NanoSilver™ Water Filter

Model: NSWF-2000

Specifications:

NANO SILVER WATER FILTER
Model: NSWF-2000
With Metal Housing + Lock + Nano Silver Coated Activated Carbon Filter + 5.0 Micron Water Filter Candle + Metal tap, spring loaded for auto shut off
Life: 2,000 liters (500 gallons)
Flow Rate: 2 to 3 liters/minute (for storage tank feeding the filter at height of 3 feet to 30 feet respectively above the filter).
H X W X D = 12" X 8.5" X 4" (30.5 cm X 21.5 cm X 10.0 cm)
Weight: 2.3 Kg (5.0 lbs)
Gross Weight when packed: 3.000 Kg (6.6 lbs)
Packing Box Dimensions: L X W X H - 14" X 10" X 7.5" (35.6 cm X 25.4 cm X 19.0 cm)

The use of safe, natural and eco-friendly nano silver over other harsher methods of disinfecting water, such as chlorination and other costly and other fragile and technically complicated methods like UV (ultraviolet) light which besides having delicate electronics, requires round the clock electricity and expensive replacement parts like UV Tubes + trained technicians to maintain them in working condition. This kind of sophisticated, expensive and delicate technology is not really suitable for remote areas with constant power outages, high voltage surges and use by Adivasi / aboriginals / indigenous people who have no experience in handling delicate electronic gadgets.

Again, silver is very eco-friendly and traces of it in their drinking water supply will also help to disinfect containers used by Adivasis / aboriginals / indigenous people to store their drinking water.

One of the hazards of de-chlorination of chlorinated water is that this de-chlorinated water now becomes a fertile ground / eco-friendly for bacteria to begin flourishing if the water is stored in non-disinfected containers or are contaminated by poor hygiene of the end users. This may be a common hazard encountered due to life style of Adivasi / aboriginals / indigenous people.

Traces of silver in the drinking water (within permissible limits) will help to strengthen the

immunity of the Adivasi / aboriginals / indigenous people, reduce their susceptibility to catching infections and help to fight against any existing infections in their body. Silver is also know to be effective in curtailing the spread of viral infections of all types including HIV. Please see attached test reports.

Silver has been used as a food item in India and large parts of Asia for thousands of years and its safety has been proven as a nutritional / dietary supplement. Please see attached article explaining the use of silver as a food item in India.

In addition, silver is approved by the Indian FDA as an Ayurvedic Medicine as it has formed a part of this ancient Indian medical science for thousands of years. So, leaving traces of silver in the drinking water is quite safe and healthy as well. Again, silver is also a part of the German Homeopathic medicine.

Again, our Nano Silver Filter does not require electricity for its operation and the need to repair is minimized as it is just a passive mechanical water filter with no moving parts that will get worn out and need periodic replacement.

All that needs to be replaced is the water filter candle and the nano silver coated activated carbon at the end of its useable life of 2,000 liters (500 gallons).

The nano silver coating on the activated carbon is superior to the older standard silver impregnation technology used to manufacture silver impregnated active carbon. Impregnation is done using silver nitrate basically to prevent bacterial buildup on the filter cartridge. This impregnation does not produce nano silver particle which are highly potent and effective for controlling the spread of infections of all types - bacterial, fungal and viral. In addition, water interacting with nano silver particles will help reduce the incidence of water borne bacterial, fungal and viral infections.

Our Nano Silver Water Filter also has an incorporated backwater feature which allows the removal of any accumulated sediments from turbid ground water.

SpaceAge®

Natural Health Center

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Innovators in Nano Biotechnologies!

