RADIOLOGICAL DECONTAMINATION: LAB DEMONSTRATION ON VARIOUS SURFACES USING ION-EXCHANGE TECHNOLOGY

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ABSTRACT

Radioactive contamination poses several cleanup problems including: safety of cleanup personnel, control of waste volume and end state contamination level. In an effort to address these problems we have investigated the use of ion-exchange resin preparation technology to treat contaminated surfaces. A variety of surfaces were contaminated with various radionuclides. These surfaces were decontaminated with ion-specific, patent pending, "mass effect" water based solutions, treating the surface as if it were an ion exchange resin. The study demonstrates the ability of "mass effect" solutions to lift radionuclides from various surfaces. Combining the "mass effect" solution with ion-specific resins creates a mixture that lifts the contamination from the surface and can capture it on the resin bead. This reduces cleanup time; controls waste volume and leave the surface in a state where no more counts are removable.

INTRODUCTION

Ion-exchange resins have long been used for wastewater cleanup and radionuclide separation. The preparation of these resins often involves activation of the resin by altering the functional groups on the resin. For example in order to create a resin which will capture iodine, the resin in the chloride form must be stripped of chlorine and substituted with a functional group with lower electro negativity such as salicylate or citrate [1]. The functional group attachment is reversible so by using high concentrations and/or larger volumes of these reactive groups, the chloride ion is forced to leave the resin due to the shear number of replacement ions competing for the site that the chlorine is bound to, the "mass effect". It is postulated that cleanup of contaminated surfaces would be facilitated by the use of similar methods, treating the contaminated surface as an ion exchange resin and using competing ions to displace the contamination. Mixing specific ion exchange resins with the solution creates an alternate deposition site for the radionuclide on a particle, which can then be removed from the surface.

MATERIALS AND METHODS

Short-lived radionuclides were chosen due to their availability as solutions. Iodine-131 as sodium iodide, Technetium-99m as sodium pertechnetate, and Thallium-201 as thallous chloride were used to simulate halogens, actinides, and group II metals respectively. Iodine-131 was obtained from Nordion, Technetium was eluted as needed from a Tyco-

Mallinckrodt Medical Mo-99/Tc-99m generator, and Thallium was obtained as thallous chloride from Tyco-Mallinckrodt Medical.

Surfaces contaminated attempted to duplicate the hospital and industrial setting. Linoleum tile (Tarkett Expressions 1/8th inch) cut into six inch squares, unwaxed, was contaminated on the porous surface which is usually applied to the adhesive on the floor. Stainless steel surfaces in a glove box were contaminated. Sections of aged, porous, poured concrete were also contaminated.

Resins were prepared from Dowex resins in the citrate, iron, and calcium forms and suspended in a dilute solution of citric acid, iron ion, and calcium ion respectively. The solutions also contained methyl and propyl parabens to prevent bacterial growth on the resin and methylcellulose as a thickening agent.

Radiacwash was purchased from Scientific Products and the manufacturer provided Bind-It as a sample. Tap water was obtained from the city of Tampa.

We formulated a latex paint to specifically bind to the ion specific resins, form a strong flexible film, but not form a permanent bond with any surface.

A lead lined stainless steel glove box vented to an array of activated charcoal filters was used as the preparation site for the contaminated surfaces.

A real world test was performed on a sink at a reactor facility. The sink contained multiple radionuclides.

Detection equipment used included a Ludlum Model 14C GM counter with a Pancake Probe, a Capintec CRC-15 dose calibrator and a Canberra solid-state detector system.

TESTING PROCEDURES

Radioactive material was measured in the dose calibrator in a syringe prior to placement on each of four samples of test material. The radioactive solution was allowed to dry for six hours before cleanup was attempted. Each surface sample, numbered one thru four, was cleaned only once. Surface sample #1 was always cleaned with the ion-specific wash containing resin, sample #2 was cleaned with Radiacwash as directed on the container, sample #3 was cleaned with tap water, and sample #4 was cleaned with Bind-It as directed on the container. Paper towels were used to absorb the cleanup solution, placed in a latex glove and measured in the dose calibrator. Surface samples were then broken or deformed to fit into the dose calibrator so that an approximation of residual activity on the surface could be determined. Residual activity on stainless steel surfaces was estimated.

