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Synthesis of silver nano powder using a simple chemical method

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Abstract - since ancient times silver has been closely associated with the civilization as it possess remarkable characteristics and finds innumerable application in my activities of human beings like medical, information technology, coatings, textiles and food packaging and handling.

As the 3-dimensional bulk materials is reduced to less than 100nm size in any one of the 3-dimensional, it exhibits extraordinary properties hitherto unknown in its cousin bulk. That is a reason why a lot of research is going on to study materials in the nano size form.

Therefore in this project is proposed to study silver metal in nano form. There are several techniques like physical, biological and chemical method to synthesis silver nano powder form. Here in this work we follow a simple method using chemicals like NaOH, $AgNO_3$, NH_4OH and L- ascorbic acid.

Processing variables with different concentrations and dopants in solutions will be studied and their morphological changes in powder will be observed using experimental tools like scanning electron microscope (SEM) and X- rays.

It is also envisaged to evolve anti-bacterial characteristics of this nano silver powder with different characteristics of the powder.

Key words: silver, nanotechnology, silver nano particles, chemical synthesis, centrifugation.

1. INTRODUCTION

Silver is one of the basic element that makes up our planet. It is a rare, but naturally occurring element, slightly harder than gold and very ductile and malleable. Pure silver has the highest electrical and thermal conductivity of all metals and has the lowest contact resistance. Silver can be present in four different oxidation states: Ag0, Ag2+, Ag3+. The former two are the most abundant ones, the latter are unstable in the aquatic environment.

Metallic silver itself is insoluble in water, but metallic salts such as AgNO3 and Silver chloride are soluble in water.

Metallic silver is used for the surgical prosthesis and splints, fungicides and coinage. Soluble silver compounds such as silver slats, have been used in treating mental illness, epilepsy, nicotine addition, gastroenteritis and infectious diseases including syphilis and gonorrhoea.

1.1 NANOTECHNOLOGY

Nanotechnology is an important field of modern research dealing with design, synthesis, and manipulation of particles structure ranging from approximately 1-100 nm in one dimension. Remarkable growth in this up-and-coming technology has opened novel fundamental and applied frontiers, including the synthesis of Nano scale materials and exploration or utilization of their exotic physicochemical and optoelectronic properties. Nanotechnology is rapidly gaining importance in a number of areas such as health care, cosmetics, food and feed, environmental health, mechanics, optics, biomedical sciences, chemical industries, electronics, space industries, drug-gene delivery, energy science, optoelectronics, catalysis, reprography, single electron transistors, light emitters, nonlinear optical devices, and photoelectron chemical applications. Nano materials are seen as solution to many technological and environmental challenges in the field of solar energy conversion, catalysis, medicine, and water treatment.

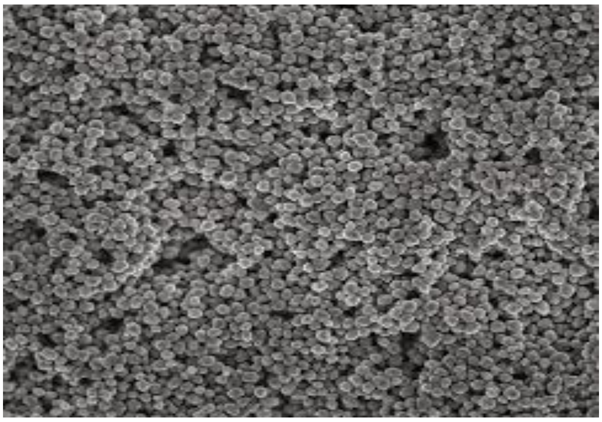
Nanotechnology is fundamentally changing the way in which materials are synthesized and devices are fabricated. Incorporation of nanoscale building blocks into functional assemblies and further into multifunctional devices can be achieved through a “bottom-up approach”. Research on the synthesis of nanosized material is of great interest because of their unique properties like optoelectronic, magnetic, and mechanical, which differs from bulk.