METROPOLIS
CLINICAL LABORATORIES
Insist on us

REPORT ON : 12/10/2006

REPORT

COLLOIDAL SILVER SOLUTION EFFICACY TESTING

RESULT SUMMARY

Organism	Concentration of solution (Prepared as per manufacturer's Instruction) Using Mono Atomic Silver Generator of SpaceAge Natural Health Center.Div. of SpaceAge Concepts (i) Ltd. Mumbai.
E. coli	No growth at 50 ppm 20 mins
Ps.aeruginosa	No growth at 50 ppm 20 mins
Sal.typhi	No growth at 50 ppm 20 mins
Sal.para typhi A	No growth at 50 ppm 20 mins
Candida spp.	No growth at 50 ppm 20 mins
Strep. pyogenes	No growth at 50 ppm 20 mins
Streptococcus pneumoniae	No growth at 50 ppm 20 mins
Shigella spp.	No growth at 50 ppm 20 mins
Proteus spp.	No growth at 50 ppm 20 mins
Klebsiella pneumoniae	No growth at 100 ppm for 40 mins.
E. faecalis	No growth at 100 ppm+ pot.citrate (before & after preparation) for 40 mins. No growth at 100 ppm+ MSM (before & after preparation) for 40 mins.
Staph. aureus (MRSA)	No growth at 100 ppm for 40 mins.
Staph. aureus (MSSA)	No growth at 100 ppm+ pot.citrate (before & after preparation) for 40 mins. No growth at 100 ppm+ MSM (before & after preparation) for 40 mins.
Coag. negative Staphylococcus	No growth at 100 ppm+ pot.citrate (before & after preparation) for 40 mins. No growth at 100 ppm+ MSM (before & after preparation) for 40 mins.

Done by
Sushmita Jain (MSc. Microbiology)
Depty. Sec. Head of Microbiology

Checked by
Dr. Shamma Shetye (M.D. Microbiology)
HOD of microbiology

Approved by
Dr. Nilesh Shah
Senior Vice President

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72HRS COLLOIDAL SILVER TREATME

Reference:Dr.
Sample Collected At:
SPACE AGE
NATURAL HEALTH CENTER, P.O.BOX 7432
#9/123 MAROL CO-OP.INDUSTRIAL ESTATE
ANDHERI (E) MUMBAI 59 Zone OS

SID: 708007867
708007867
Collected On:
06/04/2007 03:46 PM
Registered On:
06/04/200703:46 pm
Reported On:
07/04/2007 1:30PM

REPORT

Age: 0.00 Years Sex: MALE

HIV 1 RNA Quantification (Viral Load)

Test:	Quantitative RNA estimation of HIV from patient's plasma.
Method:	Real time PCR (SDS)
Probe used:	30 base pair long dual labelled oligonucleotide TaqMan probe.
Equipment:	Rotorgene from Corbett Research, Australia.
Subtypes detected:	All common HIV 1 subtypes.
Sensitivity:	53 IU/ml.
Conversion:	1 IU/ml = 1 Copy/ml
Measuring range:	53 to 35,71,428 IU/ml.
Remarks:	1. Viral load test is meant for known HIV positive patients only and it can not be used for diagnosing patient's HIV status. 2. This test can not be used for HIV-2 patients. 3. It is not advisable to compare viral loads performed by two different techniques.

Notes Added:

COLLOIDAL SILVER SOLUTION EFFICACY TESTING

100 ppm Silver Solution prepared as per manufacturer's instructions using Mono Atomic Silver Generator of SpaceAge Natural Health Centre Division of SpaceAge Concepts (India) Ltd., Mumbai and for STD Pioneer's Awareness Trust, Mumbai.

Strength of Silver Solution used: **100 ppm (freshly prepared)**

Incubation Temperature: **37 ^{0}C Incubator**

Treatment Time: **72 hours**

Viral Load before Silver treatment: **905,355 IU/ml**

Silver Solution treatment done using 10 ml of 100 ppm Silver Solution every 24 hours and terminated at the end of 72 hours.

Result:

HIV-1-RNA Quantification by Real time SDS **Below 53 IU/ml**

Dr.Vipul Patel

Accredited by CAP Certificate No. 7184943

METROPOLIS Health Services (India) Ltd.
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Misuse of ANTIBIOTICS

There is a growing concern about the rampant and unnecessary use of Drug Antibiotics for treatment of some non-life threatening ailments such as common colds and sore throat.

Antibiotics are also now in the environment, as farmers and livestock breeders have in discriminately begun using these for commercial gains. Antibiotic shots are routinely given to animals kept in unhygienic conditions as a preventive measure.

Antibiotic now, have therefore entered the Food Chain and are gradually damaging everybody's health.

Pramod Vora
Natural Health Counselor

Low Immunity is the prime reason why some people constantly catch colds/Sore Throat and other infections.

Rather than use drug antibiotics in such situations, it is always better to first explore the possibility to improve the body's own immunity.

