

Effect of Electron Radiation on Antibacterial Activity of Nano Based Fibers on *Escherichia coli* Culture Medium

¹M.R. SeyedMir, ²M.R. Nateghi, ³H.R Soltani G. and ⁴A. Mehdizadeh

¹Scientific Society of Nano Technology, Islamic Azad University,yazd Branch, Yazd, Iran

²Department of Chemistry, Islamic Azad University,yazd Branch, Yazd, Iran

³General Physician, Scientific Society of Medicine,
Islamic Azad University, Yazd Branch, Yazd, Iran

⁴Radiation Application Research School, Taft, Iran

Abstract: Introduction: While the antibacterial effects of nanosilver have been recognized, it has additional potential applications, such as in diagnostic imaging and for other therapeutic proposes. In this study, we exposed nanosilver fibers to different dosages of radiation to examine the effectiveness of antibacterial textiles on the growth of *Escherichia coli*. Materials and methods: This laboratory study examined ten flasks of *E. coli* culture medium that were radiated using a Rhodotron accelerator. The data were analyzed using a paired *t*-test with SPSS ver.18. Findings: The mean number of *E. coli* in the culture medium decreased significantly ($P=0.000$) after adding the nanosilver textiles (631 ± 38.34 vs. 951 ± 42.19). Significant differences were also observed in the number of *E. coli* after 5 kGy irradiation compared to after 15 ($P=0.048$), 20 ($P=0.025$) and 30 ($P=0.000$) kGy irradiation. Discussion: Nanosilver has many potential medical applications because of its antibacterial activity, such as for treating burns and in surgical dressings and tools.

Key words: Nanosilver • Irradiation • *E. coli*

INTRODUCTION

The antibacterial effects of nanosilver have been established, [1-3] but it has additional potential applications, for example, in diagnostic imaging as well as other therapeutic purposes [4,5]. During World War I, silver components were discovered to be the most effective for preventing and managing wound infections. The first scientifically documented medical use of silver was when Crede introduced 1% silver nitrate eye solution to prevent gonococcal infection [6]. Silver ions have been used in antimicrobial agents [7,8] antimicrobial polyester fabrics [9], and antimicrobial silk fibers and many similar products have been produced using nanoparticles [10]. A nanoparticle is sometimes defined as a particle in which at least one dimension is less than 100 nm, [11,12] and nanosilver consists of silver nanoparticles. Nano-components, especially nanosilver, are frequently used in the textile industry as antibacterial fibers. Irradiation is also useful for sterilizing nanofibers, particularly in textiles used for dressing burns. In this study, we exposed

nanosilver fibers to different dosages of radiation to develop antibacterial textiles that are more effective against *Escherichia coli*.

MATERIALS AND METHODS

Study Design: This study examined ten separate flasks *E. coli* culture medium. After adequate growth, the microbes were counted and the count was repeated after exposing the *E. coli* to a nanosilver-based textile and different irradiation dosages. The growth of other microorganisms in the culture medium and deterioration of the cultures were our exclusion criteria. The data were analyzed using a paired *t*-test with SPSS ver.18 (SPSS Inc. Chicago, IL, USA).

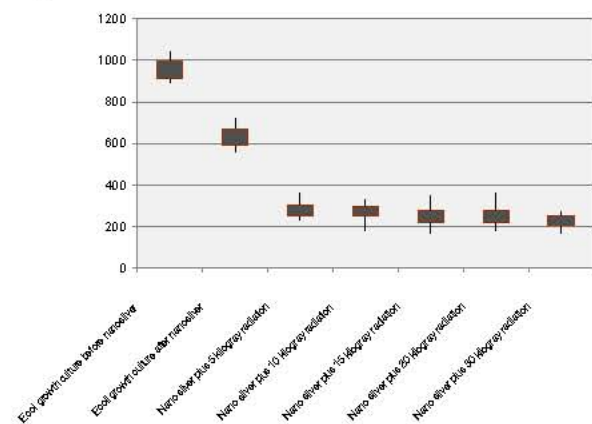
Microorganism Culture Medium: First, 10 mL of a suspension of *E. coli* at an initial dilution of approximately 10^5 cfu/mL was added to ten Erlenmeyer flasks with 70 mL of sterile phosphate-buffered saline (PBS) formalin in each flask. Then, 0.75 g of nanofibers was added to each flask.