1.2 NANOPARTICLES

The term ‘nanoparticles’ is used to describe a particle with size in the range of 1nm-100nm, at least in one the three possible dimensions. In the size range, the physical, chemical and biological properties of the nanoparticles changes in fundamental ways.

2. SILVER NANOPARTICLES

Silver nanoparticles are of interest because of the unique properties (e.g., size and shape depending optical, electrical, and magnetic properties) which can be incorporated into antimicrobial applications, biosensor materials, composite fibers, cryogenic superconducting materials, cosmetic products, and electronic components.



Silver in this form shows different properties

A. Antibacterial
B. Antiviral
C. Anti fungal

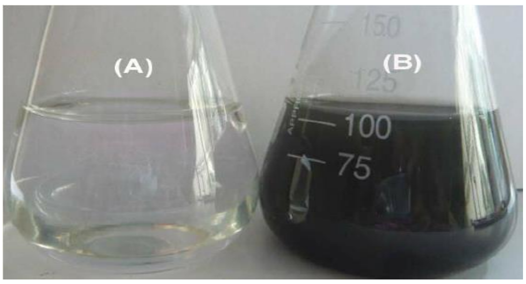
In each of the above examples, the silver nanoparticles prevent the organism's respiratory enzyme from working and so kills them in minutes

Special socks are now available that include silver nanoparticles. In order to heal conditions such as athletes foot. Research has shown that silver can also be used to treat many diseases from flu to HIV.

2.1.METHODS OF NANOPARTICLE SYNTHESIS

A. Physical approach.
B. Chemical approach.
C. Biological approach.

The most popular chemical approaches, including chemical reduction using a variety of organic and inorganic reducing agents, electrochemical techniques, physicochemical reduction, and radiolysis are widely used for the synthesis of silver nanoparticles.



Obtained silver nanoparticles after chemical approch

CHEMICAL SYNTHESIS

Chemical synthesis is a purposeful execution of chemical reactions to obtain a product, or several products. This happens by physical and chemical manipulations usually involving one or more reactions. In modern laboratory usage, this tends to imply that the process is reproducible, reliable, and established to work in multiple laboratories.

A chemical synthesis begins by selection of compounds that are known as reagents or reactants. Various reaction types can be applied to these to synthesize the product, or an intermediate product. This requires mixing the compounds in a reaction vessel such as a chemical reactor or a simple round-bottom flask. Many reactions require some form of work-up procedure before the final product is isolated.

The amount of product in a chemical synthesis is the reaction yield. Typically, chemical yields are expressed as a weight in grams (in a laboratory setting) or as a percentage of the total theoretical quantity of product that could be produced. A side reaction is an unwanted chemical reaction taking place that diminishes the yield of the desired product.

STRATEGIES

Many strategies exist in chemical synthesis that go beyond converting reactant A to reaction product B in a single step. In multistep synthesis, a chemical compound is synthesised though a series of individual chemical reactions, each with their own work-up. For example, a laboratory synthesis of paracetamol can consist of three individual synthetic steps. In cascade reactions multiple chemical transformations take place within a single reactant, in multi-component reactions up to 11 different reactants form a single reaction product and in a telescopic synthesis one reactant goes through multiple transformations without isolation of intermediates.

2.3 Applications of silver nanoparticles

Nanoparticles are of great interest due to their extremely small size and large surface due to volume ratio, which lead to both chemical and physical differences in their properties compared to bulk of the same chemical composition, such as mechanical, biological properties, catalytic activity thermal and electrical conductivity, optical absorption and melting point.

