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Brief communication

Poly(amidoamine) dendronized hollow fiber membranes: Synthesis, characterization, and preliminary applications as drug delivery devices

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ABSTRACT

Poly(amidoamine) (PAMAM) dendrons were prepared from hollow fiber membranes (HFM) consisting of bromomethylated poly(2,6-dimethyl-1,4-phenylene oxide) (BPPO) in a stepwise manner. The prepared HFM were characterized by Fourier transform infrared spectroscopy, elemental analysis, and scanning electron microscopy. The drug loading efficiency and release behavior of the PAMAM dendronized HFM were evaluated using sodium salicylate, sodium methotrexate, and Congo red as model drugs. The results suggest that PAMAM dendronized HFM can be effectively loaded with a variety of drugs and prolong the release of these drugs. The drug loading and release characteristics of the HFM depend on the generation of PAMAM dendrons grafted on the membranes. The prepared PAMAM dendronized BPPO HFM are promising scaffolds in drug delivery and tissue engineering.

1. Introduction

Hollow fiber membranes (HFM) are one of the emerging materials which have been undergoing rapid growth during recent decades. Compared with other types of membrane, HFM are still in their infancy, but have already exhibited several unique features: (1) a large surface mass transfer area; (2) low operating costs; (3) convenience of assembly; (4) flexible filtration modes (''inside out'' or ''outside in''). Besides applications in separation technology, HFM have been widely used in several biomedical fields, such as blood purification, including hemofiltration, hemodialysis, plasma separation, and blood oxygenation [1], protein separation and purification [2], enzyme immobilization [3], bioreactors [4], artificial organs [5], and drug delivery [6]. Generally, polymers including polysulfone (PS) [7], polyethersulfone (PES) [8], polypropylene (PP) [9], and polyacrylonitrile (PAN) [10] have been used for the fabrication of HFM. The scaffold materials of these HFM are hydrophobic, thus there is a significant potential for the adsorption of proteins onto the membrane surface, resulting in the activation of platelets and leukocytes, and the clotting of hollow fibers [1]. To solve this problem polymers such as polyvinylpyrrolidone (PVP) [1], poly(ethylene glycol) (PEG) [11,12], poly(glycidyl methacrylate) [13,14], poly(acrylonitrile-co-acrylic acid) [15], and poly(ethylene glycol methyl ether methacrylate) [16] were either blended with, or grafted onto scaffold materials of HFM to improve their hydrophilicity and biocompatibility.

Dendrimers are hyperbranched, monodisperse, and three-dimensional macromolecules with well-defined molecular weights, sizes, and numbers of surface functionalities [17,18]. Poly(amidoamine) (PAMAM) dendrimers, which were first reported by Tomalia in 1985, are the most investigated dendrimers [19,20]. PAMAM dendrimers can be synthesized by Michael addition of amine groups to methyl acrylate, followed by aminolysis of the resulting ester by ethylenediamine to create new reaction sites for further Michael additions. These dendrimers have large numbers of active functional groups, such as hydroxyl, amine, and carboxyl groups, on the dendrimer surface, and thus have excellent aqueous solubility and can be modified with a large number of bioactive molecules [21]. Also, PAMAM dendrimers have numerous relatively non-polar pockets in their interior, which can encapsulate hydrophobic drugs within the dendrimers [22–24]. Although the cytotoxicity of amine-terminated PAMAM dendrimers is a problem, surface modification of these cationic dendrimers by acetylation, PEGylation, or glycosylation can effectively improve their biocompatibility [25]. Based on advances in PAMAM dendrimers, we expected to be able to construct PAMAM dendrimers on the surface of HFM, and that the prepared dendrimer-functionalized HFM would combine the characteristics of HFM (scaffolding material applicability, easily recyclable, a large surface area, and easy assembly into devices) and dendrimers

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