An Absorbent for an Application to a Package for a Liquid Radioactive Isotope for Medical Usage

K. S. Bang, S. P. Lim, J. C. Lee, K. S. Seo, H. S. Han

Korea Atomic Energy Research Institute
150 Dukjin-dong, Yuseung-gu, Daejeon, Korea 305-353

Abstract

A radioactive isotope has to be safely transport from the producing center to the consuming center. The shipping package to safely transport the radioactive isotope should be able to withstand the prescribed conditions by law. In the field of nuclear medicine, the radioactive isotope is used in a liquid or capsule form. A Type A package, which is to transport liquid radioactive materials, shall be provided with a containment system composed of primary inner and secondary outer containment components or shall be provided with sufficient absorbent material to absorb twice the volume of the liquid contents. Hospitals prefer to use not only convenient but also re-usable packages. To apply an absorbent material to the Type A package, that is to transport liquid radioactive isotope, the free absorbency of the absorbents was estimated. In the case of a liquid with NaOH 0.4 %, the free absorbency of the melanine form was the most superior at 91 g/g. In the case of a liquid with Na 0.9 %, the free absorbency of the melanine form was the most excellent at 88 g/g also.

1. Introduction

The radioactive isotope is used extensively in the fields of industry, medical treatment, food and agriculture. Usage of the radioactive isotope is expected to increase continuously with the growth of each field.

The radioactive isotopes which are produced in Korea are I-131, Ir-192, Co-60, Mo-99 and Tc-99m that are made at the HANARO research reactor, and I-123, Ga-67, Tl-201 and F-18 that are produced from the Cyclotron at the Korea Institute of Radiological & Medical Sciences. These radioactive isotopes are used mainly for industry and medical treatment. The radioactive isotope which is used for medical treatment is in general use in a liquid or capsule form. In order to transport safely the radioactive isotope from the producing center to the consuming center, it needs a shipping package.

The shipping package should satisfy the requirements which are prescribed in the IAEA Safety Standard Series No. TS-R-1, US 10 CFR Part 71 and Korea MOST Act 2001-23[1-3]. These

regulatory guidelines state that the shipping package to transport the liquid radioactive isotope has to be provided with a containment system composed of primary inner and secondary outer containment components or provided with sufficient absorbent material to absorb twice the volume of the liquid contents. Accordingly, to apply the absorbent material to the Type A package that is to transport liquid radioactive isotope, the free absorbency of the absorbents was estimated.

2. Experiment of an absorbents

2.1 Absorbents

A filter paper, a facial tissue, a cellulose acetate sponge, a polyurethane sponge, a wood pulp fluff, a cotton ball and an absorbent polymer are used as absorbents of liquid. The filter paper and the facial tissue have a lower free absorbency at 1.8 g/g and 4.0 g/g respectively. The polyurethane sponge and the absorbent polymer have a higher free absorbency at 10.5 g/g and 100 ~ 1,000 g/g respectively. In order to apply them to the shipping package which is to transport liquid radioactive isotope, therefore, the polyurethane sponge, the absorbent polymer and the melanine form as absorbents were adapted, an experiment on the free absorbency of these absorbents was performed.

2.2 Method of Experiment

Radioactive isotope I-131 and I-123 are bottled in a solution with a concentration of NaOH 0.4 %, and radioactive isotope Tl-201 is bottled in a solution with a concentration of Na 0.9 %. Accordingly, the solution with a concentration of NaOH 0.4 % and the solution with a concentration of Na 0.9 % were applied as a liquid to carry out the experiment on the free absorbency of the absorbents.

The experiment for the polyurethane sponge and the melanine form was performed as follows;

- slice to appropriate size
- measure the weight of the specimen(Fig. 1)
- soak the specimen in the solution
- measure the weight of the specimen after the specimen is absorbed sufficiently in the solution

However, the absorbent polymer is made in a powder form. Therefore the experiment for the absorbent polymer was carried out as follows;

- measure the weight of the glass beaker
- pour the absorbent polymer into the glass beaker
- measure the weight of the glass beaker with the absorbent polymer(Fig. 2)
- pour the solution into the glass beaker with the absorbent polymer
- measure the weight of the glass beaker with the absorbent polymer and the solution
- allow to stand for about 60 minutes

- after 60 minutes, pour the swelled absorbent polymer into the standard sieve for filtration
- allow to stand for about 60 minutes
- after 60 minutes, measure the weight of the filtered absorbent polymer(Fig. 3)

Fig. 1. Weight of the Specimen.

Fig. 2. Weight of the Solution.

Fig. 3. Weight of the Polymer.

3. Results and Discussion

Table 1 shows the free absorbency of the absorbents in the case of the solution with a concentration of NaOH 0.4 %. The free absorbency of the polyurethane sponge was calculated as 20 g/g, the free absorbency of the absorbent polymer was calculated as 73 g/g, and the free absorbency of the melanine form was calculated as 91 g/g.

Table 1. Free absorbency of the absorbents in the case of the solution with a concentration of NaOH 0.4 %

Absorbent		Weight(g)		Free absorbency (g/g)	Average free absorbency(g/g)
		Before absorption	After absorption		
Polyurethane sponge	1	0.64	13.48	21.2	19.8
	2	1.22	23.24	19.1	
	3	1.94	37.18	19.2	
Melanine form	1	0.09	8.69	92.8	91.2
	2	0.17	15.83	91.3	
	3	0.27	24.42	89.6	
Absorbent polymer	1	0.30	22.49	75.0	72.7
	2	0.60	43.77	73.0	
	3	1.00	70.14	70.1	

Table 2. Free absorbency of the absorbents in the case of the solution with a concentration of Na 0.9 %

Absorbent		Weight(g)		Free absorbency (g/g)	Average free absorbency(g/g)
		Before absorption	After absorption		
Polyurethane sponge	1	0.65	12.97	20.1	18.3
	2	1.15	20.40	17.8	
	3	2.01	34.08	17.0	
Melanine form	1	0.07	5.91	89.2	88.4
	2	0.15	12.66	87.5	
	3	0.34	30.19	88.6	
Absorbent polymer	1	0.30	18.99	63.3	58.1
	2	0.60	32.62	54.4	
	3	1.00	62.90	56.7	

Table 2 shows the free absorbency of the absorbents in the case of the solution with a concentration of Na 0.9 %. The free absorbency in this case shows also the same tendency as in the case of the NaOH solution. The free absorbency was estimated as 18 g/g for the polyurethane sponge, 58 g/g for the absorbent polymer, and 88 g/g for the melanine form.

