

# Preliminary study for dosimetry of boron neutron capture therapy with polymer gel

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## Abstract

Boron Neutron Capture Therapy (BNCT) is a treatment that injects boron into cancer, irradiates neutrons and kills only cancer cells, and neutron dose evaluation is a very important issue. The objective of this study is to produce polymer gels by mixing various materials to evaluate patient dose and incident neutron dose in BNCT, and to evaluate its properties for neutron dose evaluation. This study used MC-50 cyclotron installed in our institution to evaluate neutron dose. Polymer gels were prepared by mixing HPLC, Gelatin, Methacrylic acid (MAA), Hydroquinone (HQ) and Tetrakis hydrozomethyl phosphonium chloride (THPC). Li<sub>2</sub>SO<sub>4</sub>, LiCl, and LiF were added to confirm neutron interaction. The neutron doses were evaluated using a total of four polymer gels. The properties of the polymer gel showed linearity as the neutron doses were increased to 5, 10, 15 Gy. In addition, as a result of repeated experiments using the same sample, the neutron dose was reproducible within 5%. The polymer gel developed in this study is expected to be used for various neutron experiments. In the future, various polymer gels will be used to investigate properties according to neutron dose rate and energy to study the polymer gel component ratio suitable for BNCT.

## 1. Introduction

Advantages of BNCT is a possibility to give high radiation doses in malignant cells and a that do not destroy healthy ones. It is important factor in BNCT to get the internal dose origination within the patient from gamma ray and neutron generated. The dose deposited due to epithermal neutron dose depend on the incident neutron energy. A gel dosimetry is able to measure 3D dose distribution. It is known that a polymer gel with Lithium compound is potentially usable in separating thermal neutron, fast neutron and gamma rays dose. The objective of this study is to produce polymer gels by mixing various Lithium compounds to evaluate patient dose and incident neutron dose in BNCT, and to evaluate its properties for neutron dose evaluation.