Application ranging from biosensing and catalysts to optics, antimicrobial activity , computer transistors, electrometers, chemical sensors, and wireless electronic logic and memory schemes. These particles have many applications in different fields such as medical imaging, nano composites, filters, drug delivery and hyperthermia of tumors.

a) Treatment of dermatitis; inhibition of HIV-1 replication

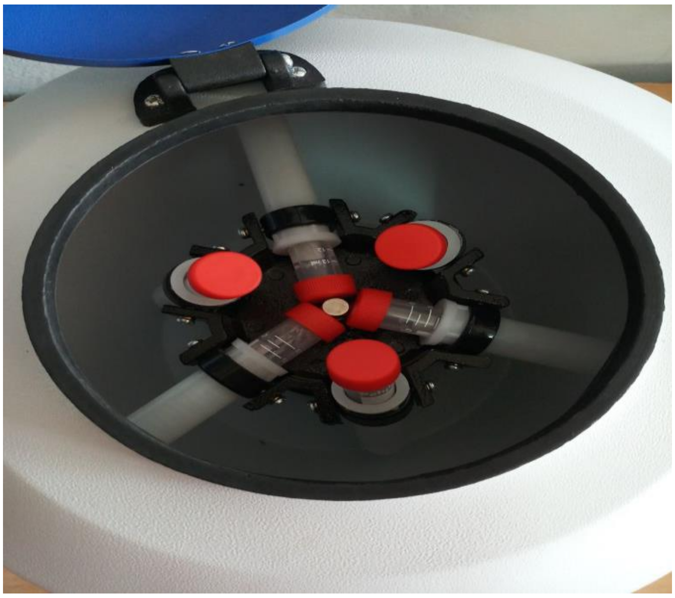
b) Treatment of ulcerative colitis & acne

c) Antimicrobial effects against infectious organisms

d) Remote laser light-induced opening of microcapsules
e) Silver/dendrimer nanocomposite for cell labelling
f) Molecular imaging of cancer cells
g) Enhanced Raman Scattering (SERS) spectroscopy
h) Detection of viral structures (SERS& Silver nanorods)
i) Coating of hospital textile (surgical gowns, face mask)
j) Additive in bone cement
k) Implantable material using clay-layers with starchstabilized Ag NPs
l) Orthopedic stocking
m) Hydrogel for wound dressing

Centrifugation

A centrifuge is a piece of equipment that puts an object in rotation around a fixed axis (spins it in a circle), applying a force perpendicular to the axis of spin (outward) that can be very strong. The centrifuge works using the sedimentation principle, where the centrifugal acceleration causes denser substances and particles to move outward in the radial direction. At the same time, objects that are less dense are displaced and move to the center. In a laboratory centrifuge that uses sample tubes, the radial acceleration causes denser particles to settle to the bottom of the tube, while low-density substances rise to the top.



centrifugation

There are three types of centrifuge designed for different applications. Industrial scale centrifuges are commonly used in manufacturing and waste processing to sediment suspended solids, or to separate immiscible liquids. An example is the cream separator found in dairies. Very high speed centrifuges and ultracentrifuges able to provide very high accelerations can separate fine particles down to the nano-scale, and molecules of different masses.

Large centrifuges are used to simulate high gravity or acceleration environments (for example, high-G training for test pilots). Medium-sized centrifuges are used in washing machines and at some swimming pools to wring water out of fabrics.

Gas centrifuges are used for isotope separation, such as to enrich nuclear fuel for fissile isotopes.

MATERIALS AND METHOD

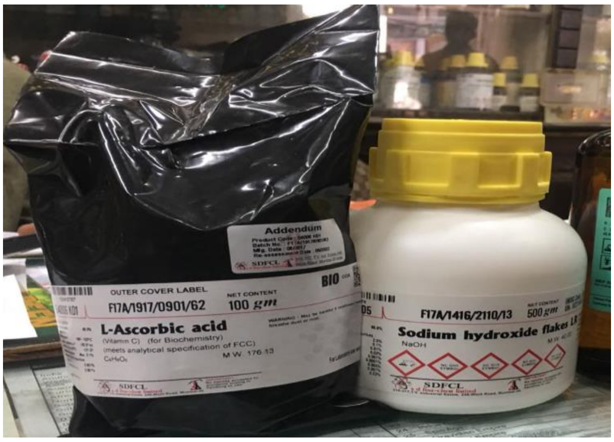
PREPARATION OF Ag nano particles

Sodium hydroxide (NAOH- 97%)

Silver nitrate ($AgNO_3$ - 99.9%)

Ammonium hydroxide solution (NH_4OH - 28-30%)

L- ascorbic acid ($C_6H_8O_6$ -99%).



