

# Silver Nano Dots Functionalized Bone Cement for Orthopaedic Medical Applications

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## ABSTRACT

The latest development in orthopaedics is the advent of silver nano particles and their applications in nano medicine. Silver nano dots in the size range of  $\leq 20$  nm can be studied to analyze their usage in the field of orthopaedics. They can be used in bone cement which are used as artificial bone replacement. Bone cements have been used very successfully to anchor artificial joints like hip joints, knee joints, shoulder and elbow joints in suffering patients in the field of orthopaedic medicine. Polymethyl methacrylate loaded with nanosilver is being considered as bone cement as the nano silver can induce very high antimicrobial activity essential for the killing of infectious microorganisms known for their anti-resistance to currently available antibiotics and antiseptics. The free space between the bone and the prosthesis is filled with bone cement which acts like an elastic buffer zone. This is necessary because the body weight and the bone cement must absorb the forces acting on the body to ensure that the artificial medical implant remains in place over the long term. In this study, we analyze silver nano dots encapsulated bone cement for medical purposes which can prevent surgical infection in replacement surgeries drastically than the methods currently in use. Also in this study it was found due to their unique properties they can accelerate the wound healing process at a faster rate than the rest of the conventional methods practiced in the orthopaedics field.

**Keywords:** Silver nano dot; Bone cement; Artificial joints; Orthopaedic applications; Nano medicine

## INTRODUCTION

In this study bone cement was used as a grouting agent between the prosthesis and the bone. It was found to be an efficient method to anchor prosthesis in orthopedic implants such as total hip replacement. Bone cement consists of two portions: [1] powder portion including pre-polymerized methylmethacrylate (PMMA) and initiator (benzoyl peroxide) and liquid portion including methylmethacrylate (MMA) monomer and promoter (N, N-dimethyl-p-toluidine) [2]. Bone cement chemically is also known as Plexiglas i.e. polymethyl methacrylate or PMMA. In this study, we analyze and study the effectiveness of silver nano dots encapsulated bone cement as a better grouting agent and orthopedic implant in medicinal applications and nano medicine related products. Silver nano dots encapsulated bone cements show immense compatibility with the body tissue before their use in surgery. It showed excellent tissue compatibility of PMMA and allowed to be used for anchorage of artificial prostheses.

## MATERIALS AND METHOD

### Chemical Reduction of Silver Nitrate

All the chemicals and reagents used in the present study were of analytical grade brought from Sigma Aldrich. In the present study, commonly available monosaccharide fructose was tested for its ability to synthesize silver nano dots of sizes less than  $<20$  nm employing the chemical reduction method and to determine any effect on surface Plasmon resonance (SPR) of the nano dots synthesized. In this unique process, a chemical solution was prepared by mixing 0.050 gms of fructose sugar in 50ml of de-ionized water taken in a conical flask. A minimal amount of 0.001 PVA was added to the above solution regularly and stirred by keeping the flask on magnetic stirrer at room temperature. Another solution of 0.00020 gms of silver nitrate was added to the above mixture drop by drop at regular intervals. This addition turned the solution to dark brown within half an hour. Thus the chemical reduction of silver nitrate has taken in rapid pace. The solution was stable for days together.

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Received: June 20, 2021; Accepted: July 14, 2021; Published: July 21, 2021

Citation: Patricia AGJ, Mahalingm MUD (2021) Silver Nano Dots Functionalized Bone Cement for Orthopaedic Medical Applications. J Nanomed Nanotech. 12: 569.

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Furthermore, the size and shape of the nano dots were dependent on the molar ratio of silver nitrate and fructose sugar. By controlling the experimental parameters, the geometry size and shapes of the silver nano dots can be tailored. Round shaped silver nano dots with controlled size and mono dispersity were synthesized at fast and rapid pace. In this method, particles with range 10nm ~20 nm were created in the lab.

### Encapsulation of Silver Nano Particles into the Orthopaedic Bone Cement

Silver nano dots were harvested by chemical reduction of silver nitrate using mono saccharide simple sugar fructose were stabilized with oleic acid were mixed with PMMA based bone cement powder to achieve 0.05 and 0.01% silver concentration in the cement. The mixture was subsequently inserted into mould at approximate dough time of one minute. The filled mould was pressed between two glass plates for one hour. Once the cement had hardened it was pushed out from the mould and stored under dark sterile conditions at room temperature. All assays were performed on cylindrical specimen 6 mm diameter and 12 mm in height prior to testing all bone cement specimens were conditioned at room temperature for one day [3-5].

The bone cement viscosity changes over time from a runny liquid into dough like state that can be safely applied and then finally hardens into solid hardened material [6-10]. The set time can be tailored to help the physician safely apply the bone cement into the bone bed to either anchor metal or plastic prosthetic device to bone or used alone in the spine to treat osteoporotic compression fractures. The polymerization heat reaches temperatures of around 82-86 °C in the body. This temperature is higher than the critical level for protein denaturation in the body. The cause of the low polymerization temperature in the body is the relatively thin cement coating, which should not exceed 5 mm, and the temperature dissipation via the large prosthesis surface and the flow of blood. From then onwards, cured bone cement can be classified as safe.

## RESULTS AND DISCUSSION

In this study it was found that the prosthesis fixed with bone cement offers very high primary stability combined with fast remobilization of patients. The cemented in prosthesis was fully loaded after the operation because the PMMA gets most of its strength within 24 hours. The necessary rehabilitation was comparatively simple for patients who have had a cemented-in prosthesis implanted. Bone cement was proven useful because specific active substances, like antibiotics, can be added to the powder component. The active substances are released locally after implant placement of the new joint, in the immediate vicinity of the new prosthesis and have been confirmed to reduce the danger of infection. The antibiotics act against bacteria precisely at the site where they are required in the open wound without subjecting the body in general to unnecessarily high antibiotic levels [9-10]. This makes bone cement a modern drug delivery system that delivers the required drugs directly to the surgical site. The main purpose was to reduce pain in suffering patients with the use of bone cement which was done with ease.

## CONCLUSIONS

From this study it can be concluded that bone cement can be considered a reliable anchorage material with its ease of use in clinical practice and particularly because of its long survival rate

with cemented-in prostheses. Also it was concluded from the study that the silver nano particles with additive poly methyl methacrylate (PMMA) has been used as a bone cement and they are very antibacterial in nature. Bone cement is the materials which are employed by orthopaedician for annexing prosthesis like hip and knee replacement surgery. It was found nano silver PMMA bone cement decreases the incidence of resistance, has low cyto toxicity and high antibacterial activity against *E.coli* bacteria and other bacterial colonies. Efforts to improve commonly used bone cements such as polymethyl methacrylate (PMMA) using silver nano dots and addition of antibiotics to bone cement is effective practice, however it is well known that antibiotics often persist for only a short period of time. We have found that the addition of nano structured additives to PMMA demonstrated increased osseointegration and osteoblast activity.

## ACKNOWLEDGEMENTS

Very thankful to Mr. J.Ramanan, Project Manager, Suntec Micro Systems, Chennai. For his funding this project and continuous support and encouragement throughout this project.

## CONFLICT OF INTEREST

The authors express there is no conflict of interest regarding this article.

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