METALLIC CATIONS PERCUTANEOUS ADSORPTION :
Uranium's particularity

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INTRODUCTION

When a radioelement (in particular with long-life) come in contact accidentally with the skin, he will be fixed strongly on the cornea coat and became a sort of storage from which he spread slowly and penetrate into the internal environment.

If the contaminant radioelement is a beta radiant emitter, this fixation to the skin can be to the origin of serious burns named radiological burns, due to the epidermal germinative cells coat destruction. The aim of the decontamination is to remove very quickly the radioelement, before he penetrates into the skin or before the nocive effects start.
Two kinds of cleansing products are used:

- Polyvalent products as soap or water,
- Specialized products as calcic salt of Diethylene Triamine Penta acetic acid (25% solution) are commonly used in France *(Fiche n°16b, Editeur Conseil scientifique de l'office de Protection contre les rayonnements ionisants BP n°35-78110F Le Vésinet-France)*. It had been demonstrated *(Gérasimo et al., (1996)* that the hypertonic properties have an important role in the action of these products.

The aim of this study is to show that a product used against chemical burns and the Diphoterine® can also be able to decontaminate with effectiveness the skin.

Chemical family	Example of radioelements	In 6 h Penetration according to the % of unloaded activity
Transition element (actinide)	Plutonium (Pu-239) Uranium (U-238, U-235)	0,01
Alkaline	Cesium (Cs-137)	3
Alkaline earth metals	Strontium (Sr-90)	0,37

Table: Cutaneous penetration of the three important families of radioelements

MATERIAL AND METHOD

1 Adsorption Study of the Radioelement in the cornea coat

On a 5 ml test tube, about 100mg of *stratum corneum* chips fragments exactly weighed, are put in hanging into a radioelement solution with a known radioactivity **A**: the set are brought to a pH-7 by the addition of soda. The quantity of radioelement absorbed by the chips is determined according to the A's radioactivity. If we suppose that the radioelement is fixed on the skin in a monoparticular film, the equation of that curve can be obtained *(Gerasimo et al. - 1996)*.
On the skin area, there is **N** possible places. Among the **N** possible places, **n** places are engaged by radioelements and (**N - n**) are still free. The adsorption equation is as following.

Occupied space = free space + radioelement in solution.

The balance constant **K** is given by: $\mathbf{K = n / (N - n) A}$
If **n** is replaced by **q** (**q** is the quantity of radioactivity fixed on the *corneum stratum* coat), we can find the Freudlich's formula: $\mathbf{q = K A^a}$

a is a coefficient which can vary between 0 and 1. **K** will be pull down if there is any product able to inhibit the radioelement adsorption by *stratum corneum* around the area. For the cleanse, 1 ml, of cleansing solution is put in contact with *stratum corneum* containing radioelement. 3 minutes after, the mix is centrifuged (6000 turns/min.) to isolated the skin cells from the rinsing solution.

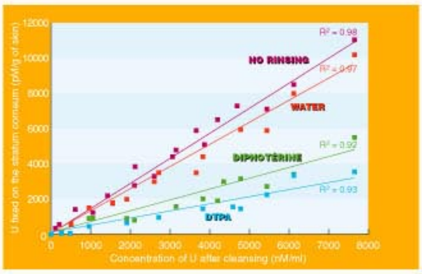
2 Radioactive products

Uranium 238 ($\mathbf{U_{238}}$), uranyl nitrate: alpha transmitter,
Cesium 137 ($\mathbf{Cs_{137}}$), cesium chloride: beta and gamma transmitter,
Strontium 90 ($\mathbf{Sr_{90}}$), strontium chloride (in equilibrium with Yttrium 90, its downward): beta transmitter.

