臺北科技大學暨振興醫院
學術合作專題研究計畫成果發表

Study on slippery Liquid-infused Porous surface coatings with low glass transition temperature polymers for extra-corporeal circulation

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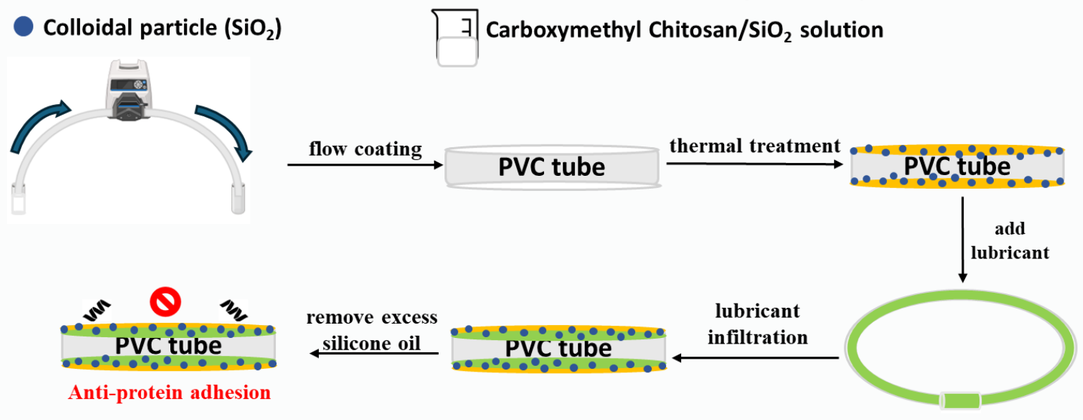
Abstract

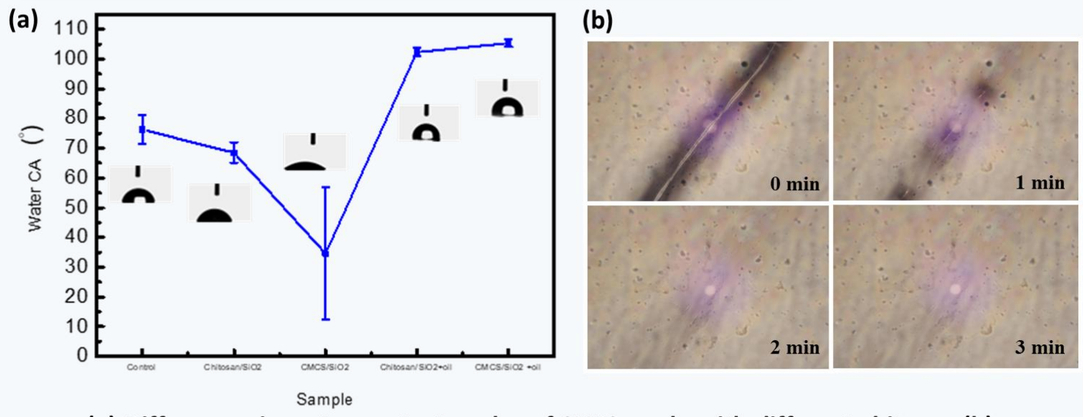
Inspired by the pitcher plant, this study employs the slippery liquid-infused porous surface (SLIPS) technique to fabricate an anti-fouling coating aimed at reducing red blood cell damage during blood transport in extracorporeal circulation tubing. The coating is constructed by forming a special structure composed of carboxymethyl chitosan (CMCS) and silica nanoparticles on the substrate, thereby creating a porous surface without the use of surfactants. Biocompatible silicone oil is infused into the pores via capillary action to form a stable SLIPS structure. The coating exhibits excellent sliding performance against various liquids such as water, alcohol, milk, and coffee, with a water contact angle of approximately 105.3° and a sliding angle below 10°, indicating superior liquid repellency. In addition, the coating demonstrates multiple functionalities, including anti-icing, anti-protein adsorption, and self-healing properties, effectively preventing the adhesion of contaminants and biomolecules. The core feature of this study lies in achieving anti-fouling performance comparable to fluorinated materials without the use of fluorine-containing compounds, while maintaining biodegradability, facile fabrication, and environmental friendliness. The coating constructed from carboxymethyl chitosan and silica nanoparticles can be applied to low-surface-energy PVC materials used in extracorporeal circulation tubing, showing great potential in anti-fouling, biomedical device, and surface modification applications.

