314. *Light Filters for the Mercury Lamp.*

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THE following observations relate to the use of filters for the quartz mercury lamp. Though lamps differ in emission among themselves and with age, the filters described below will probably be found suitable for all mercury lamps in good condition. The lamp used in the measurements was a Hanovia "Alpine Sun," D.C. model, running with 72 volts across the burner, which had been in use about 200 hours. The distribution of its ultra-violet emission is given below.

For photochemical work, light as monochromatic and yet as intense as possible is required; the shorter waves in particular must be effectively removed. Owing to the peculiar distribution of intensity in the spectrum of the mercury lamp and to the variation of sensitivity of the photographic plate with wave-length, a filter with certain photographically determined characteristics when used in conjunction with another type of light source may be unsuitable; again, many filters, *e.g.*, "Vita-glass," do not cut off sharply, but show a gradually diminishing absorption towards shorter wave-lengths. To obtain sharp "cutting" it is necessary sometimes to resort to solutions of organic substances, and here, under the conditions of very intense illumination necessary for photochemical work, changes of transmission owing to decomposition must be avoided by renewing the filter continuously from a stock vessel. The filters described below show the following features: (*a*) the infra-red is effectively removed, even from the ultra-violet filters; (*b*) the number of separate filters is reduced to a minimum; (*c*) the transmission is high with good "monochromatism"; (*d*) the stability of the filters under given energy conditions has been investigated.

EXPERIMENTAL.

To attain the requisite intensity for photochemical reactions, it is almost essential to use some form of condenser; and, particularly in the ultra-violet region, the use of round flasks as combined condenser-filters possesses advantages of convenience and economy (cf. Norrish, J., 1929, 1158). Two arrangements may be employed. Using one flask, placed a few cm. from the lamp, approx. parallel light can be obtained, while with two flasks almost in contact, and one nearly touching the burner, very much more intense light converging

to an image about 3 cm. by 0·75 cm. is obtained about 5 cm. beyond the second flask. All the measurements given in this paper were made on the light intensity at circular apertures (1—2 sq. cm.) illuminated (non-uniformly) by the image formed in the second arrangement. Similar relative though feebler intensities (about 1/4 to 1/10) may be obtained in the single flask arrangement by the modifications described below.

For the production of monochromatic light it is most convenient first to divide the whole range of frequencies into four regions with four principal filters, (*a*) yellow and green lines, (*b*) blue, violet, and 3665 Å. lines, (*c*) lines 3340—2800 Å., (*d*) lines 2800—2480 Å. Subsidiary filters in conjunction with these are used to isolate single lines.

For the first two regions, in the arrangement using two flasks, the first flask (glass, diameter 10—12 cm.), placed very near the lamp, should be filled with dist. H_2O. For the second flask, a spherical glass "Dewar" double-walled vessel of about 12 cm. outside diameter with the double walls about 1 cm. apart is suggested. The inner part is filled with H_2O, while the space between the walls should contain the following solutions :

(1) For region (*a*), 60 g. $CuSO_4,5H_2O$; 2 g. $K_2Cr_2O_7$; 55 c.c. conc. H_2SO_4; made up to 1 l. with H_2O. Combined with this filter, 3·4 mm. of Corning glass 344 transmits only the yellow lines 5790 and 5770 Å., and 5 mm. of Corning glass 512 transmits only the green line 5460 Å.

(2) For region (*b*), 20 g. $CuSO_4,5H_2O$; 300 c.c. NH_4OH aq. (*d* 0·88); made up to 1 l. with H_2O. In conjunction with this filter, 2·5 mm. of Corning glass Noviol A transmits only the blue line 4360 Å.; 2 mm. of Corning glass Noviol 0 + 1 cm. of a CCl_4 solution of I (7·5 g./l.) transmits only the line 4060 Å.; and 2—2·5 mm. of Chance's black "ultra-violet" glass transmits only the line 3665 Å.

The following measurements, made with a Moll thermopile, calibrated against a Hefner lamp, show the amounts of energy obtainable at an aperture of 2 sq. cm. placed at the concentrated image of the Hg lamp :

Å.	5790 + 5770	5460	4360	4060	3665
$Nh\nu$ per sec. $\times 10^9$	23	52	22	9	32

These results, though referring to a particular lamp at a particular time, are useful as a guide to the approx. intensity of monochromatic illumination obtainable by the above methods. The transmissions are monochromatic, and the infra-red is absent, within about 1%. Less intense light, but more nearly parallel, may be produced by the omission of the first flask of H_2O.

For the ultra-violet regions, spherical fused quartz flasks, 10 cm. in diameter (½ l.) and of good quality give good results. For region (*c*) the flask nearest the lamp should contain a solution of 70 g. of $NiCl_2,6H_2O$ (free from Co and Fe) + 30 c.c. conc. HCl, made up to 1 l. with H_2O; while for region (*d*) this stock solution should be diluted to one-fifth concn. These solutions are stable, and remove the infra-red and the 4060 Å. line, and greatly reduce the intensity of the 3665 Å. line.

