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Bacteria: A Prospective Source of Metallic Nanoparticles

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Editorial

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The rapid expansion of nanotechnology opens up new opportunities in antimicrobial research. According to the reports, biogenic metal and metal oxide nanoparticles represent a group of materials which investigated in respect to their antimicrobial effects. The antimicrobial activity of metals such as silver (Ag), copper (Cu), gold (Au), titanium (Ti), platinum (pt) and zinc (Zn), each having various properties, potencies and spectra of activity, has been known and functional for centuries. The emergence of resistance of pathogens towards antibiotics has been caused serious health problems. From this background, the metal based nanoparticles with excellent antibacterial activity have been the most broadly explored and are presently being used in a number of commercial products. In this study, we focused on the recent research works on the topic of antimicrobial activity of metal and metal oxide nanoparticles collectively with their synthesis from bacteria. Bacteria are favorite for the study due to their abundance in the surroundings and their capability to become accustomed to extreme conditions, to reproduce fast, inexpensive to cultivate and easy to control. Growth conditions such as temperature, oxygenation and incubation time can be easily controlled.

During study changing the pH of the growth medium during incubation results in the production of nanoparticles of differing size and shape, He et al., reveals that [1] it is important to control such properties, because varying sizes of nanoparticles are necessary for diverse applications such as optics, catalysts or antimicrobials. Johnston et al., elaborates that pure gold nanoparticles can be manufactured by the bacterium *Delftia acidovorans* [2]. The delftibactin production was associated with the help of resistance mechanism of *D. acidovorans* to toxic gold ions. By producing inert gold nanoparticles bound to delftibactin, the gold did not pose any toxicity for exposed cells. The mechanism responsible for the formation of metallic nanoparticles and how it can vary in different bacteria first reported by The Johnston group. Alternative methods had also been suggested by another group for gold nanoparticle synthesis by bacteria. He et al., [1] experientially observed the extracellular formation of gold nanoparticles of 10-20 nm by the bacterium *Rhodopseudomonas capsulate*. These nanoparticles were synthesized via an NADH-Dependant Reductase suggested by the said group [1,3].

Palladium (Pd) is a metal that currently being primarily used as catalysts for dehalogenation and hydrogenation reactions, is member of the Platinum Group Metals (PGM) which posses a collection of highly catalytically active metals [4]. Palladium (Pd), zero valent nanoparticles can be synthesised by means of bacteria found at Alpine sites heavily contaminated with heavy metals [4]. Pseudomonas cells were involved in boosting catalytically active nanoparticles which were effectively used in reductive dehalogenation of tri and tetra-chlorinated dioxin congeners, among all the variety of heavy metal resistant bacteria, they have found in that environment, they found that [4]. *Escherichia coli,* is also able to synthesize Pd nanoparticles with the help of hydrogenases found in the bacterium [5]. In both studies, the Pd nanoparticles were establishing the cell envelope of the bacteria which makes them attractive because they are easily accessible. *Bacillus licheniformis* can produce intracellular AgNPs [6]. After addition of silver ions, the colour of the culture turned a dark brown represents the presence of AgNPs [6]. The nanoparticles were indeed made of Ag and also that they were quite dispersed in solution according to Kalimuthu and group.

Pugazhenthiran et al. observed that intracellular AgNPs were produced when members of the Bacillus sp. were sub-cultured into media containing AgNO. The reaction need incubation time for 7 days, hence it is slow [7]. Because of the lengthy production time, this is not suitable for industrial purposes. Kalimuthu et al., proposed that there was predominantly significant as it took

only 24 hours for *Bacillus licheniformis* to create AgNPs. However, Shaverdi et al., reported about the industrial bio-production of AgNPs with the greatest potential, by were centrifugation of the culture and the supernatant was tested for the ability to create metallic nanoparticles Instead of adding metal ions to a live culture [8]. Therefore Shaverdi et al., were successfully able to create AgNPs in 5 minutes, skipping the cell lysis step by the use of culture supernatant only. Due to increased production rate and simplification in purification, the extracellular type of formation is a more desirable [9]. Sintubin et al., focused on the manufacture of AgNPs by lactic acid bacteria. Only four bacterial species were found to synthesise AgNPs among many: Lactobacillus spp., *Pediococcus pentosaceus*, *Enterococcus faecium* and *Lactococcus garvieae* [10]. Production of AgNP was a two step procedure. Ag ions were accumulated at first then, the cell wall via biosorption and then subsequent reduction of those ions produced the metallic nanoparticles [10]. The cell wall may act as a capping agent in favor of the nanoparticles, which keeps them steady by preventing aggregation and showed that by growing the pH of the medium, where reduction rate of nanoparticles increased, stated by Sintubin et al., [10].

Though Ag and AuNPs are significant due to their antimicrobial abilities, a lot of studies have been done on other metals such as uranium (U). Significant amount of study has been shown on Bacillus species due to their metal bioaccumulation abilities [6,7,11]. *Bacillus sphaericus* JG-A12 posses the ability to accumulate higher concentrations of toxic metals such as Cu, Pb, Al, Cd and U stated by Pollmann and group; found that the S-layer proteins of the said bacterium are responsible for the bioremediation of uranium in aqueous environments. The S-layer is a porous layer, contains pore, made up of of identical proteins which surround the bacterial cell and can contribute up to 15% of the total cell protein content [11]. The S-layers are about 5-15 nm thick and the pore size ranges from 2-6 nm found by Sleytr et al., [12]. The layer is responsible for the binding of heavy metals, such as U at up to 20 mg of U per gram of protein, via the carboxyl and phosphate groups of the S-layer resulting in bioaccumulation, proposed by Pollman et al., [11]. As Cu is not stable at the nanometre scale and oxidises moderately and forms copper oxide (CuO), the synthesis of copper nanoparticles (CuNPs) has established to be a little complicated in the past, [13]. As a result, if Cu nanoparticles are to be used in an application after their synthesis, they need to be estabilised. It had been postulated that, the production of pure elemental Cu nanoparticles in a study, by biological means, using *Morganella morganii* was possible [14]. *M. morganii* synthesizes the intracellular Cu nanoparticles by uptake of the Cu ions and consequent binding of the ions to any metal ion reductase or similar protein, suggested by Ramanathan and group. A further study based on *Morganella sp*. showed extracellular synthesis of AgNPs [15]. Thus, biological systems have been investigated as a sustainable resource and despicable system of synthesis. Bacteria are relatively cheap to cultivate and have a high growth rate compared to other biological systems. However before any industrial relevance can be attributed to the synthesis of nanoparticles by bacteria many more examples must be identified and, the risks must be thoroughly assessed. Whatever the choice of biological chassis, the bacterium, need to be studied comprehensively in order to gain a clearer understanding of mechanism and to close the knowledge gap in biological nanoparticle synthesis methods by different organisms.

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