SUMMARY

OF THE SESSIONS

OF THE ACADEMY OF SCIENCES

SESSION OF MONDAY NOVEMBER 4, 1839.

UNDER THE CHAIRMANSHIP OF Mr. CHEVREUL.

REPORTS AND COMMUNICATIONS

OF MEMBERS AND CORRESPONDENTS OF THE ACADEMY.

REPORTS READ

Report on the electrical effects produced under the influence of solar rays;
by Mr. **Edmond Becquerel.***

§ I. *Action of radiation on metal blades.*

" In the last report that I had the honor of presenting to the Academy, in its session of Monday July 29, 1839, I tried to highlight, with the help of electric currents, the chemical reactions that occur in contact with two liquids, under the influence of sunlight. The process I employed required the use of two platinum blades, attached to the two ends of the wire of a highly sensitive multiplier, each of which dipped into one of the stacked dissolutions. As these two blades were sensitive to the effects of radiation, it surely resulted in the compound phenomena that I will study in this new report. We will then be able to assess each of the effects produced.

* *Translated from [1] for the 200^th anniversary of the Edmond Becquerel's Birthday (https://www.ipvf.fr/)*

“ When two perfectly clean but unevenly heated platinum blades are dipped into a liquid, an electric current is immediately produced; and whether the liquid is water or alkaline water, the current is such that the heated blade takes the negative electricity from the liquid; The opposite effect occurs when acidic water is used as the conductive liquid. As the same phenomenon occurs when two blades of platinum or gold are unequally exposed to solar radiation when dipped into an acid, neutral or alkaline solution, it is important to know to what extent the calorific radiation is involved in the production of the phenomenon. To observe the effects of solar radiation, we take a wooden box blackened on the inside and divided by means of a very thin membrane into two compartments, which we fill with the test solution. A platinum blade is dipped into each of these compartments after having previously heated it to red; the platinum blades are connected to an excellent long-wire multiplier, and each compartment is finally covered with a board, in order to intercept the action of sunlight. When we want to operate, we remove each of them one after the other.

“ I first researched the order of the variously colored screens, relative to the solar radiation that acts on the platinum blades, to be able to compare it to the order of these same screens relative to the solar heat radiation, which acts on a thermo-electric cell. This order is completely different; we need only mention a yellow glass, which is very diathermic and completely intercepts any action of sunlight on the platinum blades.

“ Mr. Melloni showed that heat rays of different refractiveness* were unevenly absorbed by a water screen one millimeter thick and that the loss was due to the inverse of the refractiveness; but, as in the previous experiments, the solar rays crossed a liquid layer before hitting the platinum blades, I wanted to put the thermoelectric cell in the same relative position as the two platinum blades; so I looked for the order of the screens between the liquid layer and the thermoelectric cell. In this case, the yellow glass, mentioned above, filters only a small part of the radiant heat; the order of the other screens is quite different from the one we found for the platinum blades. It must, therefore, be concluded that it is not thermal radiation that produces this phenomenon, but rays accompanying the most refractive rays of light, as the screens seem to indicate, as well as the various parts of the spectrum.

Indeed:

“ I applied vertically one of the two blades of platinum, which had previously been

******Note from the translators :blue light or UV light is more refracted (deviated) than red light***

heated to red, to one of the faces of a glass box which had been blackened, except for a part which was opposite the blade; then having successively projected on this blade the colored rays of the solar spectrum formed by refracting the direct rays of the sun, one had a sensitive electric current only when the blade was exposed to the violet or blue rays.

" Whenever the blades are very clean, have been soaked in concentrated nitric acid and then heated to red, the rays of the spectrum have no effect in determining the production of electrical currents for which we are looking for the cause. This experiment tends to show that rays acting on platinum or gold blades, dipped into dissolutions, are more refractive than heat rays. The question now arises as to what the mode of action of these rays is in the present circumstance; this is a hard question to answer.
However, as the effects are almost undetectable when the surfaces of the blades are very clean and perfectly pickled, it could be that the effects produced, when the blades are not in this state, are due to the action of chemical rays on extremely minute corpuscles adhering to the surfaces. The nature of the corpuscles being unknown, one is naturally led to seek first of all the influence that can be exerted on the phenomenon by the presence of bodies inalterable to light, such as coal and various metal oxides placed on the blades in very thin layers. So, in this case, far from having an increase in effects when the blades thus covered are exposed to solar radiation, there is rather a decrease, the opposite result of what would happen if the phenomenon was purely calorific, the bodies placed on the platinum blades having a stronger absorbing power on the platinum. So, in this case, far from having an increase in effects when the blades thus covered are exposed to solar radiation, there is rather a decrease, the opposite result of what would happen if the phenomenon were purely calorific, the bodies placed on the platinum blades having a stronger absorbing power on the platinum.

" I have also operated with oxidizable metal blades."

"Brass blades. - Well-stripped brass blades were placed in the compartment apparatus, which contained plain water sharpened with a few drops of nitric acid; a current of 4 to 5 degrees was obtained when exposed to sunlight; then an electric current was passed through the two blades serving as electrodes; the positive blade became oxidized, while the other remained shiny; then they were successively exposed to sunlight, the shiny blade behaved as before, i.e. it took the positive electricity from the liquid, while the oxidized blade became strongly negative: having reversed the order of the blades, when they were used as electrodes, the results were still the same; one of the oxidized blades, having been put successively in the colored rays of the solar spectrum, yielded:

Rays of the spectrum.	Current intensity per first pulse.
Red	1°
Orange	“
Yellow	2
Green	4
Blue	2
Indigo	”
Violet	0

" *Silver blades.* - Perfectly pickled silver blades were placed in the apparatus with a compartment filled with water acidulated with sulfuric acid; successively exposed to solar radiation, they yielded a current of 1 to 2 degrees; the exposed blade was negative relative to the liquid: operating with the same blades that had served as electrodes and exposing the positive or oxidized blade to solar radiation, the current was not more intense.