The measurements given below were made with a special instrument consisting of a small quartz spectroscope fitted with a sodium-in-quartz photoelectric cell and Lindemann electrometer. This instrument had been calibrated at different wave-lengths by Mr. J. H. Jeffree, using a thermopile and a Paschen galvanometer, and had been fitted with a template in the plane of the spectrum to make its sensivity (in g.-mol. quanta/cm.²/sec.) uniform over the region

3665—2480 Å. Two flasks were used, almost touching, one very near the lamp, followed by plane-walled quartz cells, the intensity being measured at the region of the concentrated image of the lamp about 5 cm. beyond the second flask.

Lines transmitted, Å.	Flask 1.	Flask 2.	Plane-walled quartz cells.	Transmission measurements, $Nh\nu$/cm.²/sec. × 10^9.	Stability of filter under given energy conditions.	For arrangement using one flask replace Flask 1 by :
3665—2480	Water.	Water.	——	3665 50·0 3340 5·0 3135 20·0 3030— 15·6 2900 2900— 3·0 2800 2800— 1·4 2700 2650 4·8 2540 4·8 2480 1·4		
3340	$NiCl_2$ soln. (stock).	Uric acid, satd. soln. in H_2O at 15°.	——	3800— 0·055 3500 3340 1·65 3250— 0·17 2480	Uric acid soln. should be changed every hour.	Uric acid soln., 8—10 cm.
3135	$NiCl_2$ soln. (stock).	K_2CrO_4 soln. in H_2O: 5 c.c. of stock soln. (3·0 g. K_2CrO_4 per l.) + 5 c.c. of 2*N*-NaOH + 490 c.c. H_2O.	Potassium hydrogen phthalate soln. in H_2O (13 g. per l.), 1 cm.	3800— 0·16 3300 3135 10·0 3030 0·25 3050— 0·42 2480 2920— 0·22 2480	Fresh phthalate soln. should circulate at 250 c.c. per hr.	K_2CrO_4 soln. (4 c.c. stock soln. + 0·5 c.c. 2*N*-NaOH diluted to 50 c.c. with H_2O), 1 cm.
3135 +3030 +2970	$NiCl_2$ soln. (stock).	Auramine O soln. in H_2O; 60 c.c. stock soln. (0·125 g. per l.) + 440 c.c. H_2O.	$Ph{\cdot}CO_2H$ aq., satd. at 15°, 1 cm.	3800— 0·35 3300 3135 8·5 3030— 4·6 2970 2900— 0·15 2700 2700— 0·125 2480	Auramine O soln. should be changed every 6 hrs.; $Ph{\cdot}CO_2H$ aq. to be renewed at 1 l. per hr.	Auramine O soln. (stock), 1 cm.
3030	$NiCl_2$ soln. (stock).	Water.	Harrington's "A.R." benzene, 1 cm.	3800— 0·44 3300 3135 0·29 3030— 1·2 2900 2800— 0·067 2480	Fresh C_6H_6 should circulate at 4 l. per hr.	——
2650	$NiCl_2$ soln.: stock dil. to 1/5.	Water.	Cl gas at 760 mm., 3 cm. + soln. of pure C_6H_6 in H_2O, 1 cm. (82 c.c. of satd. soln. at 15° dil. to 100 c.c.).	3800— 0·02 2900 2900— 0·15 2800 2800— 0·35 2700 2650 1·4 2540— 0·1 2480	Fresh C_6H_6 soln. should circulate at 5 l. per hr.	——
2750—2480	$NiCl_2$ soln.: stock dil. to 1/5.	Water.	Cl gas at 760 mm., 3 cm.	3800— 0·02 2900 2900— 0·15 2800 2800— 0·4 2700 2700— 10·0 2480	Stable.	——
2540	$NiCl_2$ soln.: stock dil. to 1/5.	Water.	Cl gas at 760 mm., 3 cm. + KI_3 soln. in H_2O; 8·6 c.c. of stock soln. (12·7 g. I_2; 18 g. KI per l.) dil. to 1 l., 1 cm.	3800— 0·01 2700 2650 0·12 2540 1·25 2480 0·18	Fresh KI_3 soln. should circulate at 500 c.c. per hr.	——

For the measurement of the ultra-violet constituent of such filtered light as the above with a thermopile, see Norrish and Kirkbride (this vol., p. 1518).

It will be noted that for the ultra-violet region many of the solutions must be renewed at fairly high rates. These rates would be correspondingly less under conditions of less intense illumination. For the filter isolating 2650 Å., the C_6H_6 employed must be carefully purified by freezing out several times from ordinary high-grade C_6H_6; even with this purification, however, its transmission changes on exposure to intense illumination without circulation. The filter transmitting the line 3030 Å. is admittedly incompletely specified, since its action depends on an unknown impurity in Harrington's A.R. benzene. It is included only because of its unique property, which might be very useful for certain work, of almost removing the neighbouring strong 3135 Å. line. The C_6H_6 rapidly darkens on exposure, and high rates of flow through the filter are necessary. These unexpected properties of C_6H_6 are under investigation.

The author is indebted to the Royal Society for a grant with the aid of which the measuring instruments used were constructed.

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OXFORD. [*Received, June 23rd,* 1932.]