EXPERIMENTAL STUDY REGARDING NEW METHODS OF RADIOACTIVE DECONTAMINATION AND CLEAN-UP FOR MATERIALS THAT WERE CONTAMINATED WITH HYDROGEN-3 USED IN RESEARCH LABORATORY

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INTRODUCTION

➢ The purpose of the present work consists of finding a more efficient and less expensive decontamination method for surfaces contaminated with Tritium-labelled compounds.

➢ In the experiments there were used the polymeric hydrogels, Decogel type 1102 and type 1108.

➢ This paper presents the methods and facilities used, as well as the results obtained and their interpretation. All the experiments were performed at the Hydrogel laboratory (TRITIULAB) from IFPR-HH department for stray tritium contamination for R&D in Physics and Nuclear Engineering (IFPR-HH).

➢ The approach was to develop new methods and protocols of decontamination for Tritium laboratories facilities in keeping with the same high nuclear security requirements met by EU regulations. In accordance with these requirements, we chose a polymeric hydrogel, Decogel, because the method is easy, does not damage the surfaces, and, at the same time, does not cause pollution, while the costs involved, and necessary storage space are minimal. After considering all these aspects, it was decided that Decogel is a possibility with high chances of success for our research.

➢ The experiments are based on measurements realised on a certain number of materials (types of surfaces) that are often found in facilities specifically designed for radionuclide research, which were afterwards gathered and interpreted. For each sample of materials, we determined the difference between the results obtained from testing with wetted surfaces and the ones using the polymeric hydrogel.

➢ The paper will further develop, in a more detailed manner, the steps, aspects, and chemical compounds used in the experiment.

All the materials studied originate from the Radiobiology and Radiation Medicine Departments (IFPR-HH/NIC, TRITIULAB/NIC). The polymeric hydrogels were produced by CIB Polymers from USA.

METHOD

➢ New decontamination protocols for surfaces contaminated with Tritium (T or T3) were developed, by designing the decontamination factor for Decogel 1102 and Decogel 1108, in the case of different surfaces and contaminant types.

➢ In the experiment we used two types of contaminants: (1) ethylene solution of hydrophilic and hydrophobic tritium labelled compound mixture and (2) tritium from biodiesel vacuum pumping from which the volatile component was removed.

SELECTION OF SURFACES

➢ The following types of surfaces have been selected and prepared. Those surfaces are often found within TRITIULAB. From the selected surfaces, 20 x 20 cm samples were prepared (Fig. 1):

- type s1 stainless steel sheet with a smooth surface
- type s2 stainless steel sheet with a creased surface
- smooth sanded stainless steel with smears (false finish)
- n-decane/smooth
- glass/glass
- PVC tiles (false parallel)
- PVC specimens after UV 3650 (pavement for laboratories and offices, acrylic palhade)
- PVC type Mipastra Multiclick R (PVC wallpaper from TRITIULAB).

Fig. 1 – Preparation of surfaces

OBTAINING OF THE TRITIATED LABELLED COMPOUND SOLUTIONS

➢ A stock solution consisting of a tritiated organic compound mixture in ethanol solution was prepared.

➢ The radiative concentration of stock solution has been determined using the Triple-Stage Conversion Ratio (TSCR) method at the laboratory of Radiobiology and Radiation Medicine.

OBTAINING OF THE CONTAMINATED OILS

➢ The tritiated oils were processed for volatile components removal (blades used to keep the original activity – art.)

➢ After the removal stage, the radiative concentration of tritiated oil was determined by liquid scintillation technique.

THE SAMPLING FACTOR

➢ The radioactivity of the samples were determined for each controlled contaminated surface. Determination of sampling factor was achieved by wiping the contaminated surface with several drops of tritium compound. 5 ml SiO2 supported, followed by activity measuring at LSC. The smear used was a waste of tritium between the results obtained by the classic decontamination method (wetted surfaces) and the one using the polymeric hydrogel.

➢ The values of sampling factor [F] were obtained using equation:

\[ F = \frac{\text{in control}}{\text{in surface}} \]

where:

ΔA – activity determined on CRC (one)

RA – (Relative Conventional Activity) activity of the contaminant, controlled deposited onto analysed surface.

➢ For the determination of the experimental values obtained in the determination of the residual activity (after application of the decontamination method) it was used the average value of the sampling factor obtained for ten replicates.

RESIDUAL CONTAMINATION

➢ The residual CRC of the decontaminated surfaces with Decogel were determined by wiping using extruded polyethylene sponges and their activity determined at LSC. The obtained values in CRC were rectified using predetermined average value of the sampling factor.

➢ The CRC was determined using the following protocol:

- determination of the sampling factor for each surface;

- determination of the CRC of sampling factor for surfaces with known sampling factor;

- wiping the surface and sponge's introduction in glass vials with liquid scintillator;

- determination of the sampled activity at LSC;

- correlation between the sampled activity, the predetermined sampling factor and the total surface activity determination.

OBTAINING THE DECONTAMINATION FACTOR

➢ The values of each decontamination factor (DF) were determined using test equation:

\[ DF = \frac{\text{in CRC}}{\text{in RA}} \]

where:

RA – activity of the contaminant, controlled deposited on analysed surface [Bq];

DF – residual activity after treatment with Decogel [Bq];

CRC – activity determined at CRC and LSC;

ΔCRC – predominant mean value of the sampling factor.

Fig. 2 – Determination of decontamination factor

RESULTS

➢ The average values for the sampling factor are presented in Fig 4 for surfaces contaminated with ethanol solution of mixture of tritium-labelled compounds and Fig 4 for surfaces contaminated with tritiated oil.

➢ The maximum and minimum values are obtained for glossy glass and PVC tiles correspondingly in both situations.

➢ The average values for the sampling factor are between 0.008 and 0.0015 for surfaces contaminated with tritium-labelled compounds and slightly higher values for surfaces contaminated with tritiated oil of 0.026 and 0.044, results that are more than satisfactory.

➢ The average values for the decontamination factor are between 92.99% and 76.01% for surfaces contaminated with tritium-labelled compounds and slightly higher values for surfaces contaminated with tritiated oil between 94.80% and 76.71%, results that are once again satisfactory.

➢ The highest values were obtained again for the glossy glass, while the lowest values were obtained for the steel coated with antistatic paints in both cases.

CONCLUSION

➢ The decontamination efficiency of the Decogel has been quantified as decontamination factor (DF), which represents the ratio between tritium activity incorporated in gel and total tritium activity deposited onto the sampled surface.

➢ Both types of Decogel were proved to be efficient in the decontamination process of different types of surfaces for specific contaminants type, the DF being in 85% and 84% range in one experiment for metallic and glass surfaces.

➢ For the steel coated with antistatic paint and MIPOLAN PVC surfaces, the obtained DF was lower (75-80%). These results can be explained by diffusion of tritiated compounds inside of the metallic surfaces with consequent in a quasi-continuous removal.

➢ The decontamination factor of Decogel type 1104 for the analysed surfaces (contaminated with a mixture of tritium labelled compounds) can take values in the range of 92.99%, which in the case of Decogel type 1102 the values of the decontamination factor for the analysed surfaces (contaminated with tritiated oil) can vary between 76.01% and 98.99%, results for greater than the ones obtained with the classical method of wet wiping.

➢ This suggests a greater efficiency of decontamination when using the Decogel comparing to the classic decontamination methods.

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DECLARATION OF COMPETING INTEREST

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

REFERENCES


Fig. 3 – Average Sampling Factor (RAX)

Fig. 4 – Average Decontamination Factor