SPECIAL ARTICLES

THE PHOTOELECTRIC EFFECT AS RELATED TO THE SIZE AND SURFACE CONDITIONS OF CARBON PARTICLES

IN 1924 one of the authors tested the photoelectric effect of several dyes.[1] Films for the purpose were easily formed when using spirit soluble dyes. Experiencing considerable difficulty in preparing suitable films of certain other dyes, it was decided to try dusting or rubbing the dry powdered dye onto the test plates. The results proved quite satisfactory. Thinking that other powdered substances might be photoelectrically active, plates were prepared by holding them in the smoke from burning matches, from burning camphor gum, from a burning candle, from gas flame and from burning magnesium ribbon. Still other plates were prepared by rubbing onto them lamp black, powdered graphite from lead pencils, powdered chalk, etc. All these were active. However, those prepared by holding the plates in the smoke from burning substances were much more active, in some cases being very nearly as active as freshly polished zinc plate. This led to the conclusion that the activity of carbon was in some manner a function of its fineness.

In 1925 and 1926 the authors working at Michigan State College decided to test further the photoelectric effect of finely divided carbon. These investigations were carried on at atmospheric pressure. The apparatus consisted of a carbon arc as a source, an electrometer and a holder for the test-plates, all carefully shielded. The test-plates were of constant area, 5 x 6 cm. Solid carbon rods three eighths inch in diameter were used for the arc. A direct current was used and the source was kept constant by maintaining a constant voltage of forty volts across the arc. A highly polished plate of zinc, 5 x 6 cm, was used as a standard test-plate. In every case the plate was polished just before using.

Common black stovepipe iron was found to be inactive and it was selected for test-plates. However, it is inactive only when the coating due to the manufacturing process is on the plate. Since alcohol removed this coating the use of alcohol either as a cleaning agent or as a solvent for preparing films was discontinued. It is necessary to have an evenly distributed film or layer of the substance to be tested on the plate, and plates were so prepared by dusting the dry powdered substances onto them. The plate was thoroughly cleaned, dried and tested before the powder was dusted onto it, and, if active, was cleaned again. If it still showed a trace of activity, it was discarded.

[1] The introductory part of this work was done in 1924 at Cornell University at the suggestion of Professor E. Merritt.

The following readings were taken: Scale reading before light was turned on, time in seconds for the electrometer to indicate a deflection of ten scale divisions, scale reading at the time the light was turned off, and the average voltage across the arc during this time. An average of one hundred readings taken with the standard zinc test-plate gave 5.0 seconds as the time for a ten scale division discharge. This was taken as a standard value, and all other values were compared with it.

The carbons in Table I differ in origin, degree of hardness and fineness, and are listed according to their sources. Thus a carbon listed as redwood is carbon obtained by partially burning redwood. Usually the carbon thus obtained was ground in an agate mortar, passed through a screen of known mesh and then dusted upon the test-plates. All excessive particles were removed by jarring the plate. In some cases the particles were brushed or rubbed onto the plate, using rice paper or absorbent cotton for the purpose.

TABLE I

Substance	Note	Time of discharge Sec.
Paraffin	(2)	9.2
Paraffin	(1)	8.3
Paraffin	(4)	not active
Camphor gum	(1)	26.6
Block of sulphur		not active
Piece of camphor gum		" "
Bone black		43.2
Poplar	(5)	26.5
Southern pine	(5)	23.8
Northern pine	(5)	23.1
Redwood	(8)	70.9
Redwood 100	(7)	29.7
Redwood 80–100	(7)	44.7
Redwood 60–80	(7)	66.7
Redwood 40–60	(7)	64.9
Redwood	(3)	30.9
Cypress	(5)	13.7
Arc carbon	(6)	19.3
Chestnut	(5)	17.7
Red-oak	(5)	16.5
Gum-wood	(5)	19.2
Black-walnut	(5)	19.0

Notes:
(1) Finely divided carbon, obtained from burning, brushed on plate with rice paper or absorbent cotton.
(2) Finely divided carbon deposited on plate held eight inches above flame.

