The Development of melamine-D for the precise measurement of detection efficiencies of high energy γ-rays

Shoji NAKAMURA [1)], Hideo HARADA [1)], Hirokazu TAKAYAMA[2)] and Kiyoshi KAWADE [2)]
1)Japan Nuclear Cycle Development Institute, Tokai Works, Tokai-mura, Naka-gun, Ibaraki-ken 319-1194
2)Nagoya University, Furo-cho, Tikusa-ku, Nagoya-city, Aichi-ken 464-8603
E-mail: rgm@tokai.jnc.go.jp

In order to obtaine the precise detection efficiencies for high energy γ-rays in the prompt γ-ray spectroscopic measurement, the prompt γ-rays emitted from nitrogen contained in Melamine-D are utilized. This work shows the effectiveness of Melamine-D.

1. Introduction

Since the high energy γ-rays up to about 10 MeV are emitted in the prompt γ-ray spectroscopic experiments, it is necessary to determine the γ-ray detection efficiencies in good accuracy for such high-energy regions. The neutron capture γ-rays from ^{14}N (n,γ) reaction have been often utilized. **Figure 1** shows an example of a γ-ray spectrum obtained by the Liquid Nitrogen target. Many γ-ray peaks are observed up to the energy region of about 10 MeV. When melamine-H ($C_6H_6N_6$) is used for the target, there is a problem of strong background caused by ^1H (n,γ) reaction. Recently liquid nitrogen target was developed for this purpose [1], however, there are still some problems, i.e., the difficulty of handling the low temperature liquid, strong background γ-rays from the container, and the uncertainty of the target geometry. The melamine-D was developed as a new calibration target, whose chemical form was $C_6D_6N_6$. The cross section of deuterium is 0.5mb[2] and much smaller than that of hydrogen (332mb[2]), therefore it is expected that deuterium-exchanged melamine contributes to the background reduction.

This work aims to examine the effectiveness of melamine-D for the calibration of the high energy γ-rays.

2. Experiment

The melamine-D powder was compressed under the 2.0 t pressure power for 2 minutes by a compressor. The powder was shaped in tablets as shown in **Figure 2**, therefore the geometrical error was reduced. The tablet targets were irradiate by B-4 neutron guide facility in Kyoto University Research Reactor Institute. The neutron flux of the B-4 neutron guide is known as about 5×10^7 n/cm^{2}s. The prompt γ–rays emitted from the targets were measured by a high purity Ge detector. The appearance of the measurement set-up is shown in **Figure 3**. The usual melamine-H powder was also shaped in the same tablet, and its measurements were performed in comparison with the measurements with the melamine-D target. The irradiation times were about 10 hours for each target.

3. Results and Discussion

The γ-ray spectra are shown in **Figure 4** in for melamine-H and melamine-D targets. The γ-ray intensity of 2.2 MeV γ-ray from ^1H (n,γ) reaction in the melamine-D target was 20 times smaller than that in melamine-H, therefore the background was decreased remarkably below 2.2MeV as shown in **Figure 5**. The γ-rays with small intensities were also clearly observed. For example, the weak γ-ray peak of 1.999MeV is just located at the Compton edge of the 2.2 MeV γ-ray peak. By reducing the B.G. with melamine-D, this weak γ-ray peak was observed clearly.

4.Conclusion

To calibrate the detector for the high energy γ-rays in the prompt γ-ray spectroscopic experiment, the use of the deuterium-exchanged melamine (melamine-D) was proposed as a target. The substantiation experiment shows the effectiveness of the melamine-D target, and the γ-rays with the small emission intensities were clearly observed.

Acknowledgement

This work has been carried out in part under the Visiting Researcher’s Program of the Research Reactor Institute, Kyoto University.

Reference

[1]H.Sakane *et al*.: *KURRI Prog. Rep*., p.37 (1999).
[2] R. B. Firestone, V. S. Shirley, C. M. Baglin, S. Y. F. Chu, and J. Zipkin, Table of Isotopes, 8th edition, John Wiley and Sons, New York, (1995).