## 2. Polymer gel

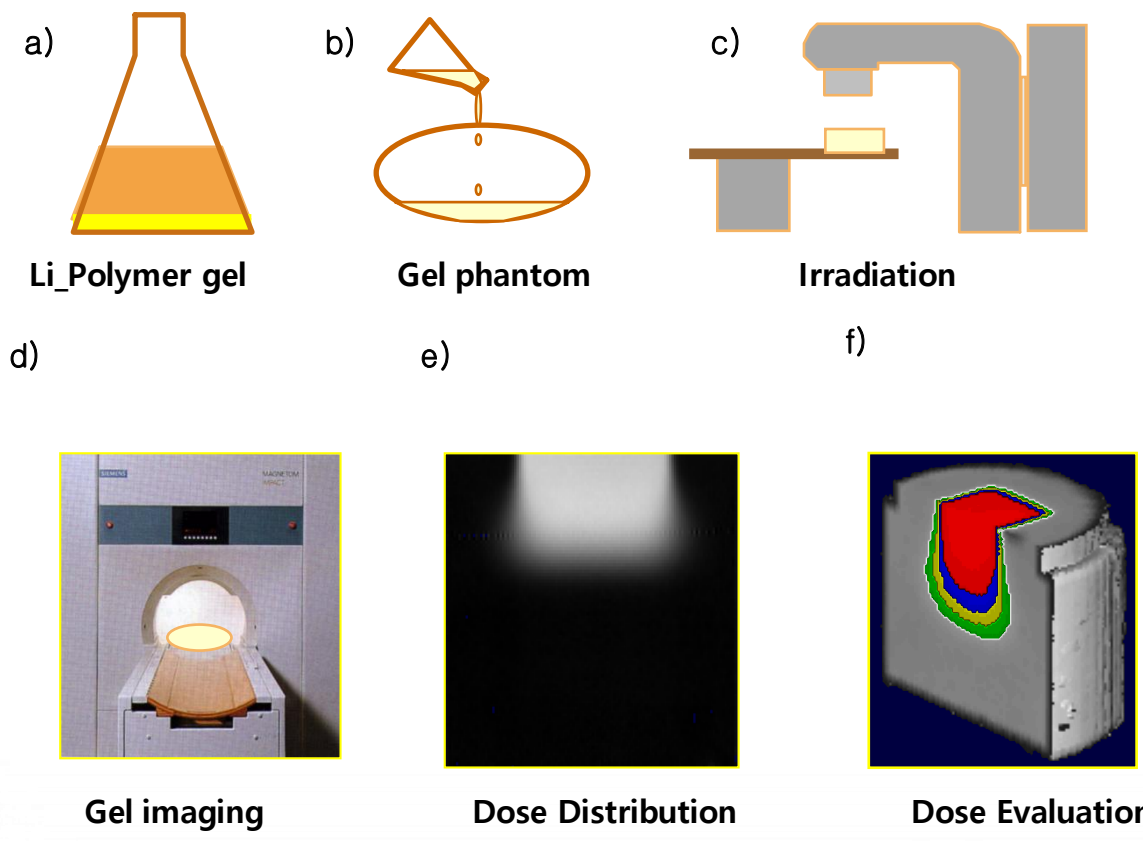


Figure 1. Gel dosimetry process

The polymer gel used in this study was prepared and analyzed in the same manner as in Figure 1. A polymer gel dosimeter according to the composition ratio was developed and the radiometric properties of the dosimeter were studied. Polymer gels were prepared by mixing HPLC, Gelatin, Methacrylic acid (MAA), Hydroquinone (HQ) and Tetrakis hydrozomethyl phosphonium chloride (THPC). Li<sub>2</sub>SO<sub>4</sub>, LiCl, and LiF were added to confirm neutron interaction (Table 1).

Table 1. Components of Li\_Polymer gel

|    |                |                  |                                 |                                 |                                                               |                                                                 |
|----|----------------|------------------|---------------------------------|---------------------------------|---------------------------------------------------------------|-----------------------------------------------------------------|
| #1 | 1. HPLC<br>86% | 2. Gelatin<br>6% | 3. Methacrylic acid (MAA)<br>8% | 4. Hydroquinone (HQ)<br>0.05 mM | 5. Tetrakis(hydroxymethyl)phosphonium chloride, THPC<br>10 mM | 6. Lithium sulfate(Li <sub>2</sub> SO <sub>4</sub> )<br>100 ppm |
| #2 | 1. HPLC<br>86% | 2. Gelatin<br>6% | 3. Methacrylic acid (MAA)<br>8% | 4. Hydroquinone (HQ)<br>0.05 mM | 5. Tetrakis(hydroxymethyl)phosphonium chloride, THPC<br>10 mM | 6. Lithium chloride(LiCl)<br>100 ppm                            |
| #3 | 1. HPLC<br>86% | 2. Gelatin<br>6% | 3. Methacrylic acid (MAA)<br>8% | 4. Hydroquinone (HQ)<br>0.05 mM | 5. Tetrakis(hydroxymethyl)phosphonium chloride, THPC<br>10 mM | 6. Lithium fluoride(LiF)<br>40 ppm                              |
| #4 | 1. HPLC<br>86% | 2. Gelatin<br>6% | 3. Methacrylic acid (MAA)<br>8% | 4. Hydroquinone (HQ)<br>0.05 mM | 5. Tetrakis(hydroxymethyl)phosphonium chloride, THPC<br>10 mM | -                                                               |