The aged, poured concrete sample contained many pits and holes, which held the resin beads. It was determined that applying the appropriate cleaning product letting it dry, and then removing the residue with a peel able latex paint would be more effective. A latex

formulation specific for the resin beads, which would also incorporate loose surface materials, but not form a permanent attachment for the surface, was developed. The surface cleaning solution was allowed to dry for one hour, after which a single coating of latex paint was applied and allowed to dry for two hours. Upon drying the latex film was easily pealed off, placed in a latex glove and activity removed was measured in the dose calibrator.

Auto radiographic testing was performed on tile samples with Iodine-131 contamination only. Photographic film in lightproof envelopes was placed on the tiles for 60 seconds, prior to cleaning, and after cleaning. The films were developed immediately after exposure.

The sink was cleaned by applying the actinide ion wash and allowing it to remain on the contaminated surface for 10 minutes. The solution and resin were then removed with paper towels.

RESULTS

The ion specific washes were much more efficient on tile and stainless steel than the other commercial washes, attaining a decontamination factor (DF) of up to 74 for Iodine-131 on stainless steel. The other commercial washes had DF's similar to tap water.

On aged concrete nothing performed very well. The ion specific washes did have DF's higher than commercial washes or tap water alone.

Table I. Decontamination of Tile Using Various Agents.

Decon. Agent		Iodine –131	Thallium-201	Technetium-99m
Ion wash	A_i	20.7 MBq	4 MBq	14.4 MBq
	A_f	1.48 MBq	0.5 MBq	0.8 MBq
	DF	13.9	8	18
Radiacwash	A_i	18.5 MBq	4.1 MBq	15 MBq
	A_f	4.7 MBq	1.8 MBq	7 MBq
	DF	3.9	2.2	2.1
Water	A_i	22.5 MBq	3.9 MBq	14.3 MBq
	A_f	8.1 MBq	1.7 MBq	9.5 MBq
	DF	2.7	2.3	1.5
Bind-It	A_i	20.7 MBq	4.2 MBq	14.5 MBq
	A_f	5.1 MBq	2.3 MBq	7.9 MBq
	DF	4	1.8	1.8

A_i = initial Activity on surface
A_f = final Activity on surface
DF = Decontamination factor = A_i / A_f

Table II. Decontamination of Stainless Steel Using Various Agents.

Decon. Agent		Iodine –131	Thallium-201	Technetium-99m
Ion wash	A_i	7.4 MBq	4.2 MBq	14 MBq
	A_f	0.1 MBq	0.2 MBq	0.8 MBq
	DF	74	21	17.5
Radiacwash	A_i	7.5 MBq	4.1 MBq	13.8 MBq
	A_f	3.2 MBq	2.5 MBq	6.8 MBq
	DF	2.3	1.6	2
Water	A_i	7.5 MBq	4.1 MBq	14.1 MBq
	A_f	3.8 MBq	1.9 MBq	7.2 MBq
	DF	1.9	2.1	1.9
Bind-It	A_i	7.4 MBq	4.3 MBq	14.0 MBq
	A_f	2.1 MBq	2.1 MBq	7.1 MBq
	DF	3.5	2	1.9

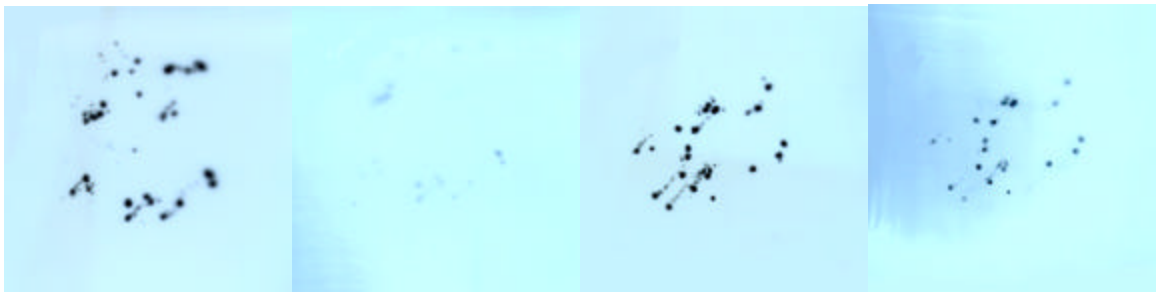
A_i = initial Activity on surface
A_f= final Activity on surface
DF = Decontamination factor = A_i / A_f

Table III. Decontamination of Concrete Using Various Agents.