All chemicals were used as received without further purification. Cleaning chemicals through re-ginning and lint-cleaning processes.

Take 0.03M $AgNO_3$ i.e, 5.1grms per 1liter of solution.

Molarity – no of moles of solute per litre of solution.

0.03M $AgNO_3$ =0.03moles of $AgNO_3$ /liter of solution.

Molar mass $AgNO_3$ =107.87+14.01+16.00 x 3

=169.88grms/mol.

Required Mass $AgNO_3$ =0.03 $AgNO_3$ x 169.88grms/mol

=5.1grms $AgNO_3$ per litre.

=0.51grms $AgNO_3$ per 100ml.

We have taken 0.51grms of $AgNO_3$ to prepare 100ml of solution.

Next we take $AgNO_3$ in one litre solution then we need to take 23% of NAOH i.e, 23grms of NAOH flakes to make 1litre of NAOH solution.

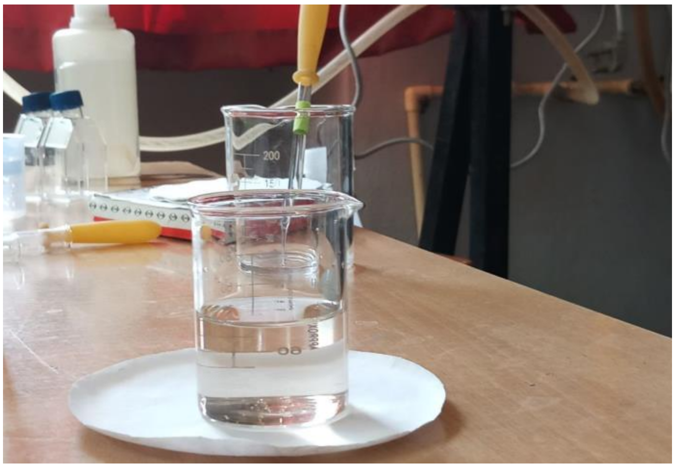
We take 100ml of $AgNO_3$ solution. We need to prepare the NAOH solution as per 100ml solution i.e, 2.3grms of NAOH flakes need to to be taken for solution.

To observe the reaction in the solutions. Choose to consider 15ml solution from both the solutions (i.e, $AgNO_3$ and NaOH)

From both solutions (i.e, $AgNO_3$ 100ml solution and NAOH 100ml). We need to take 15ml and mixed in a beaker. First pour $AgNO_3$ 15ml of solution and then of NAOH solution.

When 15ml of NAOH solution is poured in $AgNO_3$ solution. It turns yellowish brown.

Ammonium hydroxide solution was added drop-wise until the solution became clear.



Clear solution after adding ammonium hydroxide

The reduction reaction was then carried out by the addition of 0.01M L-ascorbic acid with a flow rate of 0.05ml/min for 30min.

The solution, which was subjected to vigorous agitation, turned yellow immediately and then black. The obtained solution is centrifugated and silver nanopowder will be collected at the bottom of the test tube as shown in the figure.

silver nanopowder in the test tube.

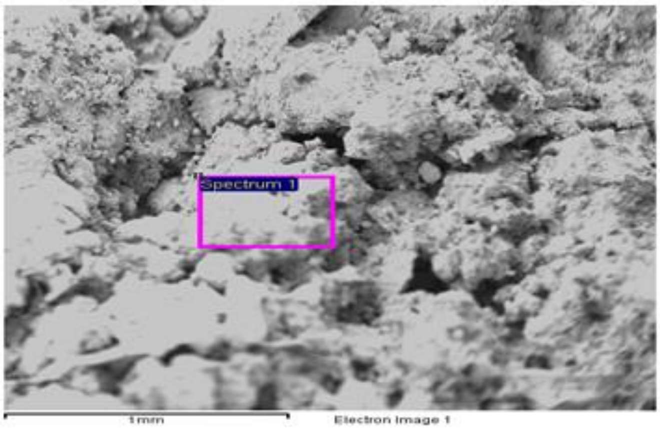
The precipitate of silver nanopowder collected is semiliquid state. Therefore heat treatment is done to extract nano particles.