## 3. Neutron measurement in MC-50

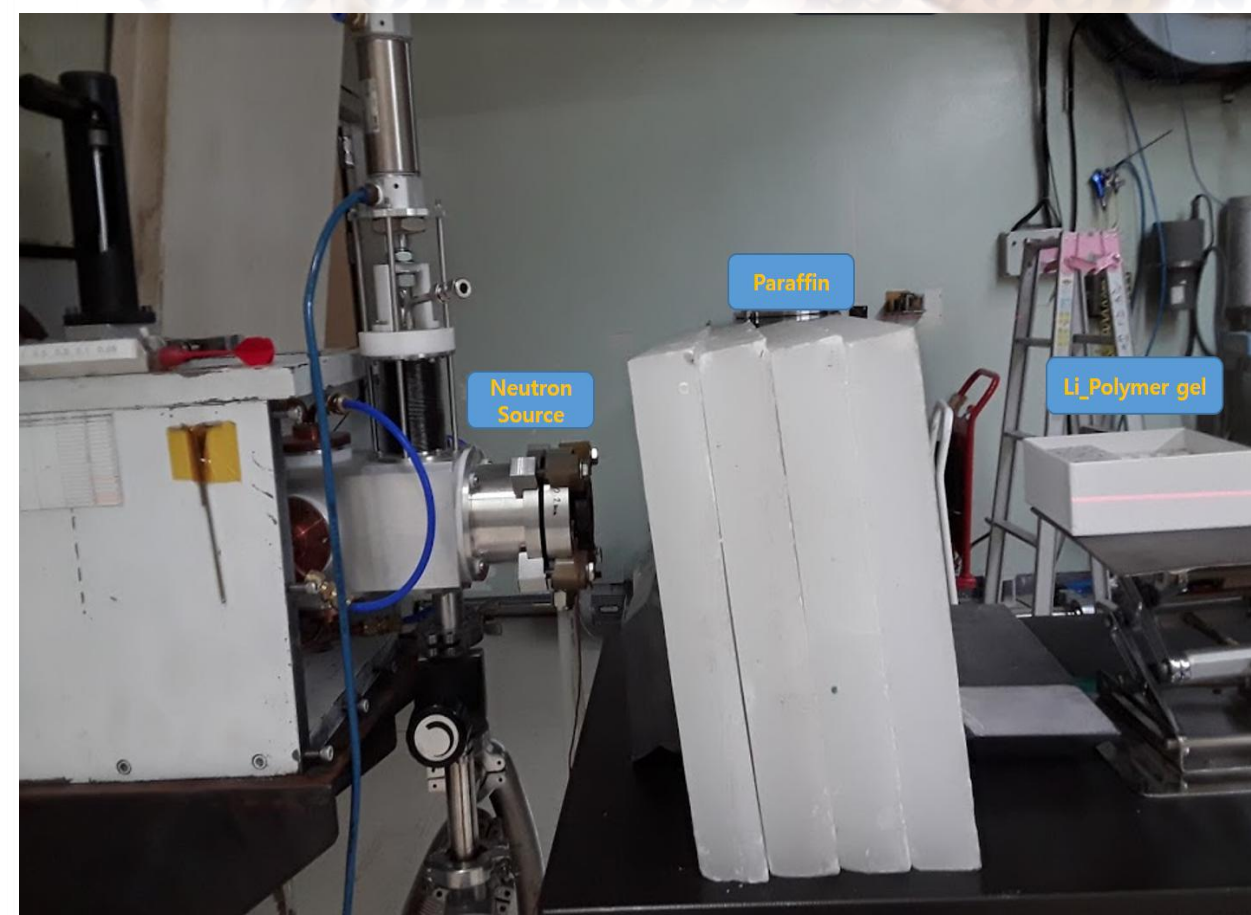


Figure 2. measurement setup with paraffin and polymer gel in MC-50

The neutron doses were evaluated using a total of four polymer gels in MC-50. In order to evaluate neutron doses separately by measuring the effects of neutrons and gamma rays separately, paraffin thickness effects were evaluated as changing the thickness of 8 cm, 12 cm and 16 cm. The OD was acquired using a spectroscopy(Ultrospec 3100 pro).