" Since this weak action could be neglected, I deposited bromine, iodine and chlorine vapors on the silver blades. With a thick layer of diode vapor, spread over the blade, a fairly intense current was obtained, directed in such a direction, that the blade exposed to the sun took up the negative electricity from the liquid, a result which indicated the action of iodine on the silver; when the layer of iodine was very thin, an electric current was obtained going in the opposite direction, which indicated a chemical action opposite to the previous one; by the first pulse of diffuse light, the current obtained, in one experiment, produced a deviation of 45 degrees.

" When bromine is used instead of iodine, the current, which is strong enough, always occurs in such a way that the exposed blade is negative relative to the liquid.

" These currents are short-lived, since an exposure of a few moments to atmospheric radiation is sufficient to completely affect the reaction of bromine and iodine with silver.

" With chlorine, the current has been so weak that the effect is no different from that obtained with platinum blades alone.

§ II. *Electric currents developed by the decomposition of silver chloride, bromide and iodide, under the influence of sunlight.*

" When silver chloride is exposed to light, it loses its chlorine and changes into sub-chloride; on the other hand, since this compound is not electrically conductive when it is in mass, and becomes so when it is in a very thin layer, it follows that the electrical effects produced on this body by solar radiation can be observed. For this purpose it is spread, when newly prepared, on a platinum blade dipped into water made conductive by the addition of a few drops of an acid, nitric acid, for example; as soon as the blade is exposed to sunlight, or even to diffuse light, the chloride blackens and the needle of the galvanometer deviates several degrees in a direction that indicates that the blade is positive; the result is easy to explain: the chloride, as it decomposes, takes the positive electricity which it transmits to the metal blade with which it is in contact, while the liquid takes the negative electricity. Here we cannot operate with a silver blade, since the reaction of the chlorine, which comes from the decomposition of the chloride on the silver, produces a current in the opposite direction to the one we are studying. A gold blade behaves in the same way as a platinum blade.

" The best way to spread the silver chloride on the blade is to place it on the blade while it is still wet and gently heat the blade in the dark; the adhesion of the chloride is such that it does not fall off, no matter what position the blade is given in the liquid.

" Silver bromide, which decomposes faster than chloride in light, also produces a stronger current. To compare the effects of radiation on chloride and bromide, two blades of platinum, each 4 square centimeters in area, were coated with chloride and silver bromide; these blades having been put in the compartment apparatus, one observed in diffuse light, 15 degrees of deviation with the chloride, and 26 degrees with the bromide. Silver bromide, in the first instants, pushed the needle to 55 degrees, at the instant when a solar ray fell upon it; in another experiment, silver bromide, in diffuse light, produced, in the first pulse, a deviation of 75 degrees.

One difference between the two bodies is that chloride gives off an equally strong current for a very long time; even after two hours of exposure to sunlight, we still have a sensitive current. It is not the same with bromide; after ten minutes of exposure to diffuse light, it has lost almost all its ability to give a current.

" Silver iodide, which does not change color significantly in light, nevertheless, under the same circumstances, produces a current almost as strong as that of chloride; however, it is not constant over such a long lapse of time. This current, produced by the silver iodide, indicates that it changes into a sub-iodide under the action of light. It is very likely that in explaining the phenomena relative to the production of the photogenic drawings made by Mr. Daguerre, one must have regard to this transformation. We will come back to this later. This property of silver chloride to yield a fairly constant current over a lapse of time allows it to be used to determine the ratios of the numbers of chemical rays that pass through the screens, as well as the distribution of the rays that affect silver chloride in the solar spectrum. Here are the results of two experiments:

Screens.	Number of rays.
Without screens	100
White glass	66
Purple glass	53
- blue.	40
- green, - yellow, - red	0

Rays of the spectrum.	Current intensity.
Red, Orange, Yellow	0
Green	trace
Blue	0°,75
Indigo	1 °
Violet	3 °
Rays beyond violet	3 °

" In summary, this Report highlights the following facts:

» 1°. The rays that accompany the most refractive rays of sunlight cause metal blades dipped into a liquid to experience such an action that electrical effects result, to which no calorific origin can be attributed.

» 2°. The decomposition of silver chloride, bromide and iodide under the influence of light produces electrical effects that can be used to determine the number of active chemical rays.

" It can be seen, therefore, that when one wishes to use the electrical effects produced in the reaction of two dissolutions one on the other, to study this reaction under the influence of light, it is necessary to take into account the action of solar radiation on the metal blades used, whose effect can be easily separated from the total effect, by operating with the apparatus filled successively with the two liquids. In another report I will come back to the distinction between these two effects. »

[1] Edmond Becquerel, Comptes rendus de l'Académie des sciences, IX(1839) 561-567

Translated by : Alexandre Crossay, Jean-Eric Bourée, Pedro Alpuim, Nathalie Bourée, Bertrand Theys (March 2020)