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Antibacterial performance of polypropylene nonwoven fabric wound dressing surfaces containing passive and active components

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ABSTRACT

A growing number of wound dressing-related nosocomial infections necessitate the development of novel antibacterial strategies. Herein, polypropylene non-woven fabric (PP_{NWF}) was facilely modified with passive and active antibacterial components, namely photografting polymerization both *N*-Vinyl-2-pyrrolidone (NVP) and glycidyl methacrylate (GMA) monomers, and the introduction of guanidine polymer through the reaction between active amino groups and epoxy groups. The modified samples were confirmed by attenuated total reflectance Fourier transform infrared spectroscopy (ATR-FTIR), X-ray photoelectron spectroscopy (XPS), respectively. Water contact angle measurement, antibacterial test, platelet and red blood cell adhesion were used to evaluate the hydrophilicity, antibacterial properties and hemocompatibility of the samples. It was found that the antibacterial properties were obviously enhanced, meanwhile significantly suppressing platelet and red blood cell adhesion after the above modification. This PP_{NWF} samples that possess antifouling and antimicrobial properties, have great potential in wound dressing applications.

1. Introduction

Polypropylene non-woven fabrics (PP_{NWF}) has been popularly used as wound dressing due to its unique characteristics, e.g., good breathability, high thermal stability and biostability, as well as low cost [1–3]. However, when contacting with physiological environment, the nature hydrophobicity of polypropylene surface can initiate a cascade of events, e.g., adsorption of blood components and thrombus, bacterial attachment and subsequent biofilm formation [4,5].

So-called "attacking" approach and "defending" approach are popularly used to impart antibacterial properties to a polymer [6–9]. The former approach prevents bacterial adhesion through the introduction of anti-fouling coatings, including but not limited to poly(ethylene glycol) (or poly(ethylene oxide)) [10,11], zwitterionic materials[12–14], glycopolymers [15–17], and poly(oxazoline) [18,19]. However, such antifouling coating cannot kill bacterial cells that are already deposited on the surface [20,21]. The latter approach utilizes various bactericides, such as antibiotics [22,23], silver ions [24–27], antimicrobial enzymes [27,28], antimicrobial peptides [29–31], cationic polymers [32–37], *N*-halamine [38–40], to actively kill bacteria. However, drug resistance or poor biocompatibility is of great concern [41,42]. In addition, the dead bacteria can serve as nutrition for the growth of bacteria [43].

For mitigating the disadvantages of the above antibacterial approaches, the passive antifouling and active bactericidal strategies have been purposefully combined together [44–46]. For example, Jiang and co-workers reported a switchable surface that integrated bactericidal and antifouling performances [16]. In which, the bactericidal property was obtained by quaternary ammonium moieties in the carboxybetaine ester backbones. The antifouling function was provided through hydrolyzing from cationic carboxybetaine ester to zwitterionic groups. More recently, Yang's group developed a two-step antibacterial and antifouling coating, i.e., attaching a reactive polydopamine layer onto surface, and reacting the diblock copolymer with the polydopamine layer via the thiol group on the PEG end [45]. Furthermore, the brush-like polycarbonates with three important components, i.e., pendent PEG for antifouling, antibacterial cations for killing bacteria, and dopamine for substrate adhesion have been

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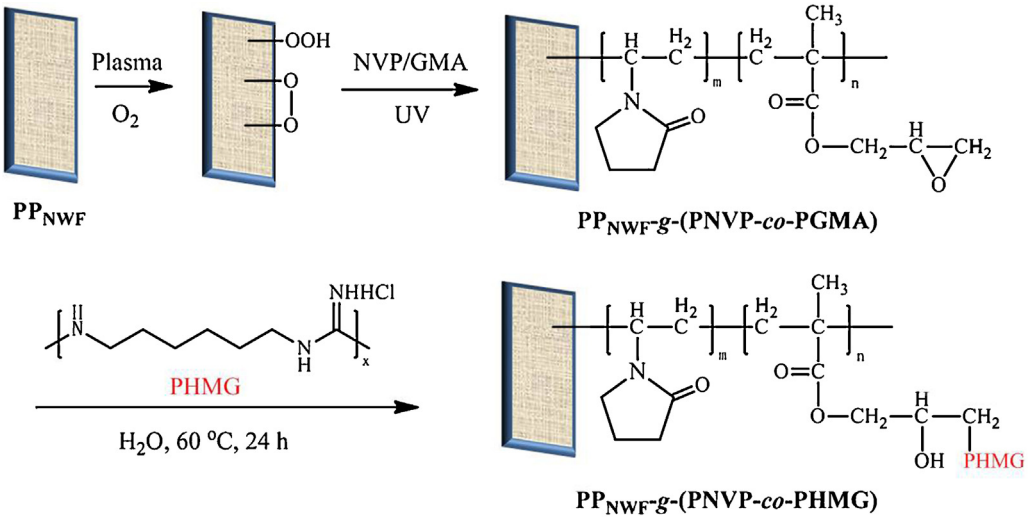

Scheme 1. Surface modification procedure of PP_{NWF} wound dressing.

