Availability of a containerless polymer gel detector and a gelatin container

Takahiro Tominaga, Munenori Yoshioka, Shin-ichiro Hayashi, Shuji Usui and Mitsutoshi Tada
Department of Clinical Radiology, Hiroshima International University
555-36 Kurose-Gakuendai, Higashi-Hirosima, Hiroshima 739-2695 Japan
E-mail: t-tomi@hs.hirokoku-u.ac.jp

Abstract. We considered an availability of the polymer gel detector without container but with a plastic wrap under assumption of the low oxygen transmissivity of a sheet of plastic wrap. And a gelatin container was also examined for a gel detector. These samples can be made easily and this containerless polymer gel detector well works without any artifacts by means of wrapping with a thin plastic sheet. Nevertheless, there is still room for improvement on preventing oxygen contamination. Combination with a gelatin container and a polymer gel detector and/or Gafchromic films has a various potential for extension of 3D dosimetry.

1. Introduction
Polymer gel detectors have been applied not only for measurements of dose distributions of X-ray, proton and heavy ion beams in radiation therapy [1], but also in boron neutron capture therapy to measure the dose sensitivity in a gel doped with boron [2], and in the dosimetry of radionuclide therapy [3]. This extensive range of application is attributed to the unique dosimetric properties of polymer gel detectors; their tissue equivalency, radiation sensitivity, spatial resolution and their potential to be a 3D dosimeter [4-6]. Nonetheless, polymer gel detectors have a number of limitations to be considered in executing the measurements. One of them is the need for supporting container to protect monomers in gel from oxygen contamination [7] and to persist the shape of gel. Well-sealed glass [8] and Barex vials are most commonly used as a detector’s container, but these compositions are not tissue equivalency, and sometime lead to artifacts and deficiency of sensitivity at container proximity [9]. In this study, we examined applying a thin plastic sheet to pack gel instead of a solid container. Recent food preservative plastic wrap is thin and has a high sealing ability. Because of that, the polymer gel detector, which has no container but is wrapped by only a thin plastic sheet, is investigated its availability as a dosimeter. Further the potential of a gelatin container for 3D dosimetry is studied.

2. Material and methods
The procedure to fabricate a containerless polymer gel detector and a gelatin container are described. In this work standard polyacrylamide base gel (PAGAT) was used.

2.1. Containerless polymer gel detector
First a container is prepared. Cooking oil is applied all over the inner side of a container, and a sheet of plastic wrap is stuck on it (figure 1a). This process makes it easy to remove gel from a container after
its solidification and prevent from oxygen contamination. Oxygen permeability of this wrap (Saran Wrap\textsuperscript{TM}, Asahi KASEI Co.) is 60 cc/m\textsuperscript{2}-day-atom, and thickness is 11\textmu m. Then pour polymer-gel solution (PAGAT) filled the container. The surface is sealed in wrap. (figure 1b) The lump of polymer-gel is removed with wrap from the container just before irradiation (figure 1c).

![Figure 1](image1.png)

**Figure.** 1 The procedure to fabricate a containerless polymer gel detector.

### 2.2. Gelatin container for polymer gel detector.

Figure 2 shows the process of making a gelatin container. The lump of gelatin is made before making a container in the same procedure as having described in 2.1. A bigger container is prepared and cooking oil is applied all over the inner side of a container and a sheet of plastic wrap is stuck on it. Then pour gelatin into the container, holding a lump of gelatin tenaciously at the centre of the container (figure 2a). On the next day a solidified gelatin container is removed from the outer container, and a lump of gelatin is removed from at the centre of gelatin container (figure 2b). A sheet of plastic wrap is stuck on the space where a lump of gelatin located. Then pour polymer gel solution filled that space. The surface is sealed in wrap.

![Figure 2](image2.png)

**Figure.** 2 The procedure to fabricate a gelatin container.

### 2.3. Irradiation and Magnetic resonance imaging

Fabricated gel samples were irradiated with 5 Gy of 6 MV photons using a linear accelerator to examine uniformity of the sensitivity. The sample made from one batch were irradiated on the next day, and the sample from another batch were irradiated one week after fabrication to examine the time degradation of sealing. MRI was undertaken approximately 24 h after the irradiation by 0.3T HITACHI AIRIS II scanner using head coil with a double spin-echo sequence at echo times TE\textsubscript{1}=20 ms, TE\textsubscript{2}=200 ms with a repetition time TR=5 sec.
Figure 3. Containerless polymer gel detector (a) and a gelatin container (b) after irradiation

3. Results and discussions
Two consecutive magnetic resonance images (R2: the transverse nuclear magnetic relaxation rates) of a containerless polymer gel detector and a gelatin container are shown in figure 4.

Figure 4. R2 images of a containerless polymer gel detector (a) and a gelatin container (b).

Line profiles of each detector are shown in figure 5 and figure 6 which correspond to the profile of the detector irradiated on the next day and one week after fabrications respectively.

Figure 5. Line profile of a containerless polymer gel detector (a) and a gelatin container (b) irradiated on the next day.
Figure 6. Line profiles of a containerless polymer gel detector (a) and a gelatin container (b) irradiated after one week.

As these profiles show, plastic wrap is useful to protect the gel detector from oxygen contamination at least one day, and the effect of the time degradation of sealing is seen as the deficiency of sensitivity at the surface in figure 6.

4. Summary
We examined an availability of the containerless polymer gel detector, and a gelatin container was applied to the polymer gel detector. This containerless polymer gel detector, which is only wrapped by a sheet of plastic wrap, well works without any artifacts and deficiency of sensitivity. The advantage of this containerless detector is; reducing a modality related error in the analysis and less ambiguity in constructing the geometry of computer simulations to evaluate dose measurements. And the combination of this detector with a gelatin container has also same advantages. Nevertheless, there is still room for improvement on preventing oxygen contamination as for the combination with gelatin container. The idea of gelatin container can be applied to another radiation detector, for instance as a holder of Gafchromic films. And the variable density of gelatin with additive may make the application of gelatin container wider extensive range, for instance as a phantom with the density of lung equivalency. As a continuation to this initial work, the following investigation are being undertaken; the examination of dose-response characteristics of a containerless polymer gel detector with much circumstance (esp. detector’s size dependence in sensitivity), and comparison with Monte Carlo simulations and a treatment planning system in radiotherapy.

5. References
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