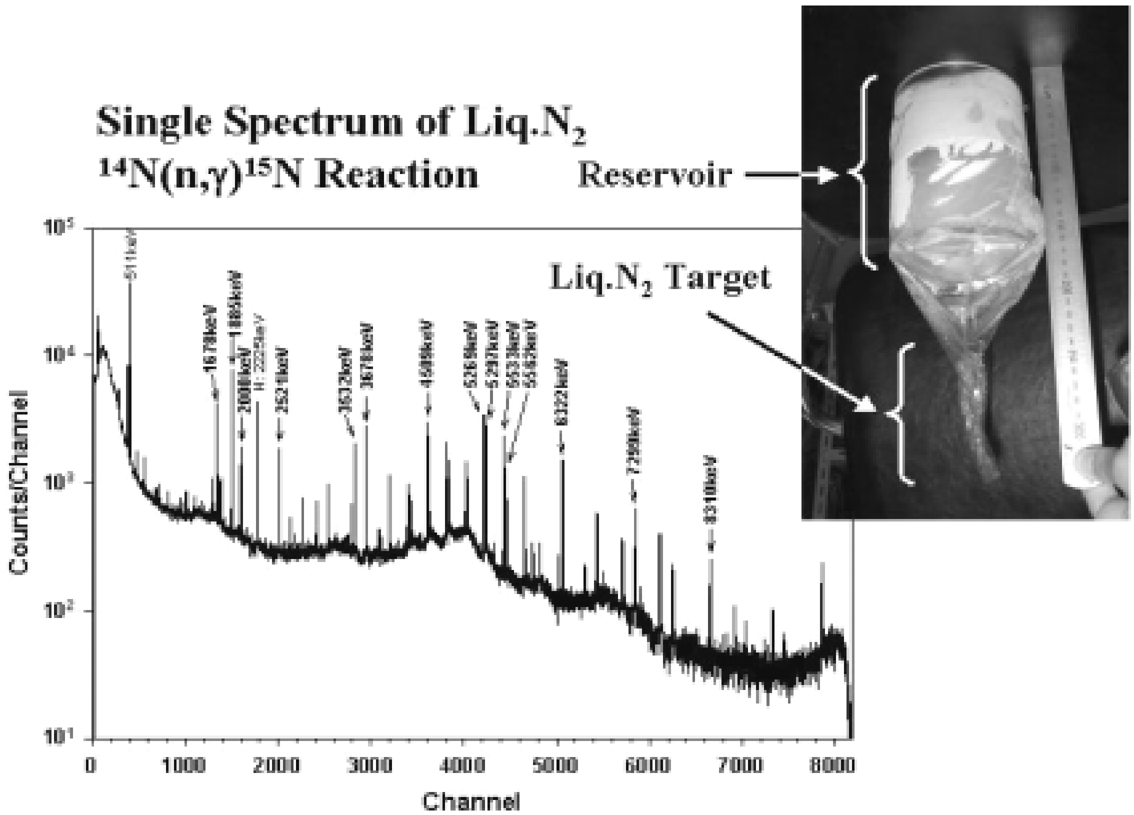

Figure 1 An example of the γ-ray spectrum obtained by the ^{14}N (n,γ) reaction and the Liq.N_2 target