Table 1: The microbe counts with different interventions for similar cultures (mean \pm standard deviation)

Samples	Mean	SD
E-coli culture medium before Nano silver	951.0000	42.19507
E-coli culture medium after Nano silver	631.0000	38.34719
Nano silver plus 5 kGy irradiation	277.0000	23.59378
Nano silver plus 10 kGy irradiation	273.0000	22.13594
Nano silver plus 15 kGy irradiation	250.0000	28.63541
Nano silver plus 20 kGy irradiation	247.0000	29.45807
Nano silver plus 30 kGy irradiation	228.0000	22.99758



Fig. 1: The Rhodotron accelerator



Curve No1: Microbe counting during different intervention in similar cultures

The flasks were kept on shaker for 1 h at 300 rpm and then incubated for 24 h. The microorganisms were counted before shaking and after the 24-h incubation. The DSC examination was done according to the 3895-98 standard method with a DSC-50 device (Shimadzu, Kyoto, Japan). The cultures were radiated using a Rhodotron accelerator, which speeds up electrons in a strong electrical field and guides them to the target through a vibrator magnetic field (Fig. 1).

Findings: The mean number of *E. coli* in the culture medium decreased significantly ($P=0.000$) from 951 ± 42.19 to 631 ± 38.34 after adding the nanosilver textiles (Table 1). After adding nanosilver to ten new *E. coli* cultures,

they were exposed to electron radiation at 5 kGy. Again, the mean number of *E. coli* decreased significantly ($P=0.000$) from 631 ± 38.34 to 277 ± 23.59 . Subsequently, radiation dosages of 10, 15, 20 and 30 kGy were examined. The 10 kGy irradiation decreased the number of *E. coli* to 273 ± 22.13 , but the difference was not significant ($P=0.758$). The 15 kGy irradiation significantly ($P=0.023$) reduced the *E. coli* count to 250 ± 22.13 . In contrast, although 20 and 30 kGy irradiation reduced the number of *E. coli* to 247 ± 29.45 and 228 ± 22.99 , respectively, the differences were not significant ($P=0.647$ and 0.152). However, a significant difference was observed in the number of *E. coli* after 5 kGy irradiation and number of *E. coli* after 15 ($P=0.048$), 20 ($P=0.025$) and 30 ($P=0.000$) kGy irradiation (Fig. 2).

DISCUSSION

Nanosilver, which is frequently used in medical research, has obvious antimicrobial activity against *E. coli* in textiles. The silver nanoparticles interact with both the sulfur-containing proteins present in bacterial cell membranes and with phosphorus-containing DNA [13-16]. The bacterial respiratory chain is disrupted by nanosilver particles. Silver has been incorporated into various natural and synthetic polymers, such as cellulose [17-19], polycaprolactone [20], chitosan [21,22], polystyrene, acrylic acid [23], and gelatin [24]. However, irradiation has considerable effects on these nanosilver-based fibers. Different irradiation dosages have remarkable effects on antimicrobial activity. For example, Chang *et al.* found that 1 mM silver nanoparticles and 10 kGy irradiation were the optimal conditions for producing modified silk fibers [25]. In our study, the antimicrobial activity of the nanosilver fibers did not increase with radiation dosage, probably due to the increasing damage to the surface of the nanosilver-based fibers with increasing irradiation dosages.

CONCLUSION

Nanosilver-based fibers have a strong effect on *E. coli* culture medium and different dosages of electron irradiation can amplify their antibacterial activity.

RECOMMENDATION

Nanosilver can be examined for different medical applications because of its antibacterial activity; better

treatment for burns and better surgical coverage and tools can be manufactured using nanosilver particles.

ACKNOWLEDGMENTS

This paper is the result of a research project titled "Effect of electron radiation on antibacterial activity of nanosilver-based cotton fabric." The authors thank the Islamic Azad University, Yazd Campus, for financial support for this project.

