Rays Emitted by Compounds of Uranium and of Thorium

Marie Sklodowska Curie (1867-1934)

Note by Mme Sklodowska Curie [1] presented by M. Lippmann, Comptes Rendus 126, 1101-3 (1898), translation by Carmen Giunta.

I have studied the conductance of air under the influence of the uranium rays discovered by M. Becquerel, and I examined whether substances other than compounds of uranium were able to make the air a conductor of electricity. In this research I employed a parallel-plate condenser; one of the plates was covered with a uniform layer of uranium or of another finely pulverized substance. (Diameter of the plates 8 cm; separation 3 cm.) One establishes a potential difference of 100 volts between the plates. The absolute value of the current which traversed the condenser was measured by means of an electrometer and a piezoelectric quartz.

I examined a large number of metals, salts, oxides, and minerals [2]. The following table gives, for each substance, the magnitude of the current i in amperes (order of magnitude, 10^{-11}). The substances which I studied but omitted from the table are at least 100 times less active than uranium.

	Amperes $\times 10^{-12}$
Uranium containing some carbon	24
Black oxide of uranium (U^2O^5)	27
Green oxide of uranium (U^2O^8)	18
Uranates of ammonium, potassium, or sodium (approximately)	12
Hydrated uranic acid	6
Uranyl nitrate, uranous sulfate, uranyl potassium sulfate (approximately)	7
Artificial chalcolite (uranyl copper phosphate)	9
Thorium oxide in a layer 0.25 mm thick	22
Thorium oxide in a layer 6 mm thick	53

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Thorium sulfate	8
Potassium fluoxytantalate	2
Potassium fluoxyniobate and cerium oxide	0.3
Pitchblende of Johanngeorgenstadt	83
" of Cornwallis	16
" of Joachimsthal and of Pzibran	67
Natural chalcolite	52
Autunite	27
Various thorites	from 2 to 14
Orangite	20
Samarskite	11
Fergusonite, monazite, xenotime, niobite, eschynite	from 3 to 7
Cleveite	very active

All the uranium compounds studied are active, and are, in general, more active to the extent that they contain more uranium.

The compounds of thorium are very active. Thorium oxide surpasses even metallic uranium in activity.

It is remarkable that the two most active elements, uranium and thorium, are the ones which possess the greatest atomic weight.

Cerium, niobium, and tantalum appear to be slightly active.

White phosphorus is very active, but its action is probably of a different nature than that of uranium and thorium. In fact, phorphorus is not active in the form of red phosphorus or in the state of phosphates.

All the minerals which demonstrate activity contain active elements. Two minerals of uranium, pitchblende (a uranium oxide) and chalcolite (uranyl copper phosphate) are much more active than uranium itself. This fact is most remarkable, and suggests that these minerals may contain an element much more active than uranium. I prepared chalcolite from pure reagents according to the procedure of Debray; this artificial chalcolite is no more active than other uranium salts.

Absorption: The effects produced by active substances increase with the thickness of the sample layer. This augmentation is very weak for the compounds of uranium; it is considerable for thorium oxide, which thus seems partially transparent to the rays it emits.

To study the transparence of various substances, one places a thin plate of them over the active layer. The absorption is always very strong. However, the rays pass through metals, glass, and paper of slight thickness. Here are the fractions of radiation transmitted through a sheet of aluminum of thickness 0.01 mm:

mm [sic]	
0.2	for uranium, ammonium uranate, uranous oxide, artificial chalcolite
0.33	for pitchblende and natural chalcolite
0.4	for thorium oxide and thorium sulfate in a 0.5-mm layer
0.7	for thorium oxide in a 6-mm layer.

One sees that the compounds of the same metal emit rays absorbed to an equal extent. The rays emitted by thorium are more penetrating than those emitted by uranium; finally, thorium oxide in a thick layer emits rays much more penetrating than those which it emits from a thin layer.

Photographic Images: I have obtained good photographic images with uranium, uranous oxide, pitchblende, chalcolite, and thorium oxide. These bodies act at a small distance, whether through air, through glass, or through aluminum. Thorium sulfate gives weaker images, and potassium fluoxytantalate very weak images.

Analogy to the Secondary Rays of Röntgen Rays: The properties of the rays emitted by uranium and thorium are very similar to those of the secondary rays of Röntgen rays, studied recently by M Sagnac. I have ascertained, moreover, that the uranium, pitchblende, and thorium oxide emit, under the action of Röntgen rays, secondary rays which, from the point of view of discharging electrified bodies, generally have a greater effect than secondary rays from lead. Among the metals studied by M Sagnac, uranium and thorium come to be placed beside and beyond lead.

To interpret the spontaneous radiation of uranium and thorium, one could imagine that all space is constantly traversed by rays analogous to Röntgen rays but much more penetrating and unable to be absorbed except by certain elements with high atomic weight such as uranium and thorium.

[1] This work was done at the Municipal School of Industrial Physics and Chemistry.
[2] The uranium used for this study was given by M Moissan. The salts and oxides were pure products from the laboratory of M Étard at the School of Physics and Chemistry. M Lacroix was willing to procure for me some mineral samples of known provenance from the collection of the Museum. Certain rare and pure oxides were given by M Demarçay. I thank these gentlemen for their courtesy.