Decon. Agent		Iodine –131	Thallium-201	Technetium-99m
Ion wash	A_i	7.5 MBq	4.1 MBq	14.8 MBq
	A_f	6.3 MBq	3.1 MBq	12.6 MBq
	DF	1.2	1.3	1.1
Radiacwash	A_i	7.4 MBq	4.0 MBq	14.7 MBq
	A_f	7.0 MBq	3.9 MBq	14.2 MBq
	DF	1	1	1
Water	A_i	7.6 MBq	4.1 MBq	14.7 MBq
	A_f	7.2 MBq	4 MBq	14.3 MBq
	DF	1	1	1
Bind-It	A_i	7.5 MBq	4.1 MBq	14.8 MBq
	A_f	7.1 MBq	4.0 MBq	14.3 MBq
	DF	1	1	1

A_i = initial Activity on surface
A_f= final Activity on surface
DF = Decontamination factor = A_i / A_f

Auto radiographic imaging visually confirms the greater efficiency of ion specific washes in removing Iodine – 131 from the tile surface.



Tile 1
20.7 MBq I-131

Tile 1
Post ion wash
1.4 MBq

Tile 2
18.5 MBq I-131

Tile 2
Post Radiacwash
4.7 MBq

Tile 3
22.5 MBq I-131

Tile 3
Post water wash
8.1 MBq

Tile 4
20.7 MBq I-131

Tile 4
Post Bind-It wash
5.1 MBq

Fig. I. Auto radiographic imaging of Tile.

Decontamination of the sink at the reactor site was very successful (Table IV). A single cleaning with the Calcium form of solution for Actinides removed many of the contaminants completely. The total activity on the sink was brought to below background levels. Washing with the iron form solution, for Group II metals, would remove the remaining metals.

Table IV. Decontamination of Sink at Reactor Site.

Isotope	Background % Total Activity	Bq Activity	Contamination % Total Activity	Bq Activity	Post Decon % Total Activity	Bq Activity	DF
Cr-51	7.6	26.4	27.4	444	*	*	*
Mn-54	0.91	3.1	1.17	18.9	6.22	4	4.6
Co-58	9.37	32.5	4.18	67.7	8.47	5.4	12.3
Co-60	8.08	28	2.95	47.7	30.69	19	2.4
Zn-65	14.72	51	5.75	93.3	*	*	*
Nb-95	26.23	91	25.57	415	*	*	*
Zr-95	26.13	90	27.17	440	*	*	*
Nb-97	5.99	20	5.25	85	*	*	*
In-113/ Sn-113	0.95	3.3	0.57	9.2	*	*	*
Cs-134	**	**	**	**	7.62	4.9	**
Cs-137/ Ba-137m	**	**	**	**	47	30	**
Totals	100	345.3	100	1,620	100	63.3	25.6

* Total removal
**Not detected prior to decontamination

DISCUSSION

Treating the contaminated surface as an ion exchange resin does appears to be more effective than the two commercial products or tap water alone at removing radioactive contamination. Whether or not the resin in the ion wash solution is required or not remains to be investigated. Separation of resin from the wipes proved to be more difficult than originally thought, so it was not attempted for this trial. Reduction of waste volume is achieved through the increased efficiency of the ion wash decontamination solutions. As shown by the real world testing, two or three repeated applications provide combined decontamination factors over 100.

The porosity of the surface definitely influenced the effectiveness of all the decontamination solutions as shown by the decrease in DF from stainless steel to tile to concrete. Increased DF could possible be achieved by creating flow of the ion wash through the pores with the use of sonication.

The efficiency of the ion washes reduces the amount of time spent in decontamination, which reduces radiation exposure to personnel.

REFERENCES

1. Dow, DOWEX Ion Exchange Resins, Using Ion Exchange Resin Selectivity Coefficients, Technical information, http://www.dow.com/webapps/lit/litorder.asp?filepath=liquidseps/pdfs/noreg/177-01755.pdf&pdf=true