The Good Zombies: Silver Nanoparticles and Laser Light Scattering

By Dana Castro, Applications Specialist

Laser light scattering has been used to characterize nanoparticles for over 50 years. This makes it the perfect technology to characterize silver nanoparticles. Silver has a long history of usage as an antibacterial agent and has even recently shown promise in the treatment of cancer. Studies of its behavior and capabilities are important now more than ever with growing antibiotic resistance, disease, and presence in consumer products. Brookhaven's instrumentation and expertise combined with these remarkable nanoparticles will further scientific discovery that has already begun.

Background

Silver has been used since the ancient Greeks and Romans for its antibacterial properties. They used it to purify their food and water.[1,2] Other populations would store liquids, such as wine and vinegar, in silver vessels to prolong their purity. Notable medical uses have been traced back to 69 BCE; today, they are in materials such as wound dressings and blood purifiers.[3]

Over the last two decades, scientists have been trying to determine the root of silver's antibacterial properties and discover what else it is capable of. One recent study has attributed part of its antibacterial mechanism to the "Zombies Effect." As a bacterium absorbs silver ions, its cells die. What remains is a non-functional bacterium that has a pool of silver inside. This silver then leaches out and can continue to "zombify" other bacteria.[4]

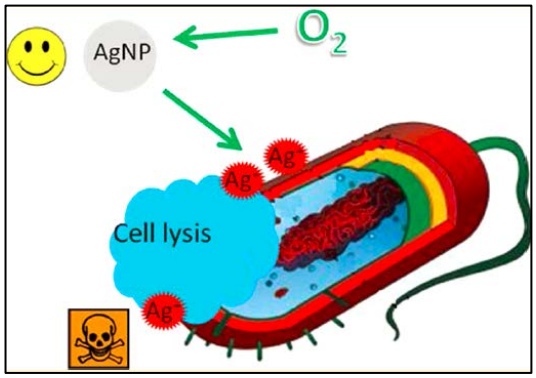

Figure 1: Illustration of bacterial death due to silver ions[5]

[1] *Illumin* **2011**, *XIII*(III)
[2] *Nat. Rev.* **2013,** *11*, 371-384
[3] *Surgical Infections* **2009**, *10*(3), 289-292
[4] *Sci. Rep.* **2015**, *5*, 9555
[5] *Nano Lett.* **2012**, *12*, 4271−4275

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As our understanding of these particles' behavior develops from studies like these, more and more research is being done to determine optimal properties that will perfect their use in a range of industries.

Introduction

Silver nanoparticles are increasingly being used in consumer products as well as medical products.[6] For consumers, items infused with silver nanoparticles such as clothing, towels, food containers, and more are available to minimize body odor, bacterial growth, and how often some items need to be washed.

ANTIMICROBIAL BATH TOWEL - SILVER INFUSED

SilverAir Ankle Sock

Figure 2: Examples of silver-infused products available to consumers[7,8]

In medicine, surgical instruments, bandages, and treatments contain or are coated with silver for the same reasons.[9] One of the most important reasons silver is making a comeback in medicine is because of the increasing rate of antibiotic resistance. These nanoparticles could provide a solution to this growing epidemic.[10]

Among other factors, the size and charge of these nanoparticles affect their efficacy and stability. Brookhaven Instruments pioneered some of the first laser light scattering technology and has long been characterizing nanoparticles for many industries. As such, researchers at Palacky University

[6] *Nano Lett.* **2012**, *12*, 4271−4275
[7] DormCo.com
[8] TheGrommet.com
[9] *ACS Nano* **2010**, *4*(11), 6903-6913
[10] *J. Phys. Chem. B* **2006,** *110*, 16248-16253

in Czech Republic and the Indian Institute of Technology in India studied these nanoparticles using Brookhaven Laser Light Scattering instrumentation to further our understanding of these widely versatile nanoparticles.

Study 1

Palacky University[11]

The researchers synthesized a wide range of silver nanoparticles by reducing complex cation $[Ag(NH_3)_2]^+$ with four different saccharides in the presence of ammonia. They tested four narrow size distributions for antibacterial activity: 44 nm, 50 nm, 25 nm, and 35 nm. The nanoparticles were characterized using a Brookhaven Instruments ZetaPlus analyzer, which performed Dynamic Light Scattering (DLS) measurements to determine particle size and polydispersity. The use of DLS allowed these researchers to confirm that their synthetic processes produced the target particle sizes and distributions. It also allowed them to see the relationship of size and polydispersity with changing ammonia concentrations, as seen in **Figures 3 & 4**.

