Supporting Information

Graphene oxide and sulfonated polyanion co-doped hydrogel film for dual-layered membranes with superior hemocompatibility and antibacterial activity

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1. Preparation and characterization of graphene oxide (GO)

Graphene oxide (GO) was prepared from natural graphite flakes by a modified Hummers method.[1] Briefly, 5 g graphite and 3.75 g $NaNO_3$ were placed in a flask. Then, 150 mL H_2SO_4 was added with stirring in an ice-water bath, and then 20 g $KMnO_4$ was slowly added for over 1 h. The mixture was stirred in an ice water bath for 2 h, followed by a vigorously stirring for 3 days at room temperature. Then, the mixture was diluted with DI water (500 mL) slowly, and the excessive $KMnO_4$ was decomposed by H_2O_2 (30 wt.%, 15 mL). The insoluble precipitations were removed by centrifugation. Then, the resulted GO solution was filtered and washed with HCl (10 wt.%, 1 L) and DI water for several times to remove the metal ions. The pristine brown GO solution was dialyzed with DI water for 1 week before use to remove any residual salts and acids.

The prepared GO was characterized with several methods. Morphological observation was carried out with a transmission electron microscope (TEM) (JEM-1200EX, JEOL, Japan). A Multimode Nanoscope V scanning probe microscopy (SPM) system (Bruker, USA) was used to obtain atomic force microscopy (AFM) image. FTIR spectrum was acquired on a FTIR spectrometer (Nicolet 560, USA) between 500 and 4000 cm^{-1}, using the KBr disk method. A Q500 Thermogravimetric analyzer (TA instruments, USA) was used to get the thermogravimetric analysis (TGA) curve of the sample under a dry nitrogen atmosphere, and the temperature ranged from 50 ºC to 700 ºC with a heating rate of 10 ºC/min.

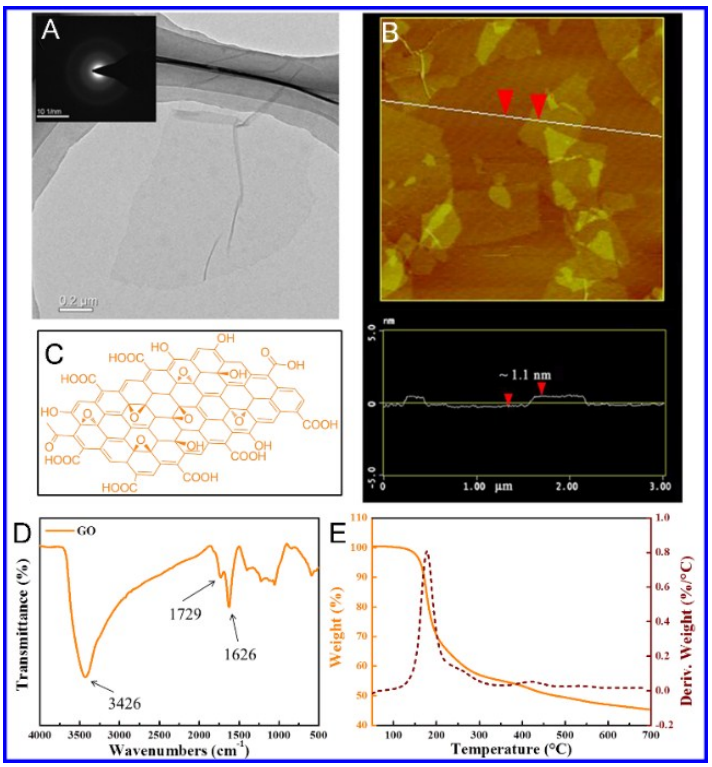

Figure S1. (A) TEM image and corresponding SAED patterns of GO. (B) Typical AFM image and cross-section analyse of GO. (C) Chemical structure of GO. (D) FTIR spectrum for the prepared GO. (E) The TGA image for the prepared GO.