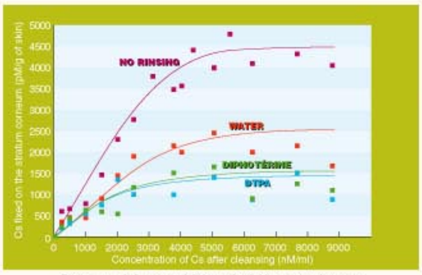
3 Radioactive measurement

Alpha spectrometry for $\mathbf{U_{238}}$, after the calcination and the deposit of the skin chips on an inox U52 cupel (Osiris-Measurement).
Total beta counting for the $\mathbf{Sr_{90}}$, after the deposit of the skin chips on the inox cupel: in fact, the measured set is the complex $\mathbf{Sr_{90}}$ + $\mathbf{Y_{90}}$.
Direct gamma spectrometry of the skin chips for the $\mathbf{Cs_{137}}$.

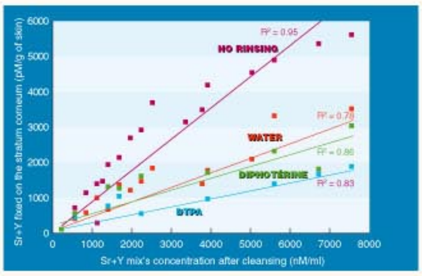
4 Results



Rinsing of Uranium (U) with different solutions



Rinsing of Cesium (Cs) with different solutions



Rinsing of Strontium and Yttrium (Sr+Y) mix with different solutions

Effectiveness of different cleansing solutions (decrease of the radioactivity in %)

	Uranium	Cesium	Strontium
Water	10%	~ 53%	50%
Diphoterine®	56%	~ 71%	50%
DTPA	67%	~ 71%	~ 74%

5 Discussion

● Uranium

The treatment of the uranium contamination is difficult and the water cleansing is not well effective because the radioelement is absorbed strongly in the skin. In fact, the polynuclear complex as the type $[(\mathbf{UO_2})_n\ (\mathbf{OH})_m]2_{n\text{-}m}$ is the one fixed, not the uranyl ion $\mathbf{UO_2}$ monomeric specie. If we consider the case "no rinsing" as the reference and compare the straight right's slope for the effectiveness' comparison, we observe that the decrease of the radioactivity: 10%, 56% and 67% respectively with water, Diphoterine® and DTPA.
The highest the uranium concentration is, the biggest will be the polymer's weight. This explains why there is a linear relation between the solution's concentration and the quantity kept by the skin. To realize a skin decontamination, it is necessary to use a cleansing solution as DTPA (*Gérasimo et al. - 1996*). Diphoterine® can also realize the decontamination. The effectiveness of these two products can be linked in one hand to their complexant properties and in the other hand to their osmolarity properties. (Diphoterine® and DTPA osmolarity are respectively 1200 and 1800 milliosmoles).

● Cesium and Strontium

The linking of these two radioelements are different from the uranium linking. The Cesium exists on its ionic and monomeric configuration; he will fixed himself on the skin but over certain concentration, all the free places are occupied; the cornea coat are therefore saturated this is expressed by a plateau. The measurements of the Cesium's plateau height show that with water, Diphoterine® and DTPA rinsing, we observe radioactivity decrease of 53%, 71%and 71% respectively.
The strontium also exist in its ionic and monomeric form, but it is always followed by yttrium who by its hydrolysis in aqueous area, will generate polynuclear complexes. If we consider the case without rinsing as the reference and compare the straight right's slope for the effectiveness' comparison, there is not significant difference between water and Diphoterine®'s cleansing and the radioactivity's decrease is around 50% in both cases. With DTPA we observe an important decrease (74%) of the radioactivity.
In both cases, water can realized the decontamination because of its existing ions into the solution as a ionic monomeric configuration. Diphoterine® and DTPA as rinsing solution, only provided a small advantage comparing to the water.

CONCLUSION

The uranium is fixed on the cornea coat of the skin while forming polymerized hydrolyzed products. This link influence the percutaneous absorption. This absolution is different from the one observed with cesium and strontium because cations are fixed as ionic monomeric configuration. the water did not realize a decontamination. We need specific products as 25% DTPA solution. Diphoterine® as well as DTPA , has complexing and hypertonic properties. Thanks to its amphoteric action, Diphoterine® can particularly be indicated for the treatment of contamination, often associated to chemical burns due to strong acid containing radioelement for example.
Finally, in the cases of eyes contamination for which there is no treatmentprecribed nowadays, Diphoterine® appears as an essential element for the emergency treatment.