RECENT RESEARCH ACTIVITIES

Modification of fibrous material by radiation technique

(Laboratory of Fiber Multiplication, RISH, Kyoto University)

Satoko Okubayashi

As polymer materials and vinyl monomers are irradiated with an electron beam (EB) that is a type of radiations, ionization and excitation occur locally and instantaneously to generate radicals in the molecules. The radicals induce hydrogen abstraction reaction, addition reaction to a double bond, crosslinking by radical recombination, decomposition, oxidation, etc., which change the properties of polymer material. Mainly two procedures, simultaneous irradiation and pre-irradiation are frequently applied for experimental operation. The polymer material pre-coated with monomers is irradiated with electron beam by the simultaneous treatment while the polymer is exposed to electron beam and then coated with the monomer by the pre-irradiation. The monomer and its polymer are immobilized to the material by chemical bonding, which is called EB-graft polymerization. New properties can be added to the base material by the EB-grafting. Recently, equipment of electron beam irradiation has been developing, and the process is widely used in industrial fields such as film and rubber. However, only a few applications to fiber materials has been reported in textile industry.

In this paper, we examined EB-graft polymerization of glycidyl methacrylate (GMA) which is a scaffolding material for incorporation of ionic groups, to non-woven and woven fabrics of modacrylic fiber consisting of vinyl chloride-acrylonitrile copolymer (provided by Kaneka Co., Ltd.) by pre-irradiation method for the purpose to prepare ion exchange fabrics.

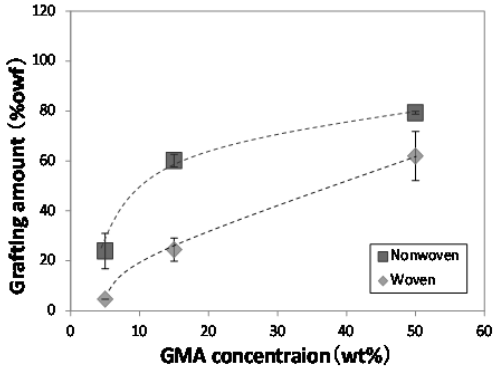

Figure 1. Effects of monomer concentration and fabric structure on grafting amount of GMA.

Table 1. Amount of radical generated on modacrylic fiber by EB irradiation.

Fabric structure	Basis weight (g/m^2)	Amount of radical (g^{-1} of fiber)x10^{18}
Woven fabric	225	3.68
Non-woven fabric	160	3.28
	221	3.40

As shown in Figure 1, weight gain indicating the grafting amount of GMA at 300 keV of accelerating voltage and 100 kGy of absorbed dose to both the non-woven and woven fabrics increased with increasing the GMA concentration, while higher grafting amount was obtained with non-woven fabric having low fiber density as compared with the woven fabric. In order to clarify the difference in the grafting amount in more detail, the amount of radicals generated in woven and non-woven fabrics after EB irradiation were colorimetrically determined using 1, 1-diphenyl-2-picrylhydrazyl free radical (DPPH). It was found that 3.3 to 3.7×10^{18} radicals were generated per fiber weight, regardless of the fabric structure and fabric thickness (Table 1). Considering the same amount of radicals generated by EB irradiation for different fabric structures, and no difference in the grafting amount at the initial stage of grafting in woven and non-woven fabrics (the results are not shown in this report), it is suggested that monomer diffusion to fiber surface and into fiber are retarded after some degree of grafting progressed for dense fabric. Finally the higher grafting amount can be obtained with a fabric having the lower fiber density.

The fabric is three dimensional unstable porous material consisting of a plenty of thin fibers. Many parameters affect monomer diffusion and reaction on and in solid fiber surface, so that the reproducibility is insufficient. This may delay its commercialization in the industry. However, the processing principle is very simple, and it is a very unique method that can provide various functions in an instant with just a few seconds of irradiation. We will continue to seek new seeds for the use of electron EB in fiber processing.