One of the factors, governing low immunity, is pH (potential Hydrogen or number of Hydrogen Ions or Acidity) of the body. The Natural pH of a healthy body, free of any disease, is always slightly Alkaline at a pH of 7.4.

When the body becomes acidic at the cellular level, it creates a breeding ground for germs, bacteria, and other micro-organisms. These can only flourish and multiply in an acidic environment. If the fluids of the body (blood, saliva, etc), are maintained alkaline, it will be well nigh impossible for these organisms to multiply or even survive.

Standard **pH Test Kits** are available to determine the pH of the fluids in the body by simply testing the pH of the saliva. There exists a very good co-relation between the pH of the saliva and other body fluids, like the blood for instance. There are **Dietary Supplements** available which helps to rapidly adjust the pH of the body and maintain it at an alkaline level.

It is noteworthy, to remember that, cancer cells do not easily multiply in an alkaline environment. Controlling and regulating body pH is one of the safest non-invasive techniques of reducing the risk of cancer or controlling or curbing or slowing down cancer cell proliferation in the Body.

Another technique to improve the immunity of the Body, is to use a **Natural Antibiotic** like **Mono Atomic Silver**. When administered orally, it can boost the Immunity of the Body. ***Mono Atomic Silver has been tested in UCLA School of Medicine, California against 650 known pathogens, microorganisms, bacteria, fungi (including Candida Albicans and Candida Globata), protozoa and viruses.*** In comparison, Drug Antibiotics are perhaps effective only against half a dozen organisms. Mono Atomic Silver has also been used to improve immunity of AIDs patients. It has no side effects as it is Biocompatible with the hu-

man body. It also has strong **Antiviral** properties. A portable pocket sized instrument for domestic use can, within seconds, produce a glass of Mono Atomic Silver. It is a low cost natural Antibiotic that is very ideally suited for treatment of the masses of a low cost economy like India which live below poverty level.

Remember, a healthy body always has higher immunity. ***Eating nutritionally and pH balanced meals*** can also go a long way to help raise and maintain the Body's immunity.

Use of **Herbal Dietary Supplements** and **Bio-Magnetic Devices** to enhance the functioning of the thymus gland can also increase the production of T-cells and improve the Body's Natural Defense Mechanism. Info at: **http://www.space-age.com/thymus.html**

Improving immunity, to prevent infections, is a safer and naturally a more harmonious way of maintaining the human body in balance. Trying to remove an infection once it has invaded the body, by trying to "kill germs" with Antibiotics can only create an imbalance in the body and weaken it further. Drug Antibiotics being **"Dumb Chemicals"**, kill everything in sight - friends and foes. They destroy the infection causing germs as well as the healthy bacteria required for digestion which work as **Probiotics** in the human body. This ends up lowering the immunity, forcing the body into a perpetual and vicious cycle of repetitive infections coupled with still lower immunity at the end of each cycle. (Fig. 1 & Fig. 2)

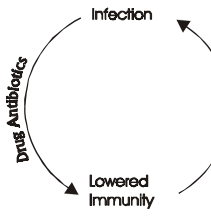

Fig. 1
Vicious Cycle of Lowered Immunity from Use of Drug Antibiotics

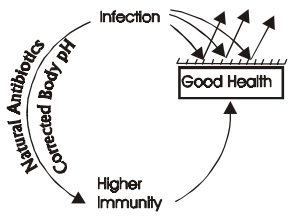

Fig.2
Vicious Cycle Broken by the Use of Natural Antibiotics and Corrected Body pH

The body weakens further with each cycle and the germs develop further resistance and immunity with each onslaught of Antibiotics. Remember, the germs also have intelligence and they will continue to evolve (develop resistance) to fight their destruction due to Bio-Chemical Warfare that you would like to conduct on the human body.

The stage is now set for diseases like Candida, Colon Cancer, etc to invade and permanently reside in the body, speedily taking it to its final destruction and premature death.