2. Surface SEM image

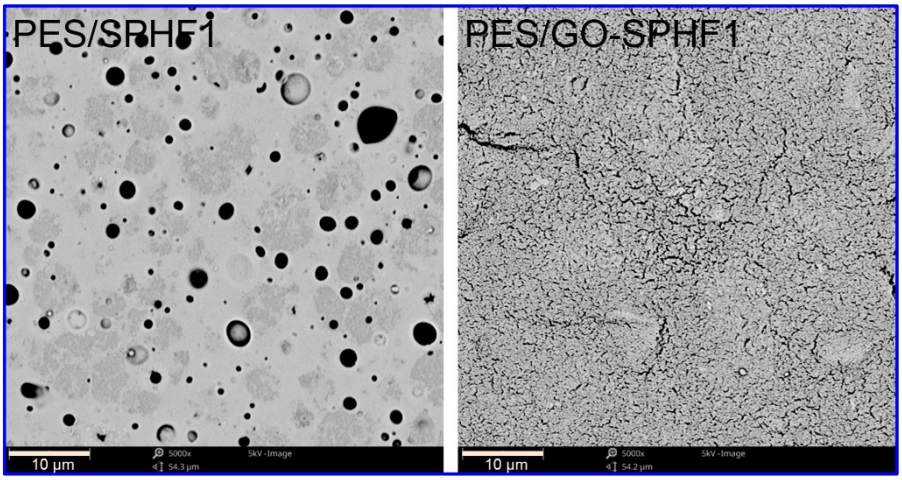

Figure S2. Typical surface SEM images of the composite membranes. Voltage: 5.0 kV; magnification: 5000× with the scale bar of 10 μm.

3. Thermogravimetric analysis for the membranes

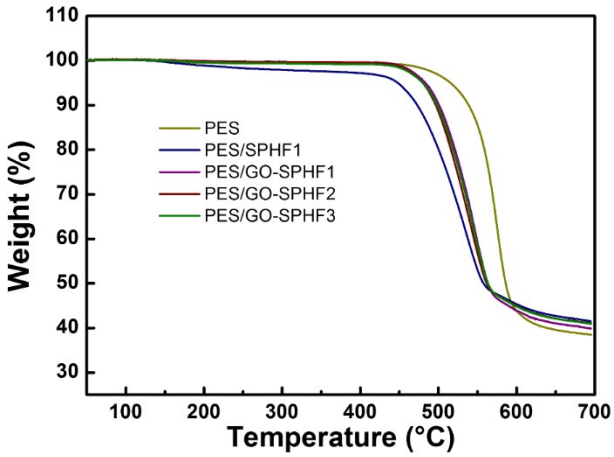

Figure S3. The TGA curves for the prepared membranes.

4. Water contact angle (WCA) measurement

The water contact angle measurements of the prepared membranes were measured using a digital optical contact angle meter DSA100 (KRUSS GmbH, Germany). A drop of deionized water (3 μL) was placed on the surface of the sample and the image of the water menisci was recorded immediately with a digital camera. The contact angle of each sample was taken as the average of six measurements at different points.

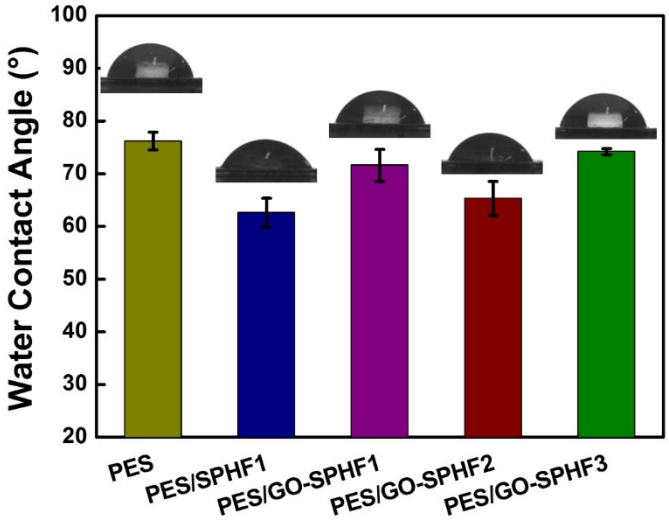

Figure S4. The water contact angles of the prepared membranes.

5. ELISA

Contact activation and complement activation are important parameters to evaluate the reaction or interaction between blood and materials; they are also direct methods to evaluate the blood compatibility of material. Commercial enzyme-linked immunosorbent assays (ELISA) were used to evaluate the contact activation, including platelet activation (Platelet Factor 4 (PF4), Boatman Biotech Co., Ltd, China) and coagulation cascade activation (thrombin-antithrombin III complex (TAT), Enzygnost TAT micro, Assay Pro, USA), as well as the complement activation (C3a and C5a, BD Opt EIA™, BD Co., Ltd, US) for the prepared membranes. The whole blood incubated with the membrane for 2 h was centrifuged for 15 min at 1000 g (4 °C) centrifugal force to obtain the testing plasma. Then, the detections were carried out according to the respective instruction manuals.[2]

