THE EFFECT OF GAMMA AND ELECTRON BEAM RADIATION ON THE MECHANICAL PROPERTIES OF THERMOSETTING POLYMER AND THEIR COMPOSITES

Yasuhiro Ikeo, Akira Hirayama, Satoshi Matsuda, Hajime Kishi and Atsushi Murakami

Department chemical Engineering, Himeji Institute of Technology, Shyoshya, Himeji, 671-2201 Japan

ABSTRACT

The degradation mechanism in molecular order of gamma and electron beam radiation for three type of thermosetting polymers (Bis-phenol type vinylester, Novolak type vinylester and Tetra functional epoxy resin) is confirmed by DMTA and swelling test in this study. The degradation in molecular order is quit big. The same manner was observed in Novolak type vinylester but not in tetra functional epoxy resin. The results of swelling test showed that the cross linking networks were destroyed by gamma or electron beam radiation remarkably for the both of vinylester resin. For the tetra functional epoxy resin gamma or electron radiation does not give any effect even in molecular order in high radiation intensity such as 20 MGy. However, the mechanical properties such as bending strength, modulus and fracture toughness of all composites (both vinylester resin and tetra functional epoxy resin composites) in which are reinforced by the chopped strand glass mat or flake like mica change a little after 20 MGy electron beam radiation.

1.INTRODUCTION

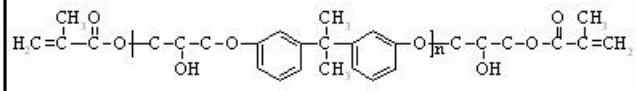
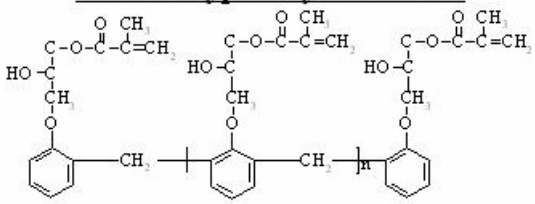
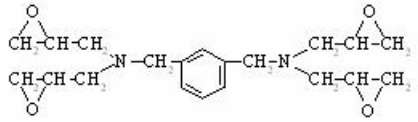
The degradation by gamma and electron beam radiation for the thermosetting polymer materials and their composites, which are used in the Nuclear power station facility, has been focused in this study. These polymer matrix composites can prevent the SCC of stainless steel of the water pool for the disposal nuclear reactor fuel, when these composites are used as a lining material on stainless steel. A few studies of the effects of gamma or electron beam radiation for the polymer matrix composites have been reported (1, 2). The knowledge of the degradation mechanism in the molecular order and the radiation-induced deterioration of polymeric composites are not enough at the moment.

2.MATERIALS & EXPERIMENTS

Three types of thermosetting polymers (Bis-phenol type vinylester, Novolak type vinylester and Tetra functional epoxy resin) and their composites were irradiated by 20 MGy of gamma and electron beam.. The chemical structure of these resins, curing

methods and reinforcements of composites are shown in Table 1. The radiation strength of 20 MGy is a same amount of the facilities getting (for example, water pool of west fuel) in the nuclear power station for 40 years. The degradation mechanism in molecular order of gamma and electron beam radiation for three type of thermosetting polymers is confirmed by DMTA and swelling tests.

Table1 Materials

Based Resin	Curing method	Reinforcement
Bis-phenol type vinylester resin 	Light curing	None
		Glass mat
	Thermal curing	None
		Glass mat
Novolak type vinylester resin 	Light curing	None
		Glass mat
	Thermal curing	None
		Glass mat
Tetra functional epoxy resin 	Thermal curing	None
		Mica flake

3.RESULT & DISCUSSION

The typical DMTA results for Bis-phenol type vinylester are shown in Fig.1. Tg and modulus of rubbery plateau decreases gradually with electron beam radiation intensity. At last Tg decreases more than 50 centigrade at 20 MGy electron radiation.

The degradation in molecular order is quit big. The same manner was observed in Novolak type vinylester but not in tetra functional epoxy resin. The results of swelling test showed that the cross linking networks were destroyed by gamma or electron beam radiation remarkably for the both of vnylester resin. For the tetra functional epoxy resin gamma or electron radiation does not give any effect even in molecular order in high radiation intensity such as 20 MGy. The networks of ester bonds in the vinylester resins may be easier to degrade against gamma and electron beam.