(3) One week after being prepared.
(4) Plate dipped in hot paraffin and cooled.
(5) Carbon ground in agate mortar and passed through 100 mesh screen.
(6) Collected at base of arc and brushed on the plate with rice paper.
(7) 40–60 is carbon passed through a 40 mesh screen upon a 60 mesh screen.
60–80 is carbon through a 60 mesh screen upon an 80 mesh screen.
80–100 is carbon through an 80 mesh screen upon a 100 mesh screen.
100 is carbon through a 100 mesh screen upon the pan below.
(8) Ground in a porcelain mortar.

Carbon obtained from cypress, poplar, redwood, southern pine and northern pine is soft, having a flaky or needle-like structure as shown by photomicrographs. Table I shows that these are not as active as carbon obtained from paraffin, arc carbons, chestnut, red oak, black walnut and gum-wood, which is hard, having a distinctive granular structure. Because of the fact that soft carbon adheres to the test-plates much better than harder grades, more particles remain on the plate per square centimeter. Thus a greater photoelectric effect was expected; however, the reverse proved to be true. Therefore, the photoelectric effect increases with hardness of the particles.

Our results indicate that the photoelectric effect varies with the size of the carbon particles. Redwood (8) (Table I) was ground in a porcelain mortar, and it was coarse and flaky. It was quite inactive. Redwood (100) was more than twice as active as Redwood (40–60). Paraffin (1) having been brushed with rice paper was more active than paraffin (2), the coarser particles having been removed by brushing. Therefore we have some reason for believing that the photoelectric effect is modified by the fineness of the particles. However, it is possible that the apparent increase in the photoelectric effect with the decrease in the size of the particles is, at least in part, due to the fact that the effective area (the area normal to the direction of the incident light) increases with the fineness.

TABLE II

Substance	Condition	Time in sec.
Graphite as manufactured	Rough and uneven	13.4
Graphite plate cut out	Rough	9.3
Same plate	Polished on buffing wheel	4.7
Same plate	Roughened with No. 00 sand paper	8.5
Hard carbon	Very hard. Cut out with hacksaw and tested (surface covered with dust)	10.8
Same plate	Polished	8.6
Hard carbon plate held in flame from asbestos wick in liquid paraffin	Completely covered finely divided carbon	4.2
Zinc plate Av. of 25 readings	Polished	5.1+
Hard carbon plate	Covered with fine carborundum dust	not active

Further results obtained more recently appear in Table II.

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THE EFFECT UPON DIGITALIS PURPUREA OF RADIATION THROUGH SOLARIZED ULTRA-VIOLET-TRANSMITTING GLASS[1]

DURING the Nashville meeting in 1927, a report[2] was made by the writer concerning *Digitalis purpurea* plants which were started under glass that transmits ultra-violet light, and later grown in the open field. Such plants, when tested physiologically, proved to be considerably more potent medicinally than were the controls which had been exposed under ordinary glass.

The question at once arose as to whether such effects would continue to be obtainable after the glass had been solarized for several months; and the purpose of this brief paper is to give a report of work done upon this point.

During the season just passed, 1928, similar experiments were made, therefore, to serve as check tests on the previous findings. All methods closely paralleled those used in 1927, except that not so many plants were used as before. Each outdoor bed this year consisted of four rows of six plants each; and each group of twenty-four plants provided a composite sample.

While the plants were under greenhouse conditions, the difference between the treated plants and the controls was much less marked than in those of last year. Whatever advantage was observable, in size or color, lay constantly with the treated plants; but, when the plants were put out-of-doors, the two groups were practically identical to the eye. It was felt at

[1] Paper read before the Botanical Society of America, December 28, 1928, New York, N. Y.
[2] A. McCrea, SCIENCE, 67, No. 1732, 277–278, 1928.