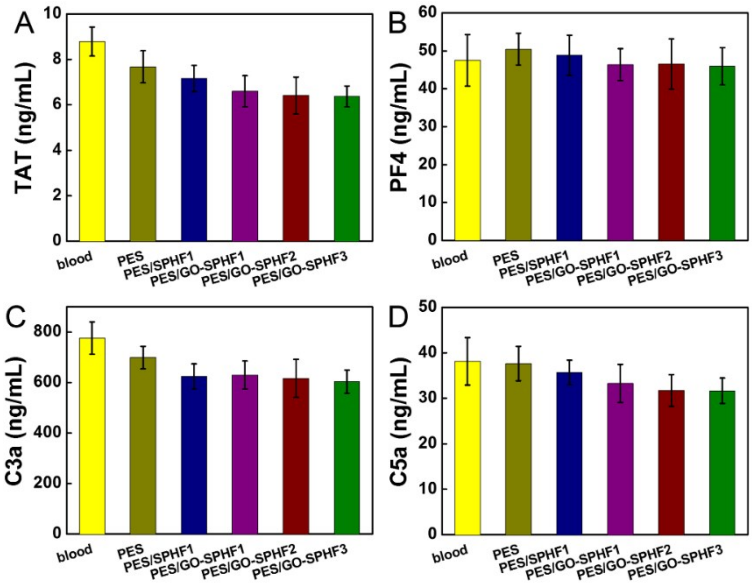

Figure S5. (A) Thrombin–antithrombin (TAT) concentrations for the samples. (B) Platelet factor 4 (PF4) concentrations for the samples. (C) C3a concentrations for the

samples. (D) C5a concentrations for the samples. Values are expressed as means ± SD, n = 3.

6. Characterization of the Ag-nanoparticles loaded membranes

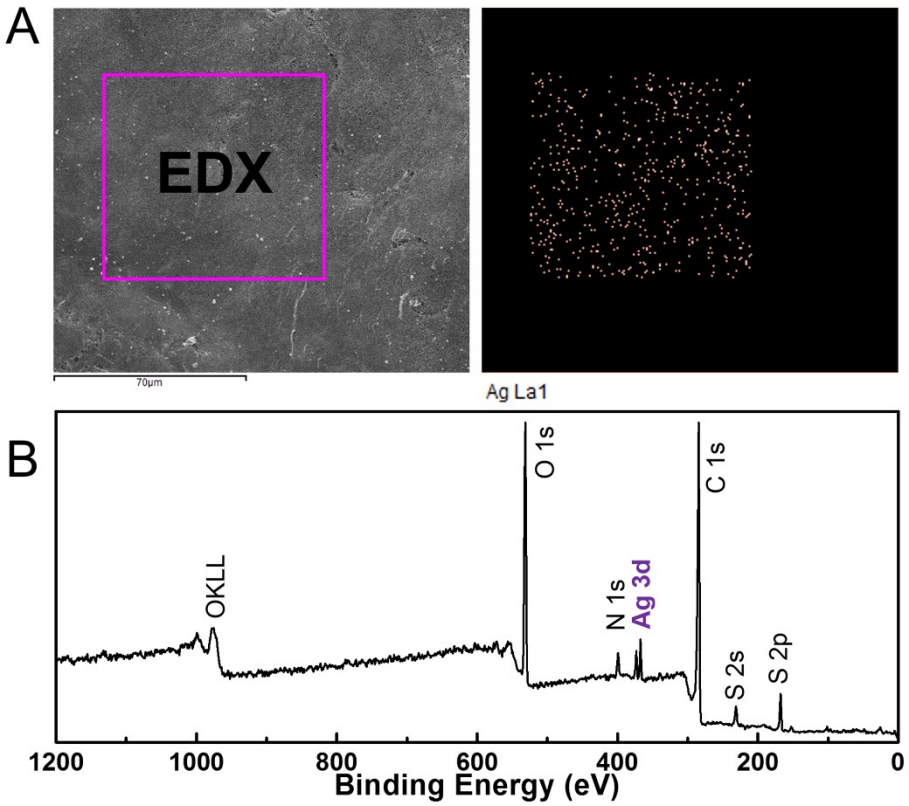

Figure S6. (A) EDX mapping analysis of the Ag-nanoparticles loaded membrane PES/GO-SPHF3-Ag. (B) XPS spectrum of the Ag-nanoparticles loaded membrane PES/GO-SPHF3-Ag.

References

1. C. Cheng, S. Li, S. Q. Nie, W. F. Zhao, H. Yang, S. D. Sun and C. S. Zhao, *Biomacromolecules*, 2012, **13**, 4236-4246.
2. H. Qin, C. Sun, C. He, D. Wang, C. Cheng, S. Nie, S. Sun and C. Zhao, *J. Membr. Sci.*, 2014, **468**, 172-183.