REFERENCES

- Elechiguerra, J.L., J.L. Burt, J.R. Morones, A. Camacho-Bragado, X. Gao, H.H. Lara, M.J. Yacaman, 2005. Interaction of silver nanoparticles with HIV-1. *J. Nanobiotechnol.*, 3: 6.
- Jose, R.M., L.E. Jose, C. Alejandra, H. Katherine, B.K. Juan, T.R. Jose and J.Y. Miguel, 2005. The bactericidal effect of silver nanoparticles. *Nanotechnol.*, 16: 2346-2353.
- Lok, C.N., C.M. Ho, R. Chen, Q.Y. He, W.Y. Yu, H. Sun, P.K. Tam, J.F. Chiu and C.M. Che, 2006. Proteomic analysis of the mode of antibacterial action of silver nanoparticles. *J. Proteome Res.*, 5: 916-924.
- West, J.L. and N.J. Halas, 2003. Engineered nanomaterials for biophotonics applications: improving sensing, imaging and therapeutics. *Annu. Rev. Biomed. Eng.*, 5: 285-292.
- Lee, K.S. and M.A. El-Sayed, 2006. Gold and silver nanoparticles in sensing and imaging: sensitivity of plasmon response to size, shape and metal composition. *J. Phys. Chem.*, 110: 19220-19225.
- Russell, A.D. and W.B. Hugo, 1994. Antimicrobial activity and action of silver. *Prog. Med. Chem.*, 31: 351-370.
- Cho, K.H., J.E. Park, T. Osaka and S.G. Park, 2005. *Electrochim. Acta.* 51: 956.
- Alt, V., T. Bechert, P. Steinrucke, M. Wagener, P. Seidel, E. Dingeldein, E. Domann and R. Schnettler, 2004. *Biomaterials*, 25: 4383.
- Lee, H.J., S.Y. Yeo and S.H. Jeong, 2003. *J. Mater. Sci.*, 38: 2199.
- Peters, K., R.E. Unger, C.J. Kirkpatrick, A.M. Gatti and E. Monari, 2004. Effects of nano-scaled particles on endothelial cell function in vitro: studies on viability, proliferation and inflammation. *J. Mater. Sci. Mater. Med.*, 15: 321-325.
- Warheit, D.B., P.J. Borm, C. Hennes and J. Lademann, 2007. Testing strategies to establish the safety of nanomaterials: conclusions of an ECETOC workshop. *Inhal. Toxicol.*, 19: 631-643.
- Ohbo, Y., H. Fukuzako, K. Takeuchi and M. Takigawa, 1996. Argyria and convulsive seizures caused by ingestion of silver in a patient with schizophrenia. *Psychiatry Clin. Neurosci.*, 50: 89-90.
- Feng, Q.L. J. Wu, G.Q. Chen, F.Z. Cui, T.N. Kim and J.O. Kim, 2000. A mechanistic study of the antibacterial effect of silver ions on *Escherichia coli* and *Staphylococcus aureus*. *J. Biomed. Mater.*, 52: 662-8.
- Sondi, I. and B. Salopek-Sondi, 2007. Silver nanoparticles as antimicrobial agent: a case study on *E. coli* as a model for Gram-negative bacteria. *J. Colloid Interface.* 275: 177-82.
- Morones, J.R., J.L. Elechiguerra, A. Camacho and J.T. Ramirez, 2005. The bactericidal effect of silver nanoparticles. *Nanotechnol.*, 16: 2346-53.
- Song, H.Y., K.K. Ko, L.H. Oh and B.T. Lee, 2006. Fabrication of silver nanoparticles and their antimicrobial mechanisms. *Eur. Cells Mater.*, 11: 58.
- Hu, W., C. Chen, X. Li, S. Shi, W. Shen, Z. Zhang, 2009. *et al.* In situ synthesis of silver chloride nanoparticles into bacterial cellulose membranes. *Mater. Sci. Eng. C.*, 28: 1216-9.
- Maneerung, T., S. Tokura and R. Rujiravanit, 2008. Impregnation of silver nanoparticles into bacterial cellulose for antimicrobial wound dressing. *Carbohydr. Polym.*, 72: 43-51.
- Barud, H.S., C. Barrios, T. Regiani, R.F.C. Marques, M. Verelst, J. Dexpert-Ghys, 2008. *et al.* Self-supported silver nanoparticles containing bacterial cellulose membranes. *Mater. Sci. Eng. C.*, 28: 515-8.
- Jeon, H.J., S. Kim and T.G. Kim, 2008. Preparation of poly(-caprolactone)- based polyurethane nanofibers containing silver nanoparticles. *Appl. Surf. Sci.*, 254: 5886-90.
- Ong, S.Y., J. Wu, M.M. Shabbir, T. Mui-Hong, L.U. Jia, 2008. Development of a chitosan-based wound dressing with improved hemostatic and antimicrobial properties. *Biomaterials*. 29: 4323-32.
- Lu, S., W. Gao and H.Y. Gu, 2008. Construction, application and biosafety of silver nanocrystalline chitosan wound dressing. *Burns*. 34: 623-8.

23. Paula, M.M., C. Vitorio Franco, 2009. *et al.* Synthesis, characterization and antibacterial activity studies of poly- $\{\text{styrene-acrylic acid}\}$ with silver nanoparticles. *Mater. Sci. Eng. C.*, 29: 647-50.
24. Rujitanaroj, P., N. Pimpha and P. Supaphol, 2008. Wound-dressing materials with antibacterial activity from electrospun gelatin fiber mats containing silver nanoparticles. *Polymer*. 49: 4723-32.
25. Chang, S.H., B. Kang, Y. Dai and D. Chen, 2009. Synthesis of Antimicrobial Silver Nanoparticles on Silk Fibers Via gamma-Radiation. *J. Applied Polymer Sci.*, 112: 2511-15.