# Electrospun Ultralow-fouling Poly(Sulfobetaine Methacrylate) for Nonadherent, Superabsorbent, Antimicrobial, and Reusable Wound Dressings

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**Statement of Purpose:** A promising polymer that can be used for advanced wound dressings is zwitterionic poly(sulfobetaine methacrylate) (PSBMA), especially if it is fabricated by electrospinning. PSBMA is a favorable material for wound dressings because it is superhydrophilic, ultralow biofouling, noncytotoxic, biocompatible, and biomimetic. Electrospinning provides several attributes important for wound dressings, including high absorptivity due to high surface-area-to-volume ratio, high gas permeation due to the porous structure, and conformability to the contour of the wound.

However, due to PSBMA's superhydrophilic nature, electrospun membranes of PSBMA, if fabricated by a conventional electrospinning method, would readily dissolve in water. The present study developed a novel 3-step polymerization–electrospinning-photocrosslinking method to fabricate fibrous PSBMA membranes that are water-stable. Such membranes have high water absorption, prohibit attachment of proteins, cells, and bacteria, are antibacterial when impregnated with silver, and can be repeatedly used if recharged with silver. Such electrospun PSBMA membranes are ideal for a novel type of nonadherent, superabsorbent, antimicrobial and reusable wound dressings.

**Methods:** The electrospun (ES) fibrous PSBMA membrane was formed by a novel polymerization-electrospinning-photocrosslinking process. Briefly, the PSBMA solution was prepared by mixing the monomer sulfobetaine methacrylate, initiators (sodium metabisulfite and ammonium persulfate), and the crosslinker (tetraethylene glycol dimethacrylate), until the solution reached a viscosity necessary for electrospinning. The solution was then electrospun to generate an electrospun membrane which was subsequently crosslinked via UV treatment to render water stability to the membrane. Polycaprolactone (PCL) was also electrospun, via a conventional electrospinning method, to form control samples that were used throughout the study. PCL was used as a control since it promotes protein adsorption, cell attachment, and bacterial adhesion. Scanning electron microscopy (SEM) was used to characterize the surface morphology of the samples.

Water absorption level of the PSBMA ES membranes and PSBMA hydrogels was determined based on the weight difference of the samples before and after water uptake relative to their dry mass. An enzyme-linked immunosorbent assay (ELISA) was used to evaluate protein resistance of the ES PSBMA membrane to fibrinogen (Fg), using PCL as control. Bovine aortic endothelial cell (BAEC) attachment on ES membranes of PSBMA and PCL was quantified using a MTT assay. Florescence images were also taken of the DAPI-stained cells. To test the bacterial adhesion, Gram-negative *P. aeruginosa* and Gram-positive *S. epidermidis* were cultured and added to ES PSBMA or ES PCL samples, stained, and imaged. Zone of inhibition, for ES PSBMA membrane infused with $AgNO_3$, was studied using a modified Kirby Bauer technique. The silver binding capacity of the ES PSBMA membrane was determined by comparing $[Ag^+]$ in $AgNO_3$ solution before and after soaking the membrane in $AgNO_3$ solution.

**Results:** SEM images show the ES PSBMA membrane has a porous structure with randomly oriented nonwoven fibers, shown in Figure 1 (left). The membrane was stable in water and exhibited high water absorption of 353%, while the PSBMA hydrogel only absorbed 81% water.

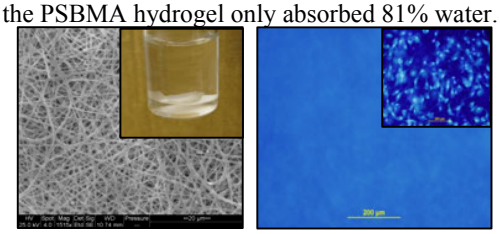

Figure 1. (Left) SEM image of the electrospun PSBMA, which is water-stable as shown in the inset; (Right) Attachment of cells on electrospun PSBMA (inset: cells on electrospun PCL).

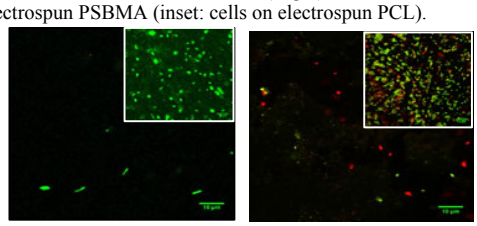

Figure 2. Attachment of *P. aeruginosa* (left) and *S. epidermidis* (right) onto electrospun PSBMA. Insets are for electrospun PCL.

The ES PSBMA membranes showed complete resistance to protein adsorption and cell attachment (Figure 1, right). The ES PSBMA electrospun membrane was also highly resistant to bacterial adhesion from both Gram-negative and Gram-positive bacteria (Figure 2). The $Ag^+$-impregnated electrospun PSBMA membrane was shown microbicidal, against both *P. aeruginosa* and *S. epidermidis,* with the zone of inhibition of 6.3 mm and 3.6 mm, respectively. The amount of silver that saturated the PSBMA fibers was 0.14g Ag/g membrane.

**Conclusions:** The present study shows that the electrospun PSBMA water-stable fibrous membranes are ideal for a novel type of nonadherent, superabsorbent, antimicrobial, and reusable wound dressings, which can effectively manage exudates, support wound healing (maintain moist wound environment), eliminate patients' pain in situ and on dressing removal, avoid formation of new wounds upon dressing removal, prevent attachment & entry of environmental bacteria, offer broad-spectrum antimicrobial activity, allow gas exchange, and can be used repeatedly.

**References:**

1. Zhang, ZJ. Biomater. Sci., Polym. Ed. 2009; 20: 1845−1859.
2. Jiang, S. Adv. Mater. 2010; 22: 920−932.
3. Dunne, WM., Jr. Clin. Microbiol. Rev. 2002; 15: 155-166.