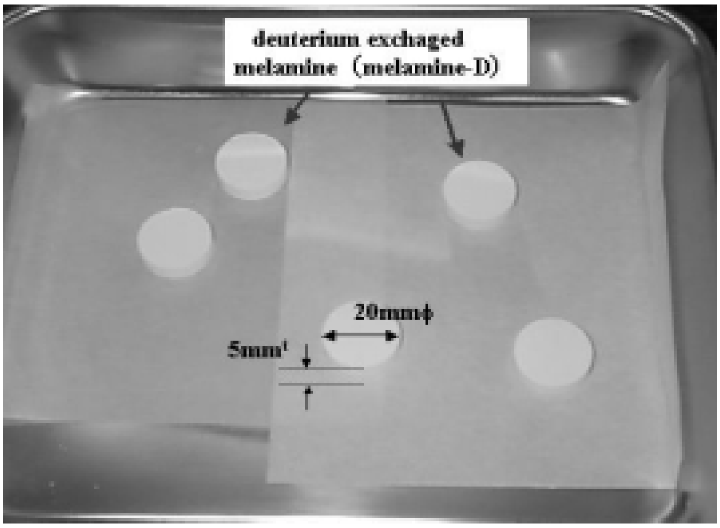

Figure 2 Melamine-D target shaped in tablets by a compressor

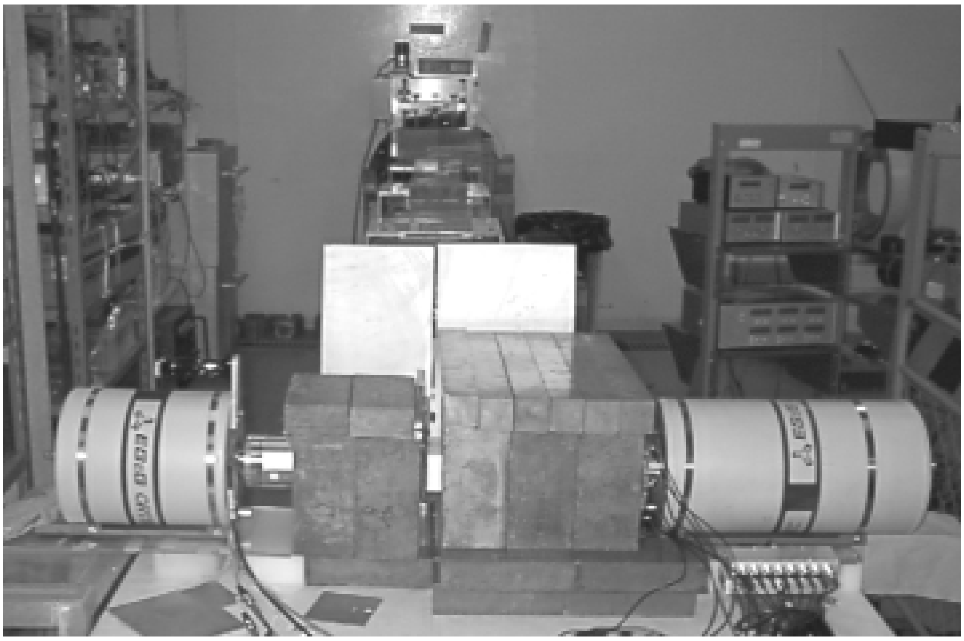

Figure 3 Appearance of the measurement set-up at B-4 neutron guide facility
in Kyoto Research Reactor Institute

