SHORT DURATION PHOSPHORESCENCE IN FUSED QUARTZ

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Abstract

The short lived phosphorescence of fused quartz was found to have a decay constant of approximately 5×10^3 sec^{-1}. The wave-length of the exciting radiation is less than 2270A. The phosphorescence radiation is a continuous band extending from 3700 to 4750A with a maximum at 4000A. Temperature changes from 20° to 240°C do not affect this phosphorescence. No phosphorescence of this type was observed in crystalline quartz.

THE luminescence of fused quartz has been observed and studied to a very limited extent.[1] Three types have been detected:[2] (1) phosphorescence of short duration, which has been observed only as fluorescence; (2) phosphorescence of long duration lasting is some cases many hours; (3) thermoluminescence, observed when fused quartz which has been irradiated with short wave-lengths is heated. These phenomena have usually been attributed to the impurities in the fused quartz, as crystalline quartz has not shown the effects. An exception to this is cited by Bailey and Woodrow[1] who found that crystalline quartz after having been raised to 1600° C showed the thermoluminescence phenomenon.

While studying the persistence of the emission of λ2537 from mercury vapor after the exciting radiation had been cut off, the authors found that a short lived phosphorescence (presumably of the first type) of the walls of the fused quartz cell containing the vapor was sufficiently intense and of such a duration as to be confused with the mercury radiation unless a spectroscope was used in the observing system. As fused quartz is widely used in studying the luminescence of vapors, measurements were made of the wave-lengths of the exciting radiation, of those of the phosphorescence radiation and of the time of decay of the latter.

Three samples of transparent fused quartz were examined. Sample *A* was obtained from the Thermal Syndicate Co., Ltd., sample *B* from the Cooper-Hewitt Electric Co., and sample *C* from the Hanovia Chemical and Manufacturing Co. All were between two and three millimeters in thickness.

[1] W. E. Curtis, Nature **113,** 495 (1924).
E. B. Ludlam and W. West, Nature **113,** 389 (1924).
D. L. Chapman and L. J. Davies, Nature **113,** 309 (1924).
W. E. Curtis, Proc. Phys. Soc. London **36,** 431 (1924).
A. C. Bailey and J. W. Woodrow, Phil. Mag. **6,** 1104 (1928).
J. C. Drummond and T. A. Webster, Nature **115,** 837 (1925).
[2] A. E. Gillam and R. A. Morton, Phil. Mag. **6,** 1123 (1928).

Experimental

The phosphorescence was measured by the rotating device previously described.[3] The radiation from a water-cooled quartz mercury arc passed through a narrow slit and fell on the sample of fused quartz about 15 mm distant. The illumination was made intermittent by means of a rotating toothed disk. Beyond the sample, rotating on the same shaft as the toothed disk was a second disk through which had been drilled a set of $\frac{1}{2}$ mm holes spaced so that a hole corresponded to each tooth. The reemitted light passed through these holes to a photographic plate a few tenths of a millimeter away. The disks were so adjusted that the cut-off of exciting radiation by each tooth of the first occurred just as a hole in the second passed on to the plate. Thus only the reemitted light reached the plate leaving a trace from which its variation with time could be determined. The time necessary to obtain a satisfactory trace varied from 30 to 120 minutes. The angular speed of the disks averaged 3600 R. P. M.

Exciting Radiation.

When a piece of polished calcite 3 mm thick, was interposed between the arc and the slit no trace of the phosphorescence was observed. Therefore the wave-length of the exciting radiation was less than 2270A, which was the limit of transmission of the calcite used, as determined spectroscopically. Spectrograms of the arc showed only two lines in this region 1942A and 1849 A. Whether one or both of these lines was responsible for the excitation was not determined.

Phosphorescence Radiation.

The phosphorescence radiation from the fused quartz was readily transmitted by ordinary glass. A spectrogram of this radiation was taken with the apparatus slightly modified. The perforated disk was replaced by a second toothed disk which rotated close to the slit of a small quartz spectrograph. The disks were synchronized so that the exciting radiation was completely cut off before the spectrograph slit was uncovered by the second disk. With the disks rotating at 2700 R. P. M. it required 25 hours to obtain a satisfactory spectrogram. The radiation recorded consisted of a single continuous band extending approximately from 3700-4750A, with a maximum at 4000A. The slit width used corresponded to about 60A. No other bands or lines were found on the plates.

Time of Decay

The time of decay of the phosphorescence was calculated from the trace on the photographic plate obtained with the apparatus as first described. The law of blackening of the plates was not sufficiently well known to determine whether the decay followed a simple exponential law or not. Assuming an exponential law the result was an exponential decay constant equal to

[3] M. W. Zemansky, Phys. Rev. **29**, 513–523 (1927).

5000 sec^{-1}. Within the precision of the determinations the results for the three samples were the same.

There was a marked difference in the intensities of the phosphorescence from different samples, in some cases as great as five-fold. A variation from point to point in each sample was observed but not studied.

No change in the rate of decay of the phosphorescence from sample *C* was found when the temperature of the sample was raised from 20° to 240° C.

No trace of this phosphorescence was found in crystalline quartz.

In conclusion the authors wish to thank Mr. L. J. Buttolph of the Cooper-Hewitt Electric Co. for the loan of the mercury arcs used in these tests.