Besides the free absorbency, the absorbing rate and the absorbing power should be considered as important factors. In the absorbing rate, the melanine form was the fastest. When the melanine form reached the solution, the melanine form absorbed the solution immediately, and it was socked into the glass beaker which holds the solution. The absorbing rate of the polyurethane sponge was a little slower than that of the melanine form. The absorbent polymer showed a very fast absorbing rate for water, but a very slow absorbing rate for not only the NaOH solution but also the Na solution.

In the absorbing power, if there is no pressure from the outside, the melanine form was the most superior, and the polyurethane sponge did not match the melanine form. The absorbent polymer showed a strong absorbing power for water, but it was difficult for the solution amount to be estimated because it was transformed into a gel type.

Fig. 4 shows the free absorbency of the absorbents according to the solution. The free absorbency in the Na solution was less than that in the NaOH solution. To design the absorbent for the Type A package that is to transport a liquid radioactive isotope, accordingly, it is desirable for the absorbent to be designed on the basis of the free absorbency in the Na solution.

The capacity of a vial within the Type A package that is to transport a liquid radioactive isotope is 12 ml. When a liquid was filled fully into a vial, the weight of the liquid was measured as 12.8 g.

Therefore, if the capacity of the free absorbency of the absorbent is designed at 25.6 g, it would be able to meet the prescribed conditions by law.

Table 3 and fig. 5 show the weight and the volume of the absorbent which soaked the Na solution of 25.6 g. In the weight, the melanine form was a little light, and the polyurethane sponge was somewhat heavier. In the volume, the absorbent polymer was small, and the melanine form was a little larger. Nevertheless the melanine form has a good free absorbency and the lightest weight, the melanine form has the largest volume because of a low density. The absorbent polymer has a high density but a relatively good free absorbency. Therefore it would be able to meet such conditions as a small volume.

According to the experimental results, the absorbent polymer is estimated as the proper absorbent. However, it consists of a powder form. Accordingly, it has to be properly transformed to apply it to the shipping package, for example, like a diaper for a baby. Also, a sufficient space within the cavity of the shipping package must be provided so that the absorbent polymer can expand, because its volume is swelled considerably when it soaks up a liquid.

The volume of the melanine is a little large relatively speaking, but it has a good free absorbency and absorbing power. Therefore, it is more likely desirable that the melanine form is applied as the absorbent of the shipping package.

To transport a liquid radioactive isotope, KAERI is currently developing a Type A package that apply the melanine form as the absorbent. Fig. 6 shows the Type A package for a liquid radioactive isotope.

Table 3. Weight and volume of the absorbent which is to absorb the Na solution of 25.6 g

Absorbent	Density (g/㎤)	Free absorbency (g/g)	Weight(g)	Volume(㎤)
Polyurethane sponge	0.065	18.3	1.40	21.5
Melanine form	0.011	88.4	0.29	26.3
Absorbent polymer	0.6 ~ 0.8	58.1	0.44	0.73

References

[1] KOREA MOST Act. 2001-23, “Regulations for the Safe Transport of Radioactive Material”, 2001.

[2] IAEA Safety standard Series No. TS-R-1, "Regulations for Packaging and Transportation of Radioactive Material”, 2000 Ed.

[3] U.S. Code of Federal Regulations, Title 10, Part 71, "Packaging of Radioactive Material for Transport and Transportation of Radioactive Material under Certain Conditions", as revised in Federal Register, Vol. 48, No. 165, 1983.

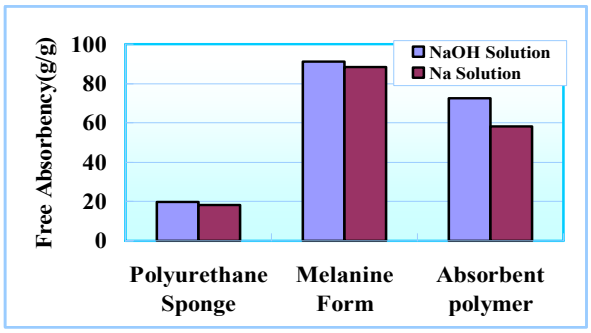

Fig. 4. Free Absorbency of the Absorbent.

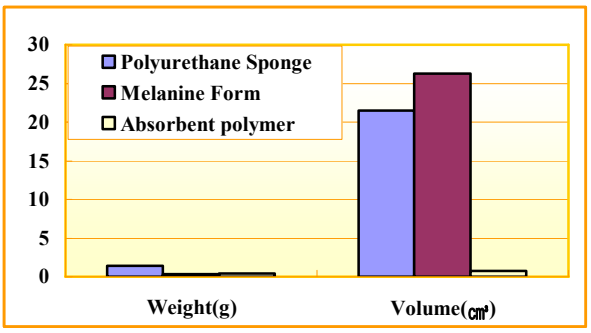

Fig. 5. Weight and Volume of the Absorbent.

Fig. 6. Type A Package for Liquid Radioactive Isotope.