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Separation functional fibers by radiation induced graft polymerization and application

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Abstract

Commercially available non-woven fabric made of polyolefines was used as trunk polymer for radiation induced graft polymerization (RIGP). Ion exchange, antimicrobial and catalytic function was introduced on the fabric by RIGP. All of these materials are commercialized. Ion exchange fabric prepared by RIGP are applied for chemical filter to remove ionic impurities in semiconductor factory and are also applied for continuous de-ionization apparatus to make pure water in combination with ion conductive spacer. Polyvinylpyrrolidone–iodide grafted fabric was produced as antimicrobial fabric and applied for mask. Metal oxide nanoparticle was immobilized onto the ion exchange fabric. This material has catalytic function and was applied for the removal of ozone from air. In all of these applications, long sheets of non-woven fabrics are applied as a trunk polymer. Manufacturing process of RIGP for long sheet is also reported here.

Keywords: Grafting; Ion exchange; Electron beam; Irradiation; Chemical filter; Pure water; Antimicrobial; Non-woven fabric; Ion exchange fabric; Ion conductive spacer; Sulfonation; Iodine; Nanoparticle; De-ionization; Ozone

1. Introduction

Radiation induced graft polymerization (RIGP) is a convenient and powerful technique. Various shapes and sizes of existing polymer, such as film, fiber, bead and hollow fiber can be used in RIGP. Despite many articles about RIGP and its applications have been published, there is few report of practical application. EBARA began to study functional materials using RIGP in 1985 at Japan Atomic Energy Research Institute (JAERI) for development of functional hollow fibers which remove both ions and particles. Thereafter ion exchange fibers by RIGP and its applications have been developed including mass production process. Four applications, chemical filter (named EPIX filter) for air purification of cleanroom, continuous de-ionization (named GDI) for pure water production, antimicrobial fabric with iodine and catalytic fabric with metal oxide nanoparticle are introduced here. All of these applications were practically used and the functional fibers are produced by EBARA.

Continuous graft apparatus on commercial basis is also introduced here. RIGP can be classified based on three factor; (1) irradiation source: electron beam (EB) or gamma rays; (2) irradiation opportunity: simultaneous or preirradiation grafting; and (3) monomer phase: vapor phase or liquid phase [1]. We applied EB and preirradiation. However, we met many technical problems in monomer phase especially for fabric. Therefore we developed a new grafting method named impregnated vapor phase grafting which has both advantage of vapor phase and liquid phase grafting. By adoption of the new grafting method, monomer use efficiency become higher and the grafted fabric was obtained in a dry state and was easy to handle.

2. Ion exchange fabric by RIGP

Ion exchange fabric is produced by continuous graft polymerization with electron beam and second reaction

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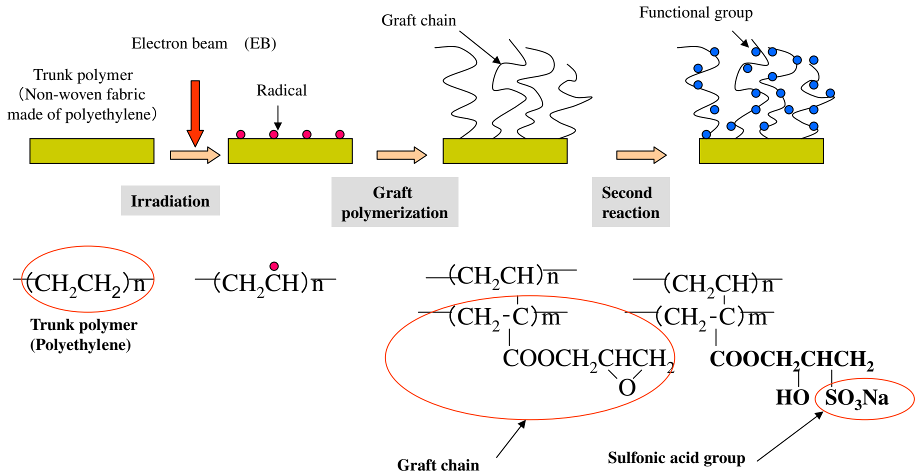
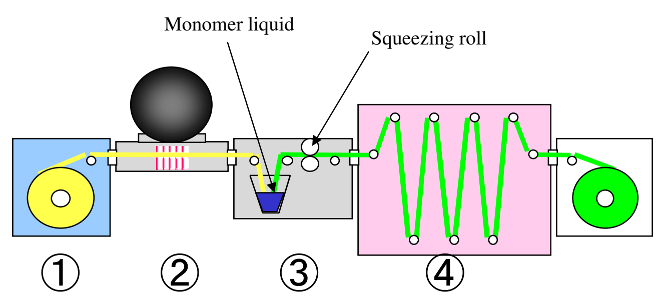


Fig. 1. Production method of ion exchange fabric by radiation induced graft polymerization (RIGP).

for introducing ion exchange function by preirradiation method of RIGP. Schematic illustration of strongly acidic cation exchange fabric using glycidylmethacrylate (GMA) is shown in Fig. 1. Long sheets of non-woven fabric made of polyolefines is irradiated by EB under nitrogen atmosphere. After irradiation of the EB, the fabric is impregnated into the monomer which has ion exchange groups or which can be converted into ion exchange groups continuously. Secondary reaction after grafting is taken place by batch process.

2.1. Continuous graft apparatus [2]

Photo 1 and Fig. 2 shows a continuous graft apparatus for mass production. Main specification of the apparatus is given below. Voltage: max. 300 keV, line speed: max. 20 m/min, irradiation width: max. 1.5 m. Trunk polymer fitting zone, electron beam, monomer impregnating zone and reaction zone are connected in series.



① Trunk polymer material fitting zone
② EB
③ Monomer impregnating zone
④ Reaction zone

Fig. 2. Schematic illustration of continuous graft apparatus.

Long sheets of non-woven fabric are set in the fitting zone. Irradiation is performed at an ambient temperature

Photo 1. Continuous graft apparatus.