## 4. Results

### ❖ Li compound

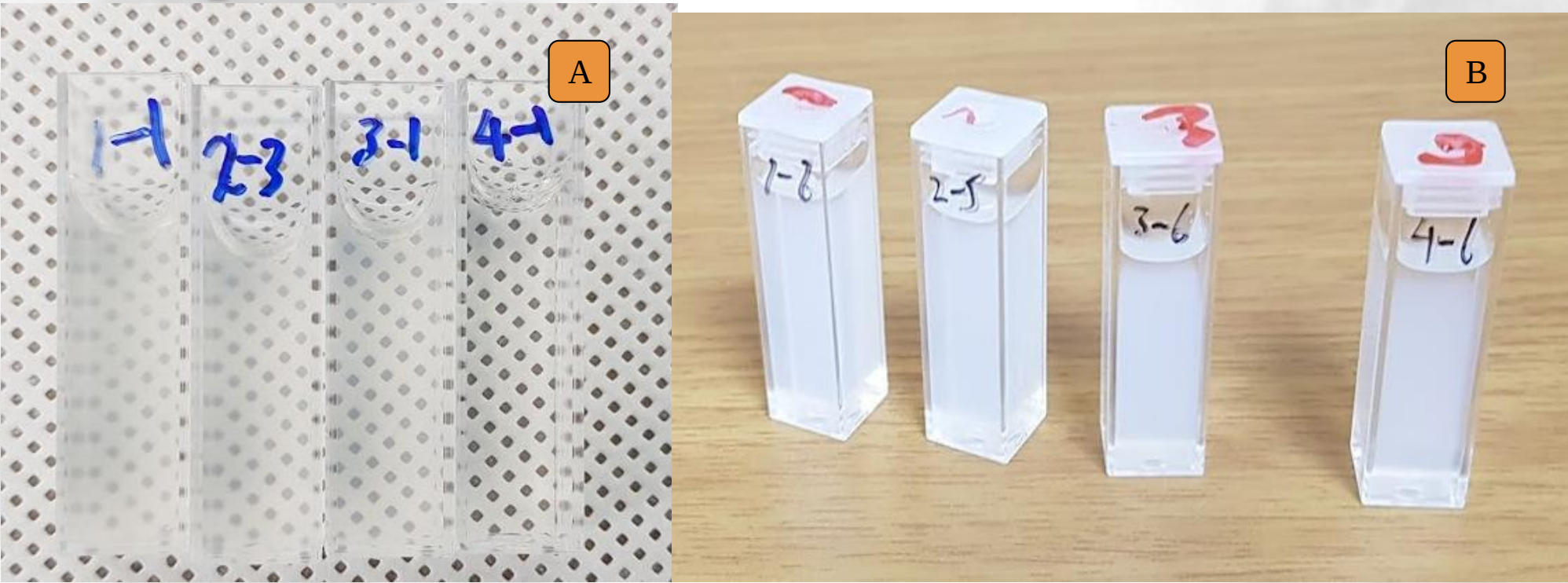


Figure 2. Li\_polymer gel Polymerization as the neutron dose: (A) 0 Gy, (B) 5 Gy

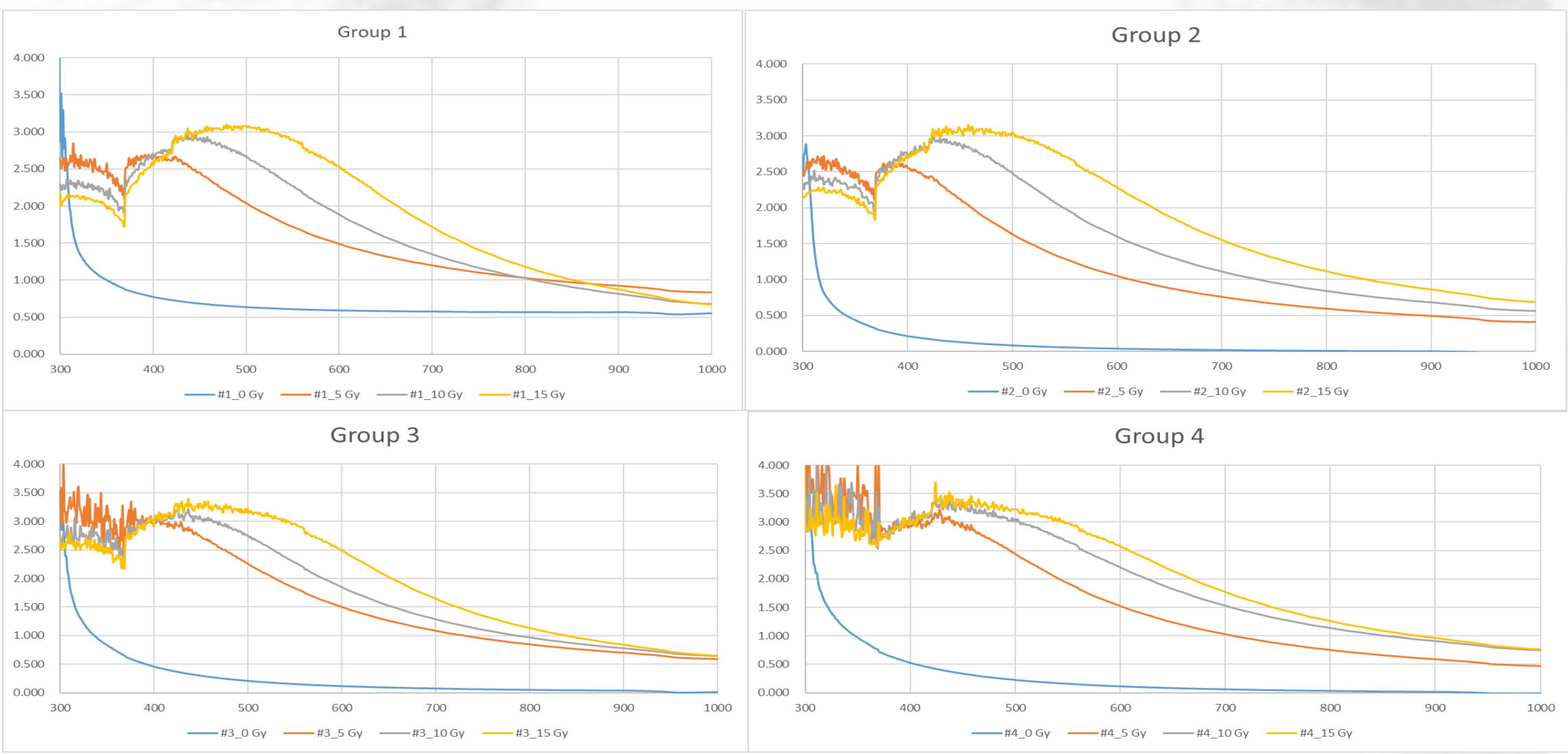


Figure 3. Li\_polymer gel spectrum as the neutron dose according to each polymer combination (Group(#) 1,2,3 and 4)