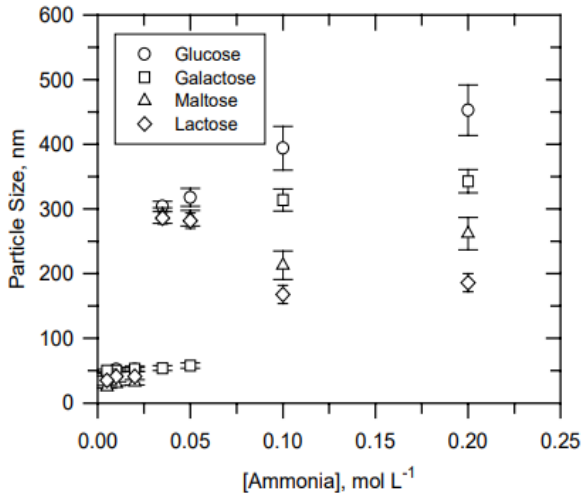

Figure 3: Particle Size vs. Ammonia concentration

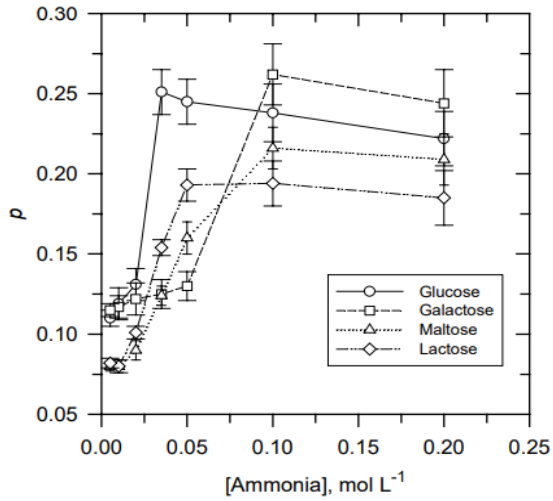

Figure 4: Polydispersity vs. Ammonia concentration

With this information, their study moved forward to demonstrate that 25 nm sized silver nanoparticles had the highest antibacterial activity while 50 nm sized silver nanoparticles had the lowest. DLS played a crucial role in this study.

[11] *J. Phys. Chem. B* **2006,** *110*, 16248-16253

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Study 2

Indian Institute of Technology[12]

The researchers synthesized two populations of silver and copper nanoparticles: 3 nm and 9 nm. Their goal was to study the antimicrobial properties of both of these nanoparticles. To confirm the size distribution of their synthesized nanoparticles, they were measured via DLS on a Brookhaven Instruments BI-200SM goniometer. The BI-200SM is a high-resolution light scattering instrument that can measure particle size, molecular weight, and more. Its ability to measure at any angle between 8° and 155° down to a tenth of a degree, its fully customizable correlator, and the option to use many different laser wavelengths makes it the perfect technology to study nanoparticles such as these. The size data collected by DLS played a crucial role in furthering the study to conclude that different strains of bacteria were more or less susceptible to nanoparticle intervention. This could lead to future study and allow these particles to be commercialized for use as antimicrobial agents.

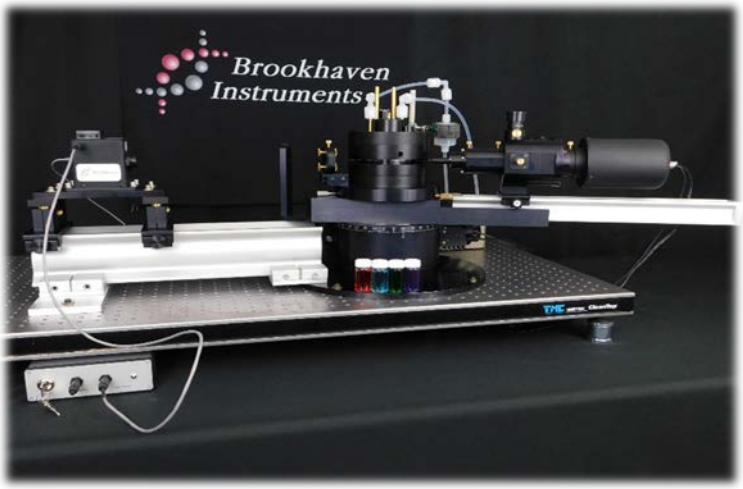

Figure 5: The Brookhaven Instruments BI-200SM goniometer

[12] *Acta Biomaterialia* **2008**, *4*(3), 707-716

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Study 3

Indian Institute of Technology[13]

The researchers synthesized a broad range of narrowly distributed silver nanoparticles in order to study the effect of size on antibacterial efficacy and develop an improved method of synthesis. Throughout the study, the researchers used a Brookhaven ZetaPALS zeta potential analyzer to monitor the stability of their synthesized suspensions. It was found that over the course of 6 months, there was no significant change in the zeta potential values. This supported that their synthetic process yields stable silver nanoparticle suspensions. This is especially important considering silver nanoparticles are known to aggregate very easily. With the ability to qualify their suspension stability, the researchers were able to continue experimentation that confirmed the antibacterial activity of the nanoparticles was dependent on size and dosage. This study could lead to these nanoparticles regularly being used as a nano-coating on surgical instruments, wound dressings, and more.

Conclusion

With a growing consumer convenience market and growing antibiotic resistance, the search for sustainable, affordable, and effective antibacterial solutions is on the rise. Silver nanoparticles offer great potential for both of these industries. This is encouraging researchers to study these nanoparticles and to seek unique technologies for their experiments. Laser light scattering offers a wide range of characterization information, from size, charge, stability, and more. This technology can broaden our understanding of these nanoparticles and help support new applications of their unique properties.

Acknowledgements

Thank you to our loyal researchers for allowing Brookhaven Instruments to play a role in your important discoveries that are changing the world. For more information about our instrumentation, please visit www.brookhaveninstruments.com.

[13] *RSC Adv.* **2014**, *4*, 3974

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