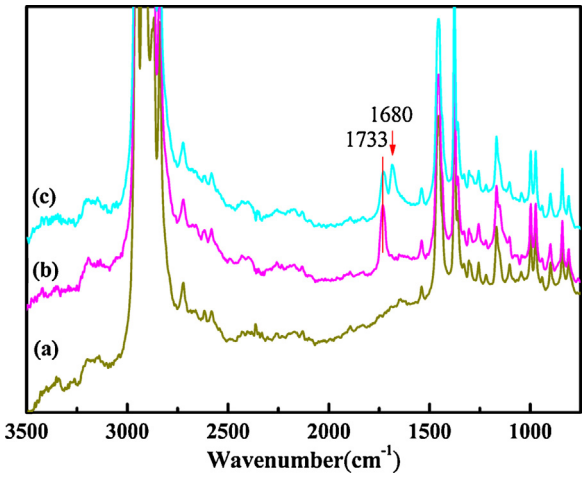

Fig. 1. FTIR-ATR spectra of the samples. (a) virgin PP_{NWF}, (b) PP_{NWF}-g-PGMA and (c) PP_{NWF}-g-PNVP-co-PGMA.

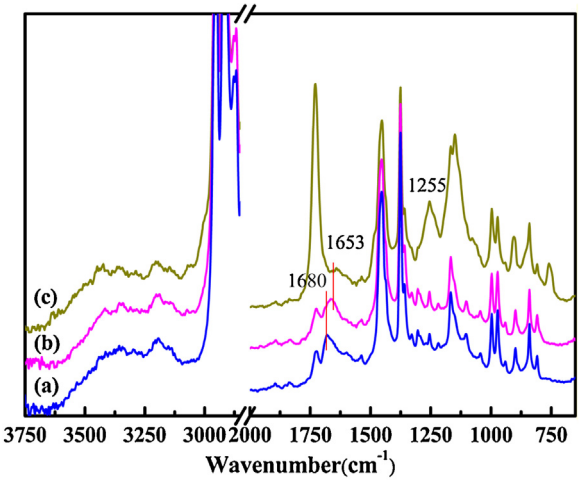

Fig. 2. FTIR-ATR spectra of the samples. (a) PP_{NWP}-g-(PNVP-co-PGMA), (b) PP_{NWF}-g-PNVP-PHMG and (c) PP_{NWF}-g-PHMG.

prepared by Yang's group and coated onto the catheter surface through simple one-step immersion. These above coating strategies not only eliminated bacteria in solution, but also inhibited bacterial fouling on the surface with excellent blood compatibility [46].

In this work, photografting polymerization of PP_{NWF} with *N*-Vinyl-2-pyrrolidone (NVP) and glycidyl methacrylate (GMA) monomers was firstly conducted, followed by the introduction of guanidine polymer through the reaction between active amino groups and epoxy groups. The biological performances of the modified samples were evaluated including antimicrobial activity, the platelet and red blood cell adhesion.

2. Experimental

2.1. Materials

Polypropylene non-woven fabric (PP_{NWF}) made by melt-blown and with an average pore diameter of 0.22 μm was obtained from Beijing JDKR Co., Ltd. (Beijing, China). Hexamethylenediamine guanidine hydrochloride (PHMG) was purchased from Top Science. Glycidyl methacrylate (GMA) was provided by Shanghai Aladdin Chemicals (China). *N*-Vinyl-2-pyrrolidone (NVP) was

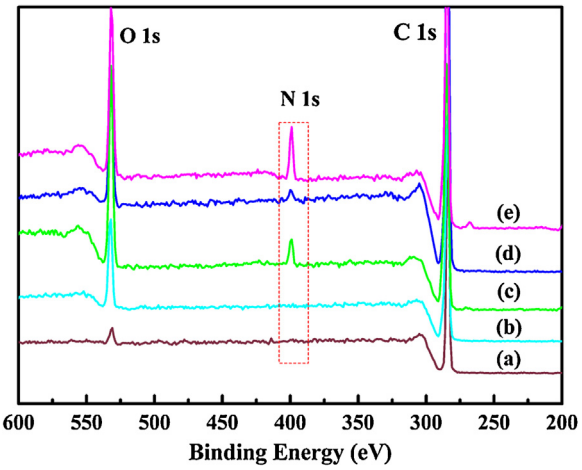

Fig. 3. Total XPS spectra of the samples. (a) the virgin PP_{NWF}, (b) PP_{NWF}-g-PGMA, (c) PP_{NWF}-g-PHMG, (d) PP_{NWF}-g-PNVP-co-PGMA and (e) PP_{NWF}-g-PNVP-PHMG.