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FOSTER D. SNELL, INC

CONSULTING CHEMISTS  
ENGINEERS

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INTERIM REPORT  
TO  
U. S. ARMY CHEMICAL CORPS  
CHEMICAL AND RADIOLOGICAL LABORATORIES  
ON

REMOVAL OF RADIOACTIVE CONTAMINANTS FROM HUMAN SKIN  
UNDER

CONTRACT NO. DA 18-108-CML-4747

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Summary.

This is an interim report to the Chemical and Radiological Laboratories under Contract No. DA 18-108 CML-4747 on the removal of radioactive contaminants from human skin.

In accordance with the provisions of the contract, the decontaminating efficiencies of various products were evaluated. Their effectiveness was determined on human hair in vitro and on living human skin.

Several superior decontaminating agents for use on human skin have been developed. Some of these new formulations have proved superior to commercial detergents.

The techniques developed during the first year of the program have been modified in order to give more meaningful results.

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~~CONFIDENTIAL~~1. Introduction.

After careful consideration, it was decided to delay the experimental phases of the program in order to take the fullest advantage possible of the results obtained in a different, but closely related, research project which has just been brought to a successful close in this laboratory. As a consequence, considerably less than half of the contemplated experimental work has been actually carried out. On the other hand, this has resulted in progress out of proportion to the time spent and allowed a much more efficient use of the limited number of human subjects available.

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2. Experimental Work.

A. Human Hair

Two series of experiments were carried out, one on human hair in vitro and one on human skin in vivo.

For the first series, untreated, but clean samples of hair were obtained from a hair dealer. Small bundles, about one inch long and containing approximately 125 hairs, were prepared by dipping the ends in paraffin. Each bundle was then contaminated with a drop of the fission products plus synthetic soil in aqueous suspension described in earlier reports, dried under an infra-red lamp, and the activity determined with a Geiger counter. Each bundle was then placed in a 150 ml. conical flask containing 20 ml. of detergent solution. These were then agitated for ten minutes in a shaker having a frequency of five cycles per second and an amplitude of one and one-half inches. This was followed by two shake rinses with 20 ml. of distilled water, the first for three minutes, and the second for one minute. The bundles were then dried under an infra-red lamp and counted with a Geiger counter.

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In the course of decontamination studies for the past year and a half the efficiencies of the following commercial products have been determined:

All  
Breeze  
Calgio  
Calgonite  
Carolite 1000  
Cheer  
Chiffon  
CP Cleaner  
Dreft  
Duz  
Fab  
Felso  
Flobar  
Gold Dust  
Ivory  
Kirkman Flakes  
Lux  
Noca  
Oxydol  
Radiacwash  
Rinso  
Silver Dust  
Surf  
Sweri  
Tide  
Vel

These products include light and heavy duty soaps, light and heavy duty syndets, and special radiological decontaminants. As expected, the soaps alone have not proved to be very efficient,

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although the addition of a good sequestrant improves them greatly. The synthetic detergents range from extremely poor to excellent. Some are improved by the addition of sequestrants, others are not. The special radiological decontaminants have generally proved disappointing, with the exception of CP Cleaner. Of the sequestrants used, Calgon, sodium tripolyphosphate, and the tetrasodium salt of ethylene diamine tetraacetic acid (Versene) proved to be of about equal value, and all were much superior to either citric acid or sodium citrate. These tests were performed on a dozen different types of surfaces, and although each type behaved quite differently, the superiority of some of the products has been consistently in evidence. Of the detergents listed above, the following proved to be the most efficient; Tide, Carolite 1000, All and CP Cleaner.

Based, then, on all previous experience in radiological decontamination, a series of experiments was carried out on human hair in vitro. In all of the following tables, activities are given in counts per minute, and have been corrected for background.

TABLE I

Surface: Human Hair  
Detergent: Distilled Water

<u>Initial Count</u>	<u>Final Count</u>	<u>Per Cent Removed</u>
18100	15100	16.5
15400	12300	19.7
14700	8560	41.7
Mean		25.9
Standard Deviation		±7.1
Standard Error of Mean		±5.0

The distilled water runs were made to serve simply as a base. Of greater interest, of course, was a series of runs using one per cent solutions of Tide and of various formulations developed in this laboratory.

