Electrospun Silk with Selenium Nanoparticles Inhibits Bacterial Proliferation

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Introduction

In the past decade, the incidences of bacterial skin and soft tissue infections have dramatically increased. Alarmingly, many of these infections strains have developed resistance to conventional antibiotic treatment options. Antibiotic resistance is a growing epidemic and is estimated by the Centers for Disease Control and Prevention to cost $20 billion annually in excess health costs and $35 billion in other societal costs. Thus, it is evident that new strategies are needed to combat this impending public health crisis. To address this issue, research was conducted to examine the effects of a nanocomposite scaffold comprised of selenium nanoparticles and silk on skin cell and bacterial cell growth.

Silk has been shown to possess many beneficial properties for skin regeneration by promoting collagen synthesis, re-epithelialization, wound healing, atopic dermatitis alleviation, and scar reduction.[1] In addition, electrospun silk possesses a morphology similar to that of native extracellular matrix in the body. Unfortunately, silk has also been shown to promote bacterial growth. Selenium is a novel material in biomedical applications and has shown beneficial properties for reducing bacterial infections.[2] In addition, the selenium nanoparticle coating process developed by the authors is facile and versatile, allowing researchers to deposit selenium nanoparticles as an antibacterial additive to a variety of biomaterials.[3,4]

Materials and Methods

Silk fibroin was extracted from *Bombyx mori* silk worms and resuspended in formic acid at a concentration of 8% (w/v) for electrospinning into silk scaffolds. After electrospinning, selenium nanoparticles were synthesized onto the silk scaffolds using established protocols.[2] By varying reaction conditions, two distinct populations, 40 and 70 nm diameter nanoparticles, were coated onto the scaffold. *In vitro* assays measuring cellular activity were conducted for mammalian cells, human dermal fibroblast, using a MTS assay to quantify metabolic activity, and bacterial cells, *Staphylococcus aureus* and *Staphylococcus epidermidis* (

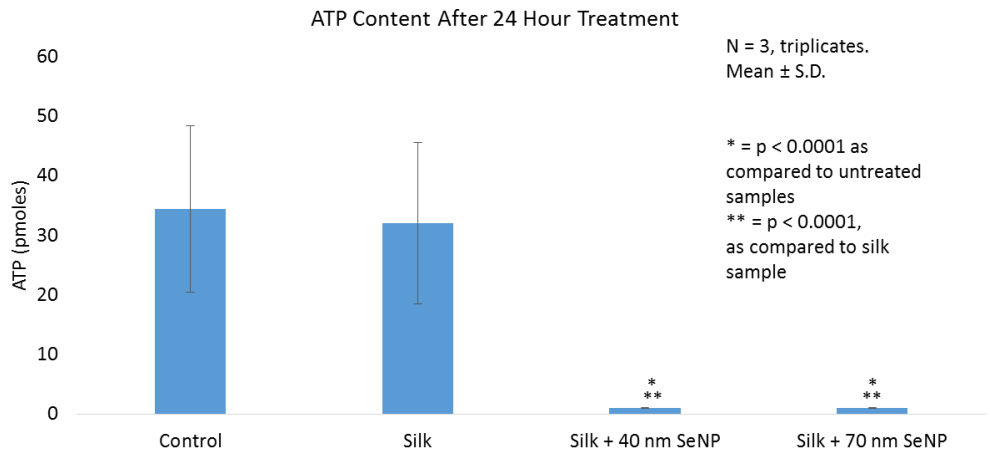

Figure *1*: Luciferase assay measuring ATP content of Staphylococcus epidermidis after 24 hours of inoculation. Bacteria grown on silk samples displayed similar ATP content as bacteria grown on the untreated control sample; bacteria treated with both the 40 nm and 70 nm sized selenium nanoparticles had a 97% reduction in ATP content as compared to the silk sample.[5]
), using a luciferase assay to detect adenosine triphosphate (ATP), the unit of biochemical energy. Cellular morphology was characterized by scanning electron microscopy as well as by confocal microscopy.

