PROPERTIES OF RADIATION SYNTHESIZED WATER SOLUBLE POLYMER- CARRAGEENAN HYDROGELS AND THEIR APPLICATIONS

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Novel hydrogels prepared by gamma irradiation of kappa carrageenan (KC) and Iota carrageenan (IC) with the monomers. N-vinyl-2-pyrrolidene (VP) and N-isopropylacrylamide (NiPAAm) and the polymer polyethylene oxide (PEO) were characterized in terms of gel fraction, swelling capacity, tensile strength and response to environmental stimuli. The carrageenan incorporated in the resulting hydrogels through radiation crosslinking contributed to greater physical, chemical and mechanical properties of the hydrogels. Gel fraction was optimum at 20 kGy for VP-IC/KC network (Fig 1a). The hydrophilicity of the PVP hydrogel was enhanced by the carrageenan resulting in higher degrees of swelling (Fig 1b). Tensile strength increased significantly upon the addition of carrageenan (Fig 1c).

The potential applications of these novel hydrogels are presented. A new hydrogel was prepared by irradiating KC and polyvinylpyrrolidene (PVP-KC). The PVP-KC hydrogel has been clinically tested to be an effective wound/burn dressing. A promising radiation dose indicator consisting of an acid-sensitive dye incorporated in a matrix of either KC or KC/PEO has been developed.

Fig. 1 Physico-Mechanical Properties of Radiation Synthesized PVP-Carrageenan Hydrogels: a) Gel Fraction b) Swelling c) Tensile Strength
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Radiation technology has emerged as an environment-friendly, commercially viable technology with broad applications that can essentially contribute to achieve the goal of sustainable development. This technology is based on the use of ionizing radiation to modify the structures and properties of materials in different industrial applications particularly in health care, polymers, and environmental applications. In the field of materials science, radiation technology produces high performance polymeric materials with unique physical and chemical properties. Most of the application in the past centered around synthetic polymers such as polyethylene, polyvinylchloride, polytetrafluoroethylene, polyethylene oxide. However, while the radiation effects on synthetic polymers have been well studied, and have resulted in the development of a variety of applications, they are limited to a few polymers such as polyethylene, polyvinyl chloride, and polytetrafluoroethylene. Nevertheless, radiation technology has emerged as a viable option for processing natural polymers which can significantly improve their properties. Carrageenans, for instance, which are hydrophilic polymers from red seaweed, have been found to be a promising candidate for radiation processing. Carrageenan finds concrete application as hydrogel for burn dressing, as radiochemical dosimeter and as plant growth promoter. Carrageenans are hydrophilic polymers that comprise the main structural polysaccharides of numerous species of seaweed e.g., Eucheuma, Chondrus, Gigartina, Fuculoria. Due to their half-ester sulfate moieties, they are strongly anionic polymers. They are composed of D-galactose units linked alternately with α 1,3 and β 1,4 linkages. These sulfated galactans are classified according to the presence of the 3,6 anhydrogalactose on the 4-linked residue, and in the number and position of the sulfate group.
A series of hydrogels from gamma irradiated aqueous solutions of N-vinyl-2-pyrrolidone (VP), PVP polymer and carrageenan were prepared. The influence of dose, concentration of carrageenan and VP on the gel fraction, swelling capacity and mechanical properties of hydrogels were investigated. Gel formation was saturated at 20 kGy for all hydrogel systems. Assuming that all VP will be crosslinked, about 71.5% gel fraction should be obtained. Gel contents of all hydrogels reached.

Carrageenan-based Go-no-Go radiation dose indicator is available commercially for visual radiation indicators to determine whether the irradiation and medical products sterilization need assurance program of radiation processing. A Go-No-Go radiation indicator is an important tool in quality assurance program of radiation processing. A Go-No-Go radiation indicator is being developed for both medical products sterilization and food irradiation. It consists of phenol red, an acid-sensitive dye mixed homogeneously with a polymer base such as carrageenan and some water soluble polymers (WSP). Carrageenan releases the sulfate group during irradiation thereby changing the pH around the carrageenan environment. This change in pH will elicit a reaction from the acid-sensitive dye resulting in a change in color as the right pH is reached.

Industrial radiation processing such as food irradiation and medical products sterilization need visual radiation indicators to determine whether the products have been irradiated or not. The radiation dose indicator is an important tool in quality assurance program of radiation processing. A Go-No-Go radiation indicator is available commercially for medical products sterilization in the range of 25 kGy. However, there is no similar indicator for food irradiation in the range 1 – 10 kGy. The carrageenan-based Go-no-Go radiation dose indicator is being developed for both medical products sterilization and food irradiation. It consists of phenol red, an acid-sensitive dye mixed homogeneously with a polymer base such as carrageenan and some water soluble polymers (WSP). Carrageenan releases the sulfate group during irradiation thereby changing the pH around the carrageenan environment. This change in pH will elicit a reaction from the acid-sensitive dye resulting in a change in color as the right pH is reached.

Conclusion

New carrageenan-based hydrogels were prepared by gamma irradiation of N-vinyl-2-pyrrolidone with carrageenan, N-isopropylacrylamide with carrageenan, and PEO with carrageenan. Through crosslinking and/or grafting, carrageenan renders greater swelling capacity and gel strength as well as marked response to environmental stimuli (temperature, ionic strength, pH) to the resultant hydrogels. These novel hydrogels open opportunities for developing other applications such as controlled release systems for drugs, fertilizers, pesticides, etc. These hydrogels may be developed as components of chemical and biosensors. A novel hydrogel consisting of PVP and carrageenan has been clinically tested to be an effective burn/wound dressing. The product is ready for technology transfer. A new radiation dose indicator consisting of an acid-sensitive dye in a matrix of carrageenan and carrageenan-PEO hydrogel is being developed based on the observation that sulfates are released upon irradiation of carrageenan.