The number of Antibiotics capable of controlling infections, are diminishing rapidly, due to the indiscriminate and repetitive use of Antibiotics. The day is not far away, when the Pharmaceutical Industry may be unable to offer newer and more powerful Antibiotics. The strength of the Antibiotics now being used has grown to such an extent that their after effects linger on in the body for days after their use has been stopped. Replacing the friendly bacteria lost from the body is getting more difficult with each passing day. The present typical Therapeutic Dose of Lactobacillus Acidophilus is 1.0 Billion living organism to be taken twice a day for at least 10 to 15 days after completing the Antibiotic course. Such therapeutic doses are presently not available at the chemists; so correction of the damage done by Drug Antibiotics becomes an uphill task. The body then becomes unbalanced and depleted of its internally manufactured B-Complex Vitamins. Therapeutic doses of B-Complex, as per US Standards, not being readily available, sets the ground work for a host of chronic ailments to invade and begin destroying and rapidly aging the body.

- Please stop the unnecessary use of dangerous Antibiotics.
- Please reserve drug Antibiotics only for life threatening situations.
- Please protect the environment and your body by minimizing the use of these Drug Antibiotics

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Micron Size and ppm of Silver in Colloidal Solution

Please note micron in Metric system is micrometer = 1.0 µm = 1000 nanometers = 1000 nm

Most Silver Colloidal Solutions available in the market are 30 ppm and have particle of 100 to 200 nanometer diameter or 0.1 to 0.2 µm (micrometer in size).

When you say 30 ppm it means 30 parts per million or 30 mg of silver in 1000 mL = 1.0 liter = 1.0 L or 1.0 Kg of water.

Silver particles around 200 nanometer are able to kill microorganisms - bacteria and fungi which affect skin and hair.

For viral infections you need to go below 200 nanometer in size.

So colloidal silver is effective inside the body and the mg doses are small enough not to be of any toxic consequences.

We consume 4.0 mg to 8.0 mg of silver foil on one pan or a single piece of barfi as a food item in India without any toxic effect. We have done this for thousands of years.

However the dose in milligram of colloidal silver is too low to cause any toxicity in the human body. 30 ppm silver solution will have only 30.0 mg of silver if you drank a whole 1000 mL (1.0 Liter) at a time.

Typically for human consumption 3 ppm silver solution is fine. This means there is 0.75 mg in a 250 mL of silver solution. This dose is roughly 10% of the amount one consumes in a single piece of pan or barfi. This dose is good for oral use to fight gram positive and gram negative bacterial and fungal infections of all types.

200 nanometer silver particles can easily penetrate the pores of the skin which are typically 2 micron = 2 micrometer = 2 µm = 2000 nanometer in size and larger. Hair diameter is typically 50 to 200 µm in diameter. Red Blood Cells are 8 µm (micrometer) in diameter. So 200 nanometer (0.2 µm) silver particles can easily penetrate the skin and also be in a position to enter the cells in the body i.e. are effective for transdermal and intracellular penetration.

Typical dose required for topical applications either by way of gel or spray is 30 ppm. In case of very high bacterial load one can safely go up to 100 ppm.

Another important use of silver is to disinfect OR / OT in hospitals and areas where pharmaceutical and food preparations are being made to keep the bacterial count to very low levels. It is important to note that bacteria do not develop resistance to silver and are therefore very safe and effective in the long run as you are using a natural antibiotic which is a know nutrient for the human body.

PubMed

Abstract

Water Sci Technol. 2012;66(12):2772-8. doi: 10.2166/wst.2012.523.

Water treatment using activated carbon supporting silver and magnetite.

Valušová E[1], Vandžurová A, Pristaš P, Antalík M, Javorský P.

Author information

Abstract

Recent efforts in water purification have led to the development of novel materials whose unique properties can offer effective biocidal capabilities with greater ease of use and at lower cost. In this study, we introduce a novel procedure for the preparation of activated carbon (charcoal) composite in which magnetite and silver are incorporated (MCAG); we also describe the use of this material for the disinfection of surface water. The formation process of magnetic MCAG composite was studied using ultraviolet-visible spectroscopy. The results demonstrated the high sorption efficiency of $AgNO_3$ to magnetic activated carbon. The antimicrobial capabilities of the prepared MCAG were examined and the results clearly demonstrate their inhibitory effect on total river water bacteria and on Pseudomonas koreensis and Bacillus mycoides cultures isolated from river water. The bacterial counts in river water samples were reduced by five orders of magnitude following 30 min of treatment using 1 g l^{-1} of MCAG at room temperature. The removal of all bacteria from the surface water samples implies that the MCAG material would be a suitable disinfectant for such waters. In combination with its magnetic character, MCAG would be an excellent candidate for the simple ambulatory disinfection of surface water.

