similar way to that for red light.

Therefore, so far as the present experiments are concerned, the essential distinction between the effect due to the red rays and that to the infra-red rays seems not to exist.

Theoretical discussion of the facts obtained here will be given, when more exhaustive experiments of this sort shall have been made.

Summary.

(1) The induced photo-dichroism by infra-red rays was studied with a photographic plate ("Imperial Gaslight Plates, warm Tone.") The plates were first illuminated by the polarised infra-red light of the 2000–900mμ region, then developed with a paraphenylene diamine-silver developer of Lumière and Seyewetz and fixed. The induced photo-dichroism thus produced was measured by the Lippich half-shadow polarimeter.

(2) The plates were found to be sensitive dichroistically to infra-red rays.

(3) The sign of the induced photo-dichroism produced was negative. The type of curves obtained by plotting the relative dichroism against the time of illumiuation was similar to that for red light. The influence of different intensities of the light, times of development etc. upon the dichroism was also similar to that for red light, so that the essential distinction between the photo-dichroistic effect for infra-red light and that for red light was not found.

Chemical Laboratory,
Tokyo University of Literature and Science.