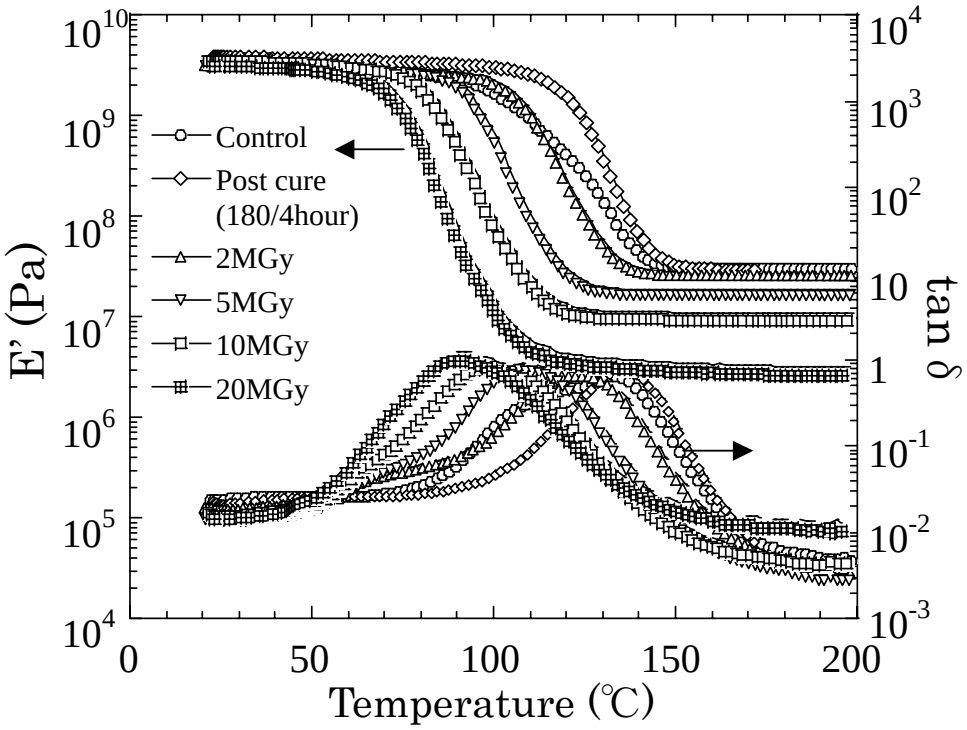


Fig.1 The effect of electron beam radiation on dynamic viscoelastic properties

However, the mechanical properties such as bending strength, modulus and fracture toughness of all composites (both vinylester resin and tetra functional epoxy resin composites) in which are reinforced by the chopped strand glass mat or flake like mica change a little after 20 MGy electron beam radiation as shown in Fig.2.

From another life prediction tests we can also conclude that these thermosetting polymeric composites are useful laminate materials for stainless steel to prevent the SCC in the nuclear power station environment.

4.CONCLUSION

The degradation in molecular order against gamma and electron beam is quit big in Novolak type vinylester. For the tetra functional epoxy resin, the radiation does not give any effect even in molecular order in high radiation intensity such as 20 MGy. On the other hand, the mechanical properties of all composites (both vinylester resin and tetra functional epoxy resin composites) does not change even after 20 MGy electron beam radiation. We can conclude that these thermosetting polymeric composites are useful laminate materials for stainless steel to prevent the SCC in the nuclear power station environment.

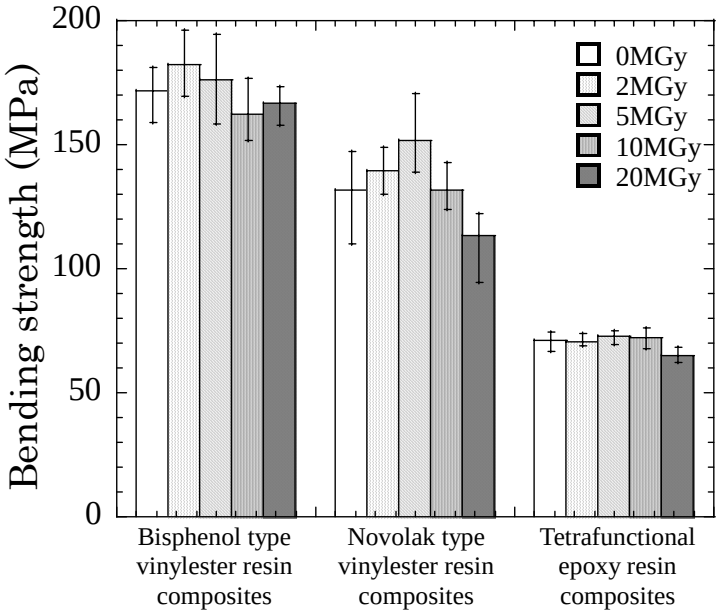


Fig.2 The effect of electron beam radiation on the mechanical properties for thermosetting polymer composites

References

(1) S. Egusa, *Cryogenics*, **31**, 7(1991).

(2) T. Sasuga and A. Udagawa, *Polymer*, **32**, 402(1991).

(3) T. Saito and T. Seguchi, *J. Elect. Insu. Mater. of Japan*, **85**, 19(1985).