### ❖ Response Vs. Paraffin thickness

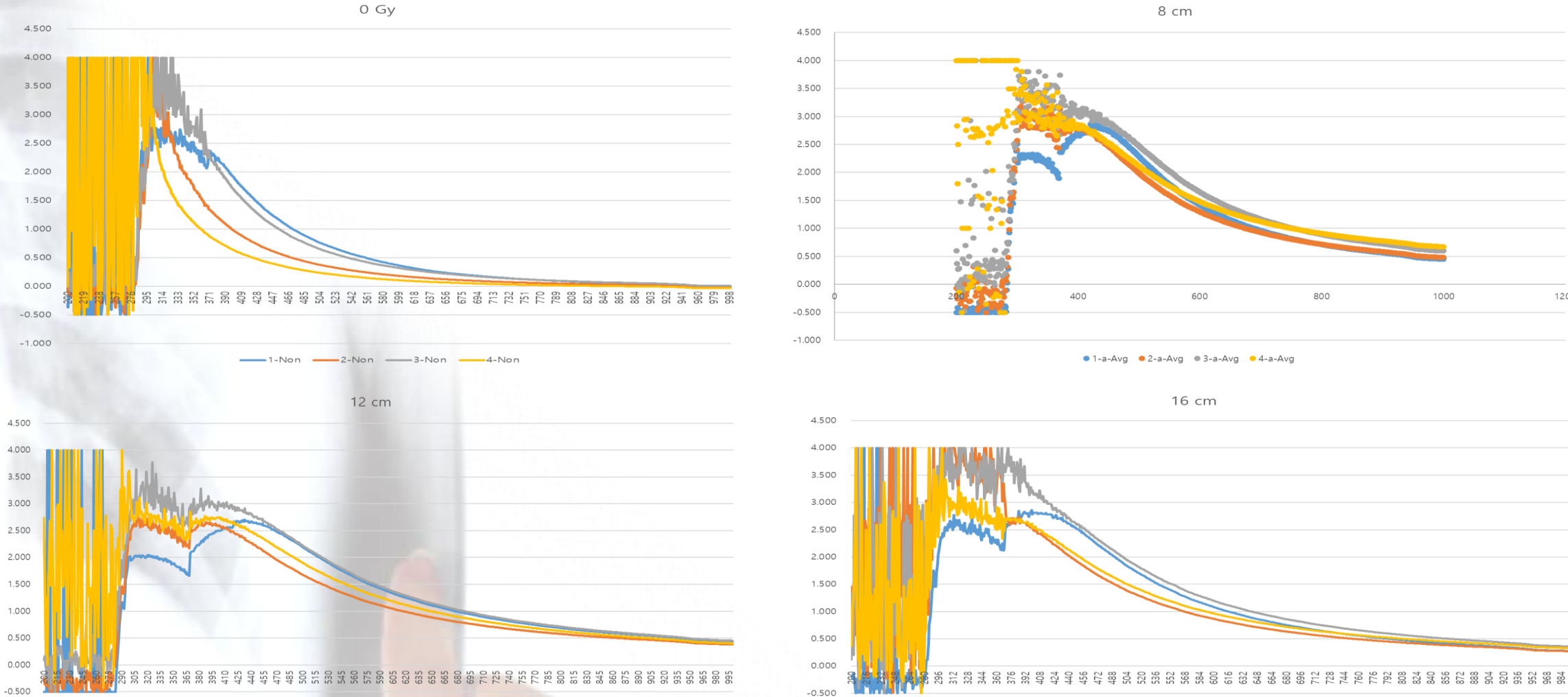


Figure 4. Li\_polymer gel spectrum as paraffin thickness change (0, 8, 12 and 16 cm)

As a result of preliminary research, visible and dosiological responses to neutron sources were confirmed, and there was no difference between groups when the thickness of paraffin was 4 cm. There is also no difference between groups even if the thickness of paraffin is up to 16 cm. Additional experiments will be conducted by establishing thermal neutron conditions.

## 5. Conclusion

In this study, The polymer gel developed in this study is expected to be used for various neutron experiments. In the future, various polymer gels will be used to investigate properties according to neutron dose rate and energy to study the polymer gel component ratio suitable for BNCT

### ❖ Acknowledgement

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