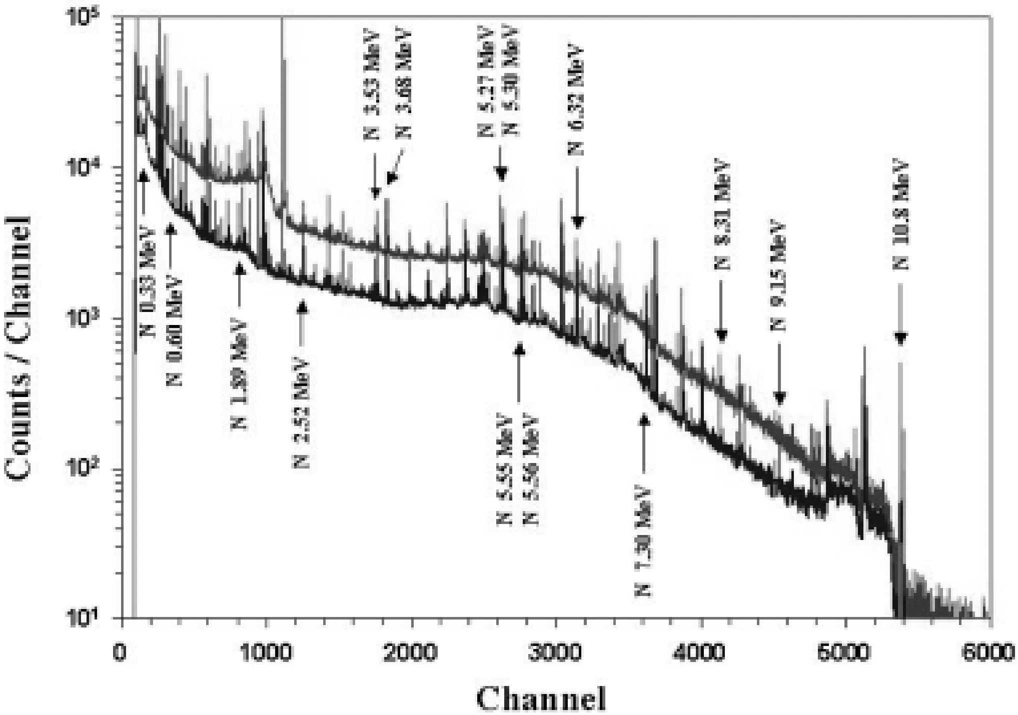

Figure 4 Gamma-ray spectrums obtained with melamine-H (upper) and melamine-D (lower) targets

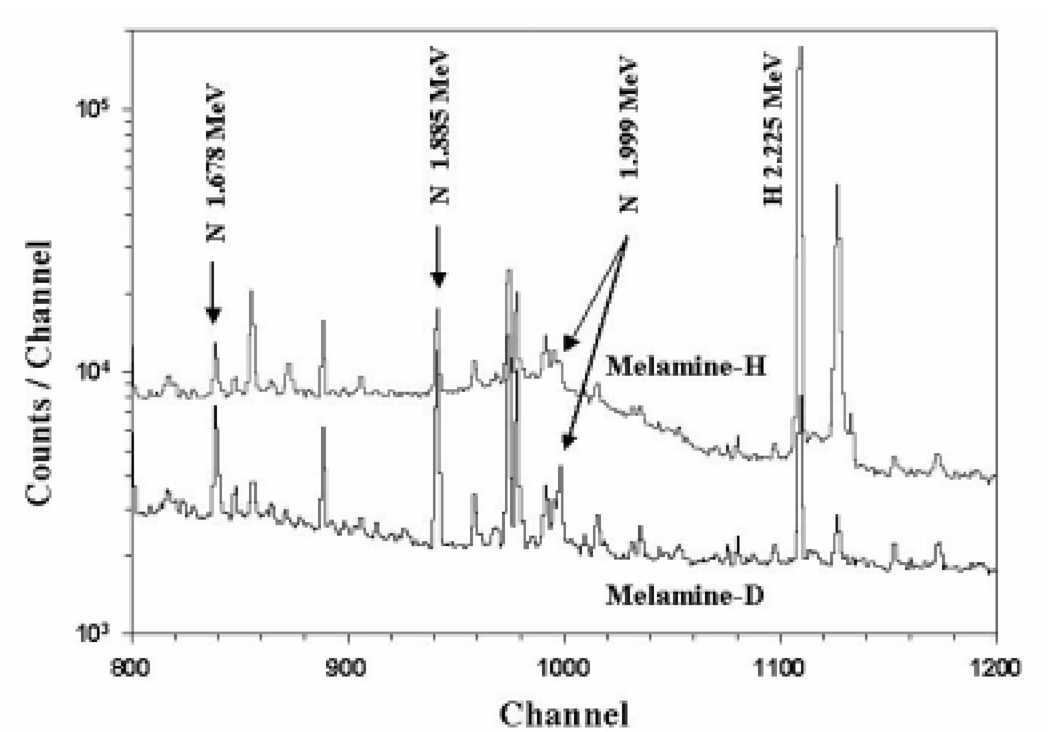

Figure 5 Gamma-ray spectrums around the 2MeV energy region extracted from Fig.4