TABLE II

Surface: Human Hair  
Detergent: 1.0% Tide

<u>Initial Count</u>	<u>Final Count</u>	<u>Per Cent Removed</u>
21500	3750	82.6
18800	3630	80.7
20200	3450	83.0
17300	3350	80.6
12500	2230	82.1
21100	3730	82.4
Mean		81.9
Standard Deviation		±0.9
Standard Error of Mean		±0.4

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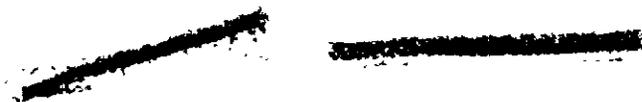


TABLE III

Surface: Human Hair  
Detergent: 1.0% DC \*

<u>Initial Count</u>	<u>Final Count</u>	<u>Per Cent Removed</u>
14100	1640	88.4
17700	1440	92.8
18900	1370	93.5
21900	2630	88.1
26600	3840	85.6
18200	1420	92.2
Mean		90.1
Standard Deviation		±2.9
Standard Error of Mean		±1.3

\*30% Duponol ME, 65% Calgon, 5% Carboxymethyl cellulose.



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TABLE IV

Surface: Human Hair  
Detergent: 1.0% D4V \*

<u>Initial Count</u>	<u>Final Count</u>	<u>Per Cent Removed</u>
16700	4600	72.5
27400	9600	65.1
14500	2910	80.0
28100	5280	82.3
21900	5620	74.3
24100	8630	64.4
Mean		73.1
Standard Deviation		±6.8
Standard Error of Mean		±3.0

\*30% Duponol ME, 65% tetrasodium salt of ethylene diamine tetra-acetic acid (Versene), 5% carboxymethyl cellulose.

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Since mixed fission products is the radioactive component of the contaminant, a possibility exists that a combination of polyphosphate and organic sequestering agents would prove superior to either when used alone. Accordingly, a formulation was prepared using equal parts of Calgon and Versene together with Duponol ME and CMC.

TABLE V.

Surface: Human Hair  
Detergent: 1.0% DCV \*

<u>Initial Count</u>	<u>Final Count</u>	<u>Per Cent Removed</u>
19400	2880	85.2
20500	2950	88.2
17500	2560	85.4
15100	2700	82.2
9300	1660	82.1
14700	1960	86.7
Mean		84.9
Standard Deviation		+ -2.2
Standard Error of Mean		+ -1.0

\*30% Duponol ME, 32.5% Calgon, 32.5% tetrasodium salt of ethylene diamine tetraacetic acid (Versene), 5% carboxymethyl cellulose.

The results, however, indicate that the combination of Calgon and Versene is even less efficient than Calgon alone. This was confirmed by doing a series of experiments with formulations based on Nonic 218, a non-ionic detergent.

TABLE VI

Surface: Human Hair  
Detergent: 1.0% NC •

<u>Initial Count</u>	<u>Final Count</u>	<u>Per Cent Removed</u>
18700	4880	74.0
17900	5230	70.8
17700	4190	76.4
31500	7900	75.0
22700	5150	77.5
24100	5420	77.4
Mean		75.2
Standard Deviation		±2.3
Standard Error of Mean		±1.0

\*30% Nonic 218, 65% Calgon, 5% carboxymethyl cellulose.

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TABLE VII

Surface: Human Hair  
Detergent: 1.0% NV \*

<u>Initial Count</u>	<u>Final Count</u>	<u>Per Cent Removed</u>
26800	5990	77.6
15300	4370	68.6
26600	5520	79.2
18600	5570	70.0
17300	4480	74.2
24700	6390	74.3
Mean		73.9
Standard Deviation		+3.8
Standard Error of Mean		+1.7

\*30% Nonic 218, 65% tetrasodium salt of ethylene diamine tetraacetic (Versene), 5% carboxymethyl cellulose.

TABLE VIII.

Surface: Human Hair  
Detergent: 1.0% NCV \*

<u>Initial Count</u>	<u>Final Count</u>	<u>Per Cent Removed</u>
20300	5780	71.6
16400	5060	69.1
14900	4740	68.4
16400	4900	70.1
17800	5540	68.8
17600	5260	70.1
Mean		69.7
Standard Deviation		$\pm 1.1$
Standard Error of Mean		$\pm 0.5$

\*30% Nonic 218, 32.5% Calgon, 32.5% tetrasodium salt of ethylene diamine tetraacetic acid (Versene), 5% carboxymethyl cellulose.

The results of Tables VI, VII, and VIII, however, merely confirmed those of Tables III, IV, and V. In fact, while Calgon and Versene proved of about equal value when used with Nonic 218, the combination of the two sequestrants was definitely inferior.

The use of five per cent instead of one per cent solutions improved the performance greatly except in the case of the Duponol-Calgon-CMC formulation.