Experimental section



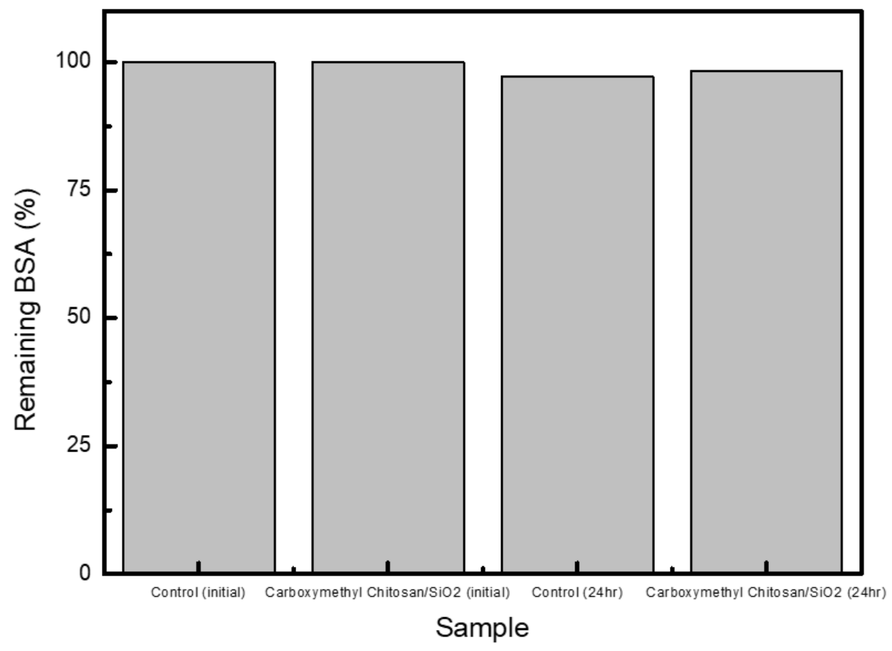
The fabrication of slippery lubricant-infused particulate coating of PVC tube.

Water contact angle and self-healing



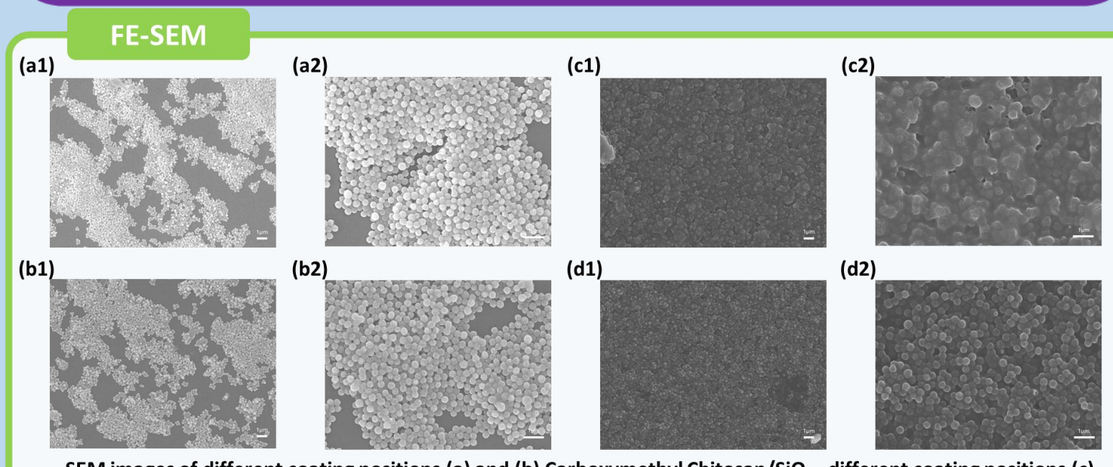
(a) Differences in water contact angles of SLIPS made with different chitosan.(b) Self-healing of SLIPS.

Anti-protein adsorption



Anti-protein adsorption for Control and Carboxymethyl Chitosan/SiO2 BSA remaining (%) after 24 hr .