PMID: 23109597 [PubMed - indexed for MEDLINE]

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Highly efficient Ag/C catalyst prepared by electro-chemical deposition method in controlling microorganisms in water. J Mol Cat-A Chem

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Highly efficient Ag/C catalyst prepared by electro-chemical deposition method in controlling microorganisms in water

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Abstract

The present work highlights the high efficiency of silver nano-particles deposited over activated carbon, by electro-chemical deposition method, in controlling microorganisms in water. The anti-bacterial activity of the catalysts were determined qualitatively by testing the presence of coliforms in water after contacting with the catalyst, using a Readycult reagent. The catalytic characteristics of these materials are obtained by SEM (scanning electron microscopy), XRD (X-ray diffraction) and TPR (temperature programmed reduction). TPR results clearly indicate the presence of metallic silver in the dried catalyst prepared by electro-chemical deposition method and the presence of silver oxide and/or nitrate precursors in the catalysts prepared by impregnation method. SEM results indicate the presence of Ag particles in nanometer size. Comparison of the anti-bacterial activity of the Ag/C catalyst prepared by electro-chemical deposition method with that of the Ag/C catalyst prepared by conventional impregnation technique indicate that lower amount of former is sufficient in controlling the microorganism which is not the case with the latter. The main advantage of Ag/C catalyst prepared by electro-chemical deposition is that no pretreatment conditions like reduction are required for deactivation of microorganism in water, which is not the case with the catalysts prepared by impregnation technique.

Keywords: Ag nano-particles; Electro-chemical deposition; Microorganisms; Active carbon

1. Introduction

Water pollution is one of the main crisis faced by millions of people and majority of the water-borne diseases are spreading because of the poor quality of water, particularly due to the presence of bacteria and viruses in the water. There are several methods of water purification like chlorination, iodination, ozonation, UV-purification, reverse osmosis and using silver catalysts. Chemical purification like adding chlorine or iodine or applying ozone to kill the bacteria has several disadvantages, for example excess chlorination could lead to cancer. Other methods like UV-purification and reverse osmosis are not cost affective. Ever since silver has been recognized as an anti-bactericide, its application in purification of water is increasing. Heinig [1] developed a catalytic cartridge-containing layer of silver micro-crystals deposited on α-alumina and showed that lightly bound nascent oxygen on micro-crystals of silver readily oxidizes bacteria or viruses and completely disintegrates them. The anti-bacterial and antibiotic action of silver compounds are reported in the literature [2–4]. The catalytic oxidation by the metallic silver in the walls of the container as well as reaction with the dissolved monovalent silver ion probably contributes to the bactericidal effect of silver vessels [5]. Supported silver catalysts are reported to be effective in deactivating microorganism [6,7]. Antelman [8] in his research indicated that in an aqueous medium the peroxide Ag(III) works about 240 times as fast as Ag(I) and is upto 200 times more effective a disinfectant than Ag(I) compounds or metallic silver. Electrically

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driven silver ions are reported to overcome a critical problem in the treatment of serious bone infections [9] and severely burned hands and figures [10]. Further, silver is used in the silver–copper ion treatment in the sanitation of swimming pools with minimal or no chlorine usage [11].

Generation of silver nano-particles in water by silver ion generators is recently a popular technique. The present work aims in the generation of silver nano-particles on active carbon by electro-chemical deposition method where in these nano-particles are utilized in controlling the microorganisms in water. Also, the advantages of these catalysts over the Ag/C catalysts prepared by conventional impregnation technique have been emphasized in the study of the biological activity of these catalysts in controlling the microorganisms. Further, the differences in the activities of the two catalysts has been explained by the characteristic techniques used viz., XRD, SEM and TPR.

