Reduced Temperature Electron Beam Sterilization of Low Concentration Hydrogels Leads to Less Degradation and Therefore Less Viscosity Change

Hydrogels, such as those based upon carboxymethylcellulose (CMC), are used for a variety of applications in a number of industries including the food, personal care, and pharmaceutical industries due to their superior properties as a binding, thickening, and stabilizing agent in these end uses. The most important property that makes CMC useful in these applications is its high viscosity in a low concentration [2]. When sterilization is needed, at a low concentration of CMC in solution, the hydrogel is degraded, resulting in a less viscous solution.

Studies conducted using CMC solution by Lee (1) and Choi (2,3) have made attempts to reduce the degradation effects. They investigated possible steps to reduce the viscosity change. The three steps were:

1. Comparing electron beam with gamma irradiation for sterilization
2. Processing the hydrogel in a frozen state
3. Adding vitamin C as a radical scavenger

Their results indicated for a 30 kGy dose of a 3% solution, when using electron beam irradiation versus gamma irradiation, the viscosity was 29% of the original viscosity for electron beam irradiation versus 4.6% for gamma irradiation. (3) The higher dose rate for electron beam processing produced a lower concentration of free radicals than gamma processing. The authors also found using lower energy electrons <10 MeV, resulted in less degradation.

After irradiating the CMC held at a temperature of -70^{o}C using dry ice, the room temperature viscosity of a 3% solution at a 30 kGy retained 46% of the original viscosity.

When vitamin C was added in a 0.5% concentration, the post irradiation viscosity was 42% of the original viscosity. Therefore, the same result can be achieved through freezing the hydrogel without needing to add vitamin C.

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Applying the results to another cellulose hydrogel, a trial was conducted at E-BEAM Services, Inc. using a practical, production-oriented experiment with Hydroxypropyl Methyl Cellulose (HPMC) based hydrogels. The hydrogels were irradiated using 4.5 MeV electrons at two doses, 15 kGy and 30 kGy. Irradiation at room temperature resulted in a viscosity of 16% and 2% of the original viscosity, respectively. Additional samples were placed in a freezer and frozen at a temperature of -20°C and then irradiated. The viscosity of these frozen samples was 62% and 30% of the original viscosity, four times and 15 times better than the ambient samples. The results of the experiment are below in Figure 1.

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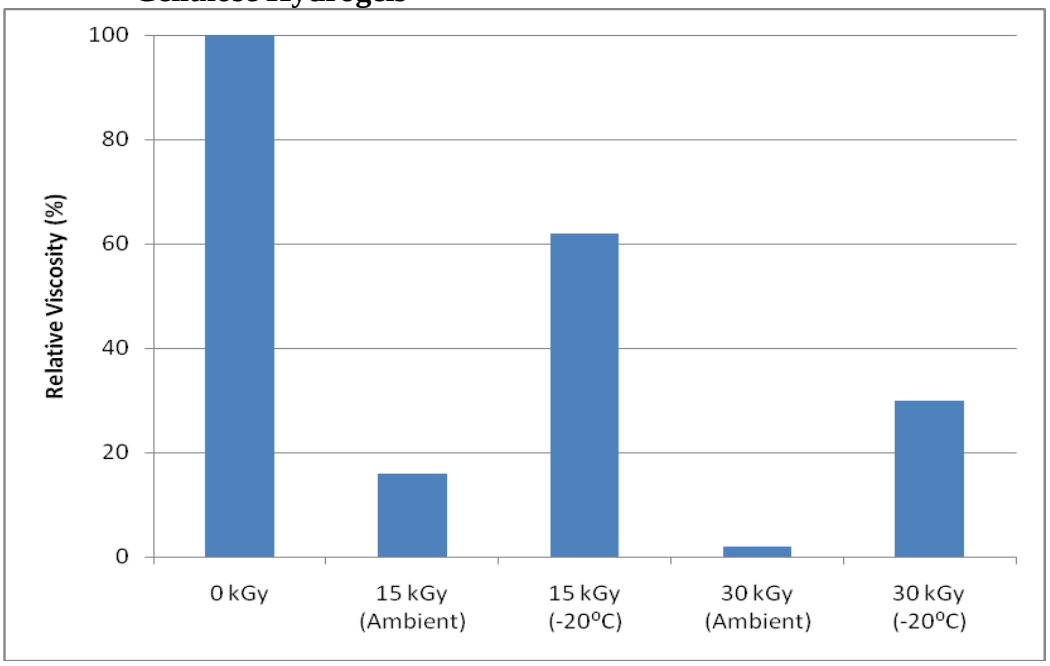
Hydrogels are three-dimensional crosslinked hydrophilic polymers, which are able to swell in liquids. Polyvinylpyrrolidone (PVP) has been used successfully as a base material for the preparation of hydrogel wound dressings for two decades (1). Hydrogels provide good biocompatibility and are widely applied, not only as wound dressings but also as drug delivery systems. CMC is another commonly used base material for making hydrogels. To crosslink a CMC based hydrogel using irradiation, the concentration of CMC must be greater than 5% in addition to the CMC needing to have a high degree of substitution. Without these properties, degradation of the CMC hydrogel will occur. CMC is mainly used for controlling a viscosity level without gelling.

Figure 1. Viscosity of Irradiated Low Concentration Hydroxypropyl Methyl Cellulose Hydrogels



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