FE-SEM

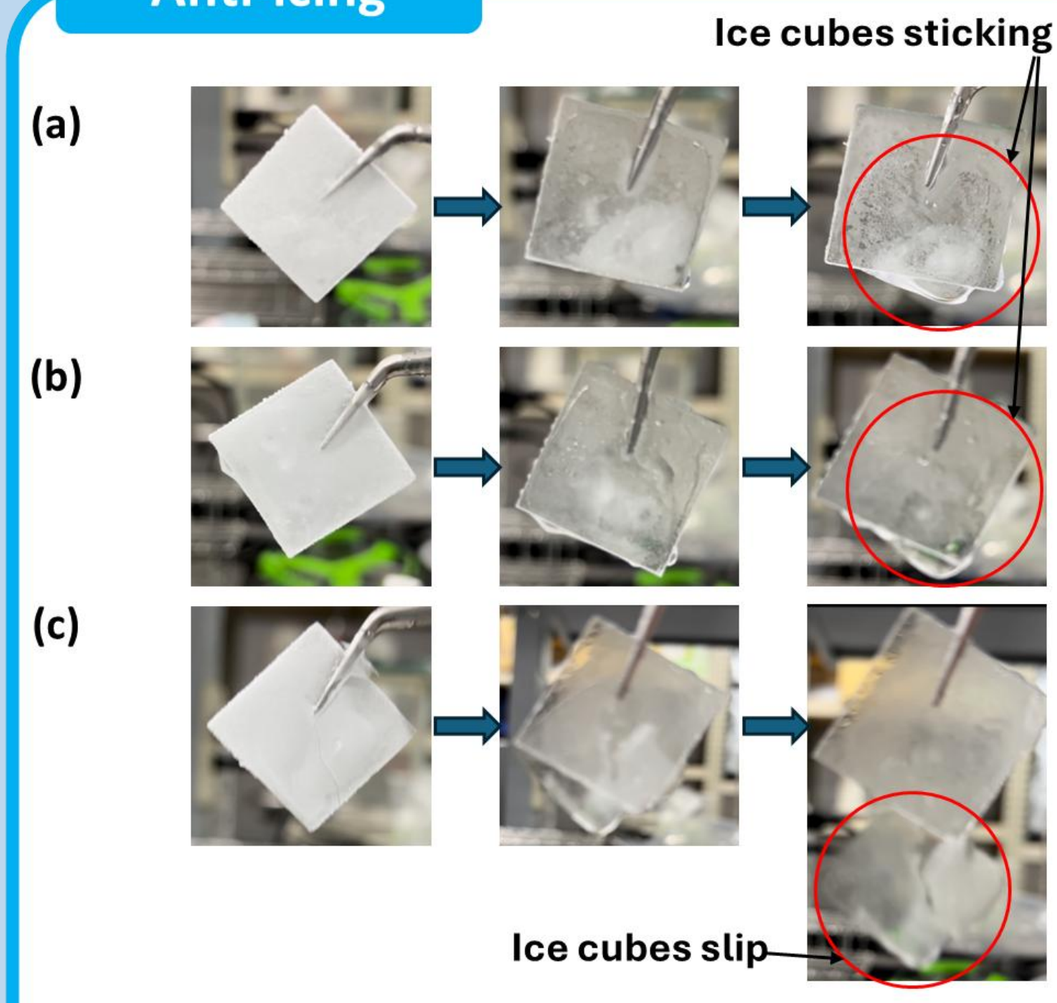


SEM images of different coating positions (a) and (b) Carboxymethyl Chitosan/SiO_2 , different coating positions (c) and (d) Chitosan/SiO_2 .SiO_2 nanoparticles are observed in (a), (b), and (d), while (c) shows no SiO_2, indicating a more uniform distribution in the Carboxymethyl chitosan/SiO_2 coating.

Anti-fouling

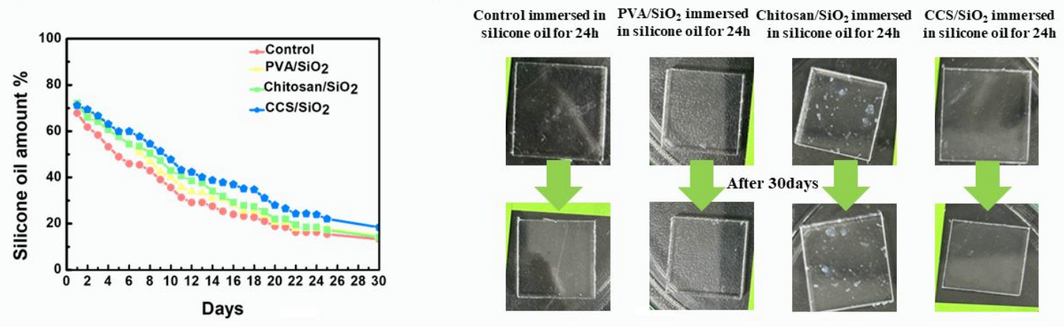
Photographs of four liquids, from left to right: water, coffee, milk, and alcohol on (a) Control(b)Chitosan/SiO_2(c)Carboxymethyl Chitosan/SiO_2, demonstrate the anti-fouling ability of these surfaces. Drip water and alcohol to (d) Control and (e) Carboxymethyl Chitosan/SiO_2 , PVC tube demonstrate the anti-fouling ability of these surfaces.

Anti-icing



Anti-icing process for (a) Control, (b) Chitosan/SiO_2, (c) Carboxymethyl Chitosan/SiO_2.

Durability



Durability of (a) different interlayers to make silicone oil form a lubricating layer on the porous surface, (b) difference in surface lubrication after 30 days.