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TABLE IX.

Surface: Human Hair  
Detergent: 5.0% DC \*

<u>Initial Count</u>	<u>Final Count</u>	<u>Per Cent Removed</u>
14900	1800	87.9
15800	1420	91.0
16600	2700	83.7
Mean		87.5
Standard Deviation		±2.6
Standard Error of Mean		±1.9

\*30% Duponol ME, 65% Calgon, 5% carboxymethyl cellulose.

TABLE X.

Surface: Human Hair  
Detergent: 5.0% NC \*

<u>Initial Count</u>	<u>Final Count</u>	<u>Per Cent Removed</u>
27500	1080	96.1
27600	1050	96.2
28100	970	96.6
30100	1000	96.7
28800	1130	96.1
29000	1020	96.5
Mean		96.4
Standard Deviation		±0.3
Standard Error of Mean		±0.1

\*30% Nonic 218, 65% Calgon, 5% carboxymethyl cellulose.

TABLE XI.

Surface: Human Hair  
Detergent: 5.0% NCV \*

<u>Initial Count</u>	<u>Final Count</u>	<u>Per Cent Removed</u>
23300	1960	91.6
24000	1900	92.1
27000	1870	93.0
Mean		92.2
Standard Deviation		$\pm 0.6$
Standard Error of Mean		$\pm 0.4$

\*30% Nonic 218, 32.5% Calgon, 32.5% tetrasodium salt of ethylene diamine tetraacetic acid (Versene), 5% carboxymethyl cellulose.

Once more it is seen that a combination of polyphosphates and organic sequestrants is less effective than polyphosphates alone.

A mixture of two detergents of different types was tried next. For this, Duponol ME, an anionic product (lauryl sodium sulfate), and Nonic 218, a non-ionic (polyethylene glycol tertdodecyl thioether), were used.

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TABLE XII.

Surface: Human Hair  
Detergent: 5.0% DNC \*

<u>Initial Count</u>	<u>Final Count</u>	<u>Per Cent Removed</u>
22000	2600	88.2
20300	2170	89.4
17200	2200	87.2
Mean		88.3
Standard Deviation		$\pm 0.9$
Standard Error of Mean		$\pm 0.6$

\*15% Duponol ME, 15% Nonic 218, 65% Calgon, 5% carboxymethyl cellulose.

As in the case of the sequestrant mixtures, the use of two different detergents in combination is not desirable.

In order to connect further the work on human hair with earlier experiments, a number of runs were made with Ivory, Tide, Carolite 1000, and our Oronite D60-Calgon-CMC formulation. Ivory was used as a representative soap, Tide as one of the very best generally available household detergents and Carolite 1000 as a superior special-type product.

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TABLE XIII.

Surface: Human Hair  
Detergent. 5 0% Ivory

<u>Initial Count</u>	<u>Final Count</u>	<u>Per Cent Removed</u>
23400	13000	44.5
31100	13800	55.7
26300	12900	51.0
Mean		50.4
Standard Deviation		$\pm 4.6$
Standard Error of Mean		$\pm 3.3$

The Ivory solution, although freshly made, was extremely thick, and doubtlessly the results do not give a fair representation of the detergent powers of soap. On the other hand, all of the work done in this laboratory on various surfaces and using various washing technics invariably show that soaps are not as efficient as syndets. The Ivory runs were made simply for the sake of completeness.

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With Tide the following results were obtained.

TABLE XIV.

Surface: Human Hair  
Detergent: 5.0% Tide

<u>Initial Count</u>	<u>Final Count</u>	<u>Per Cent Removed</u>
23500	3010	87.2
20300	2400	88.2
25100	2420	88.1
Mean		87.8
Standard Deviation		$\pm 0.4$
Standard Error of Mean		$\pm 0.3$

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Carolite 1000 was used alone and in combination with Calgon and CMC. At this point it should be noted that, due to an oversight on the part of the manufacturer, Carlstadt Chemical Company, the concentration used and listed in earlier reports was incorrectly stated to be 5%, whereas the true value was actually 30%.

TABLE XV.

Surface: Human Hair  
Detergent: 5.0% Carolite 1000

<u>Initial Count</u>	<u>Final Count</u>	<u>Per Cent Removed</u>
36500	5100	86.0
15600	2900	81.5
27400	10100	63.1*
10200	1460	85.7
13900	2350	83.1
16300	2750	83.1
Mean		79.6 (83.8)
Standard Deviation		$\pm 7.8$ ( $\pm 1.7$ )
Standard Error of Mean		$\pm 3.5$ ( $\pm 0.8$ )

\*If this apparently anomalous value is excluded from the calculations, the values in the parentheses will be obtained.