Results and Discussion

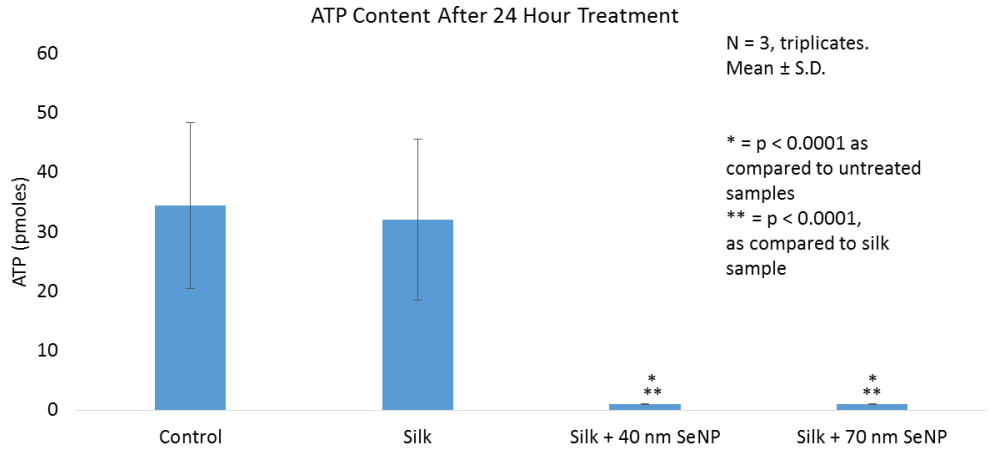

Figure 1: Luciferase assay measuring ATP content of *Staphylococcus epidermidis* after 24 hours of inoculation. Bacteria grown

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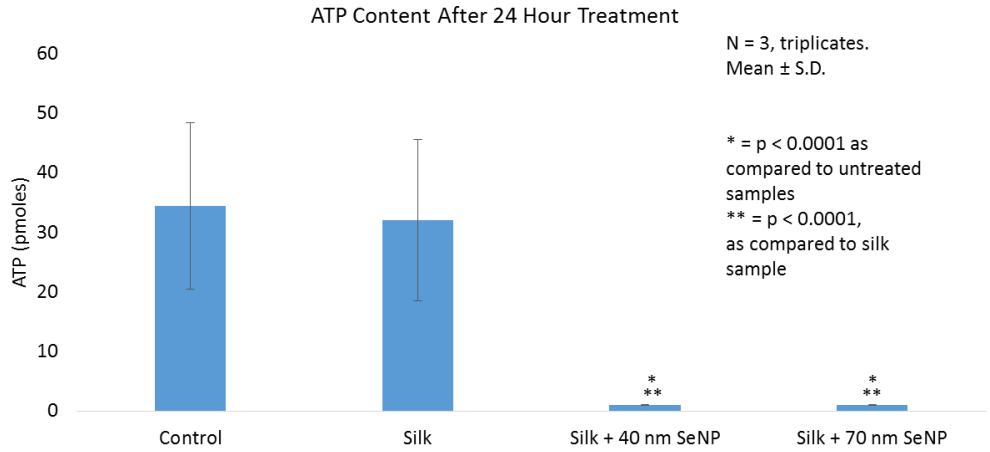

Figure *1* shows the ATP content of a *Staphylococcus epidermidis* strain derived from a catheter outbreak after 24 hours of inoculation on an untreated tissue culture surface (control), silk samples without selenium nanoparticles, silk samples with 40 nm diameter nanoparticles, and silk samples with 70 nm selenium nanoparticles. The bacterial ATP content on the selenium-treated samples were statistically reduced (97% reduction) as compared to that of the untreated samples. In addition, the addition of selenium reduced the ATP content of the *Staphylococcus aureus* species while enhancing the metabolic activity of human dermal fibroblasts. Microscopy images confirm an attainment of a reduction in bacterial load on the selenium-treated surfaces and show signs of disrupted bacterial membranes on selenium-treated samples. These studies show that selenium nanoparticles can selectively inhibit bacterial proliferation while maintaining good mammalian cellular activity and warrant further study as an antibacterial agent.

Acknowledgement

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