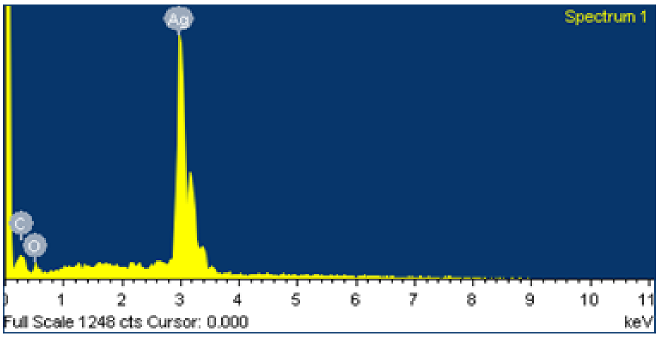
Heat treatment is essential because nanopowder collected in the form of semi liquid which contains water molecules. We can heat the silver nanopowder which is in the test tube using Bunsen burner or furnace. In furnace the temperature is need to be fixed. (i.e, 100°c)

After heating the aqueous silver nanopowder it converts from semi liquid state to solid state. The solid state powder is need to be collected as shown in the figure.

Collection of silver nanopowder after heat treatment.

Results





Spectrum processing:

Peak possibly omitted: 7.540 keV

Processing option: All elements analyzed (Normalised)

Number of iterations = 2

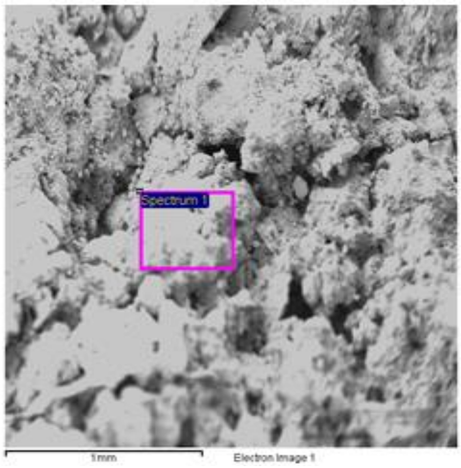
Standard:

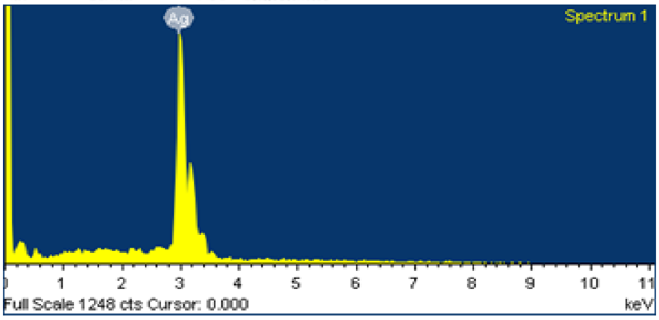
C CaCO3 1-Jun-1999 12:00 AM

O SiO2 1-Jun-1999 12:00 AM

Ag Ag 1-Jun-1999 12:00 AM

Element	Weight %	Atomic %
C K	1.34	9.25
O K	3.46	17.85
Ag L	95.20	72.90
Totals	100.00	





Spectrum processing :

Peak possibly omitted : 7.540 keV

Processing option : All elements analyzed (Normalised)

Number of iterations = 1

Standard :

Ag Ag 1-Jun-1999 12:00 AM

Element	Weight %	Atomic %
Ag L	100.00	100.00
Totals	100.00	

CONCLUSION

We have reported for the first time how inorganic nanoparticles interact with a hierarchically ordered natural polymer. While growing, the nanoparticles electrostatically bound the microfibrils to improve the structural organization. Notably, the concentration of nanoparticles exhibiting such influence on the macroscopic properties was less than 0.1% based on fiber weight. The large surface area of the nanoparticles resulting from the uniform dispersion is responsible for the maximized functionality observed.

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