Covalent attachment of deoxyribonucleic acid (DNA) to diazo-resin (DAR) in self-assembled multilayer films

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Summary

Construction of covalently attached multilayer films was achieved by irradiating layer-by-layer self-assembled multilayer films of DNA and DAR with ultraviolet (UV) light.

Introduction

Due to its biological characteristics, DNA is currently exploited for the tumor gene detection, gene therapy and various biosensors [1]. As a kind of biomolecular materials with special polyanionic double-helix structure, DNA can be electrostatically incorporated into simple chemical microenvironments, especially into a self-assembled film. This has received considerable attention and a lot of efforts have been paid for its functionalization. An aligned cast film of electrostatically capped DNA-lipid complex presented novel properties of anisotropic electric conductivity and ability to capture some drugs [2]. But it is difficult to construct alternate multilayers with multi-components by means of casting films. Consecutively alternating self-assembling provided a convenient technique and was widely applied in preparation of multilayers with multi-components [3]. This method has also been employed for the fabrication of multilayers of DNA and polyelectrolytes [4]. Liu [5] studied the interaction between DNA in multilayers and low-weight dye molecules in solution. However, DNA is easy to be desorbed in some salt solutions, which will restrict its practical application in assembled systems. So, it is necessary to strengthen the stability of the multilayers. A novel approach to improve the stability is to fabricate covalently attached multilayer films through the photoreaction between the adjacent layers in the multilayers. Zhang [6] et al showed confidently covalent connection between DAR and PAA, PSS and some dye anions in self-assembling multilayers, respectively, and their stability was greatly strengthened in inorganic salt solution. In order to obtain a stable composite multilayer of DNA and polyelectrolytes, herein we reported the preparation of covalently attached alternate multilayers of DNA and DAR through UV light irradiation. The stability of the multilayer was confirmed by etching it in aqueous salt solution.

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Experimental

Materials

The following chemicals were used as supplied. Poly(diallyldimethylammonium chloride) (PDDA) (Scheme 1.) was purchased from Aldrich (Mw. ca. 10000-20000). Polycationic DAR was kindly provided by Cao WX [7]. The average molecular weight of the DAR was ca. 2500. Salmon sperm DNA Sodium Salt (DNA-Na\(^+\)) fragment was purchased from AMRESCO and used without any further purification. Deionized water was used and the pH value of the DNA solution and the rinsed water were adjusted to 3.0.

Scheme 1. Structures of materials used in the deposition process. (a) DAR; (b) PDDA; (c) DNA

 Instruments

UV-Visible spectra were obtained by using a Shimadzu 3100 PC spectrophotometer. Fourier transform infrared (FT-IR) spectra were collected at a 4 cm\(^{-1}\) resolution on a Bruker IFS66V FT-IR spectrometer equipped with a MCT detector, and typically 2048 interferograms were coadded to yield spectra in a high signal-to-noise ratio. For the Grazing-reflection-absorption FT-IR (GRA-FTIR) measurement, a reflection attachment (Spectra-Tech. FT-80 RAS) was employed at the incident angle of 78°, together with a JEOL IROPT02 polarizer. A 16 w medium mercury lamp (with a filter at 365 nm) was used to irradiate the films at a distance of 6.5 cm.

Multilayer construction and covalently attached connection

Quartz wafer used to assemble DNA/DAR was rinsed as our previous report [6]. They were cleaned and coated with PDDA by immersing the plate into a 1 % aqueous PDDA solution for 20 min, rinsed with deionic water and dried by pure nitrogen. The covalently attached DNA films on the substrate were fabricated as following method. Dipped the PDDA-coated substrate alternately into aqueous solutions of DNA (1 mg/ml and pH = 3.0) and DAR (1 mg/ml) for 20 min, with intermediate deionic water (pH = 3.0) rinsing and N\(_2\) drying. Repeating these two steps in a cyclic fashion could form multilayer films. Next, the above-fabricated films were exposed under UV light (wavelength = 365 nm) for a given time to ensure that the photoreaction proceeded completely. In this way, the partially covalently attached multilayer films were obtained. The deposition process of the films was conducted in the dark to avoid the decomposition of the DAR.

Results and Discussion

Figure 1 showed the UV-Vis spectra of 2, 4, 6, 8 and 10 layer pairs of DNA/DAR