Accepted Manuscript

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PII: S0266-3538(16)30579-6

DOI: 10.1016/j.compscitech.2016.11.022

Reference: CSTE 6585

To appear in: *Composites Science and Technology*

Received Date: 22 June 2016

Revised Date: 18 November 2016

Accepted Date: 19 November 2016

Please cite this article as: Liu X, Souzandeh H, Zheng Y, Xie Y, Zhong W-H, Wang C, Soy protein isolate/bacterial cellulose composite membranes for high efficiency particulate air filtration, *Composites Science and Technology* (2016), doi: 10.1016/j.compscitech.2016.11.022.

Soy protein isolate/bacterial cellulose composite membranes for high efficiency particulate air filtration

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Abstract

Particulate matter (PM) and toxic chemical pollutants are pervasive in the air. However, conventional petroleum-based and chemically synthesized polymers providing commercial air filters are not eco-friendly materials and can cause secondary environmental pollution. To address this serious issue, developing an environmentally friendly and multi-functional air filtering material is in critical need. In this study, soy protein isolate (SPI) and bacterial cellulose (BC) are employed to study the potential of biomaterials as high efficiency air filtering materials. Soy protein isolate contains many functional groups on its structure and these functional groups were exposed for interactions with pollutants via denaturation process using acrylic acid treatment. The 3D nano-network of BC contributes to the preliminary physical capturing of PM particles, while the functional groups of SPI further attract the PM particles via electrostatic attraction and dipole interaction between the filter materials and the PM particles. It is found that the resulting SPI/BC composite with the appropriately modified SPI possesses extremely high removal efficiencies for particulate pollutants with a broad range of sizes: 99.94% and 99.95% for $PM_{2.5}$ removal efficiency and PM_{10}, respectively, under extremely hazardous air conditions, while maintaining a very high air penetration rate of 92.63%. The mechanism responsible for this high filtration performance of the SPI/BC composite material is analyzed. These study results reveal that functional structures of the biomaterial provide a huge potential for applications in green multi-functional air filters.

Keywords: bio-material, biocomposite film, soy protein, cellulose, filtration mechanism

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