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TABLE XVI.

Surface: Human Hair  
Detergent: 5.0% CaC \*

<u>Initial Count</u>	<u>Final Count</u>	<u>Per Cent Removed</u>
10500	840	92.0
12500	1490	88.1
10200	960	91.6
Mean		90.5
Standard Deviation		$\pm 1.8$
Standard Error of Mean		$\pm 1.2$

\*30% Carolite 1000, 65% Calgon, 5% carboxymethyl cellulose.

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A formulation based on Oronite D60 gave the following results:

TABLE XVII.

Surface: Human Hair  
Detergent: 5.0% OC \*

<u>Initial Count</u>	<u>Final Count</u>	<u>Per Cent Removed</u>
10700	940	91.4
13300	620	95.4
16000	2160	87.6
Mean		91.5
Standard Deviation		$\pm 3.2$
Standard Error of Mean		$\pm 2.2$

\*30% Oronite D60, 65% Calgon, 5% carboxymethyl cellulose.

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Two other commercial products All and CP Cleaner, were next used. All is a product of low foam value designed for automatic washers. Its main active ingredient is Sterox, a non-ionic polyoxyethylene ether. CP Cleaner is advertised as a special radiological decontaminant in competition with Radiacwash and Flobar, although the manufacturers also proclaim its excellence as a general-purpose detergent.

TABLE XVIII.

Surface: Human Hair  
Detergent: 5.0% All

<u>Initial Count</u>	<u>Final Count</u>	<u>Per Cent Removed</u>
13500	1280	90.5
14500	1040	92.8
15200	1180	92.2
Mean		91.8
Standard Deviation		+1.0
Standard Error of Mean		+0.7

TABLE XIX.

Surface: Human Hair  
Detergent: 5.0% AC \*

<u>Initial Count</u>	<u>Final Count</u>	<u>Per Cent Removed</u>
16100	851	94.7
18500	918	95.0
21500	1490	93.1
Mean		94.3
Standard Deviation		±0.8
Standard Error of Mean		±0.6

\*30% All, 65% Calgon, 5% carboxymethyl cellulose.

CP Cleaner was also tried alone and in combination with Calgon and CMC.

TABLE XX.

Surface: Human Hair  
Detergent. 5.0% CP Cleaner

<u>Initial Count</u>	<u>Final Count</u>	<u>Per Cent Removed</u>
14100	1240	91.2
13400	937	93.1
12600	796	93.8
Mean		92.7
Standard Deviation		±1.1
Standard Error of Mean		±0.8

TABLE XXI.

Surface: Human Hair  
Detergent: 5.0% CPC •

<u>Initial Count</u>	<u>Final Count</u>	<u>Per Cent Removed</u>
17000	1410	90.4
14700	1530	89.6
13500	1020	92.4
Mean		90.8
Standard Deviation		±1.2
Standard Error of Mean		±0.8

\*30% CP Cleaner, 65% Calgon, 5% carboxymethyl cellulose.

Three more formulations based on anionic  
detergents were then used.

TABLE XXII.

Surface: Human Hair  
Detergent: 5.0% AeC \*

<u>Initial Count</u>	<u>Final Count</u>	<u>Per Cent Removed</u>
29700	3480	88.3
11800	1600	86.5
26300	2920	88.9
Mean		87.9
Standard Deviation		±1.0
Standard Error of Mean		±0.7

\*30% Aerosol 22, 65% Calgon, 5% carboxymethyl cellulose.

TABLE XXIII.

Surface: Human Hair  
Detergent: 5.0% AnC \*

<u>Initial Count</u>	<u>Final Count</u>	<u>Per Cent Removed</u>
16900	1880	88.9
17800	1540	91.3
18100	1390	92.3
Mean		90.8
Standard Deviation		±1.4
Standard Error of Mean		±1.0

\*30% Antaron L-135 (also sold as Igepon T-73), 65% Calgon, 5% carboxymethyl cellulose.

TABLE XXIV.

Surface: Human Hair  
Detergent: 5.0% UC \*

<u>Initial Count</u>	<u>Final Count</u>	<u>Per Cent Removed</u>
19800	1510	92.4
25300	2570	89.9
27500	3660	86.7
Mean		89.6
Standard Deviation		±2.3
Standard Error of Mean		±1.6

\*30% Ultrawet 30DS, 65% Calgon, 5% carboxymethyl cellulose.