2. Experimental

2.1. Preparation of catalysts

2.1.1. Preparation of Ag/C catalyst by conventional impregnation method

Ag/C catalyst with silver loading of 2 wt.% was prepared by impregnating aqueous solution of requisite amount of silver nitrate on to dried and purified active carbon. The excess amount of water was then evaporated on a hot plate followed by drying in an oven at 110 °C for about 12 h. The dried sample thus obtained was calcined in air at 400 °C for 4 h followed by reduction in H_2 flow for a period of 2 h at 250 °C. The resultant catalyst has been designated as AgC-IMP. The active carbon (M/S. Norit, with surface area $\sim$1000 $m^2\,g^{-1}$) support used, has been purified by a sequential treatment with hot conc. HNO_3, hot distilled water, hot conc. NH_3 solution and hot distilled water for at least three times and was then dried in an oven at 110 °C prior to the impregnation of silver over it.

2.1.2. Preparation of Ag/C by electro-chemical deposition

The silver solution was firstly generated by passing low but constant dc voltage electricity (40 V) through the silver electrodes (0.4 mm thickness and 10 mm width and 100 mm long plates) immersed in distilled water. This solution was then used to test the presence of microorganism activity in the water samples. The Ag/C catalyst by electro-chemical deposition method designated as AgC-EC was prepared by taking requisite amount of purified active carbon in distilled water and silver particles were generated by the above method while maintaining a constant rapid stirring for a calculated amount of time so as to obtain a 2 wt.% of Ag in the finished catalyst. The excess water was then evaporated over a hot plate followed by drying in an oven at 110 °C for 12 h.

2.2. Characterization of catalysts

2.2.1. Scanning electron microscopy (SEM)

This technique has been used to find out the range of Ag particle sizes obtained when run time of passage of low voltage current passed through the silver electrodes immersed in water was varied. The aqueous samples containing silver particles were mounted on aluminium stubs coated with gold in Hitachi-5GB vacuum evaporator and micrographs were recorded on a Hitachi S-520 SEM instrument.

2.2.2. Powder X-ray diffraction

The XRD patterns of reduced sample of AgC-IMP and dried sample of AgC-EC were recorded on a Siemens D 5000 X-ray diffractometer using Ni filtered Cu Kα radiation.

2.2.3. Temperature programmed reduction (TPR)

TPR patterns of dried samples of AgC-IMP and AgC-EC were obtained using a home made on-line quartz microreactor interfaced to a thermal conductivity detector (TCD) which in turn is connected to a data station (comprising of a standard GC-software supplied by Hindetron, India) for recording the profiles. H_2/Ar (6 vol.% of H_2 and balance Ar) mixture was used as the reducing gas at a heating ramp of 5 K/min from 303 to 973 K and kept at the final temperature isothermally for 30 min. The experimental details of the TPR run are discussed elsewhere [12].

2.3. Activity test

Ready cult® Coliforms 50 supplied M/S. E. Merck; Germany was used for the detection of total coliforms in the water samples. The composition of this reagent is as follows.

2.3.1. Composition in g/blister

Tryptose-0.25, NaCl-0.25, sorbitol-0.05, tryptophan-0.05, di-potassium hydrogen phosphate-0.135, potassium dihydrogen phosphate-0.1, lauryl sulfate sodium salt-0.005, X-GAL-0.004, MUG-0.0025 and IPTG-0.005.

2.3.2. Principle

The high nutritional quality of the peptones and the incorporated phosphate buffer guarantee rapid growth of coliforms where as lauryl sulfate largely inhibits the accompanying flora, especially the gram positive. By adding the chromogenic substrate X-GAL, which is cleaved by coliforms and the fluorogenic substrate MUG that is highly specific for *E. coli*, the simultaneous detection of total coliforms and *E. coli* is possible. The presence of total coliforms is indicated by a blue-green color of the brath and *E. coli* by a blue fluorescence under UV-light.

2.3.3. Procedure

To a 50 ml of water (to be tested for coliforms) sample taken in a sterile, transparent 100 ml vessel with screw cap, the granules of Ready cult coliforms reagent was added by

Table 1
Effect of run time on the particle size of silver

S. no.	Voltage (V)	Run time (min)	Range of Ag particle size (nm)
1	40	5	50–100
2	40	10	100–120
3	40	20	250–1000
4	40	30	600–1500

breaking the snap pack. The vessel was sealed, shaken completely to dissolve the granules and incubated for 24 h at 310 K. Any color change of the brath to blue-green confirms the presence of coliforms. If the brath remains slightly yellow (no color change), it is an indication of absence of total coliforms. This is a blank test, i.e., without adding any Ag catalyst. The same procedure was adapted for testing the activity of the catalysts by adding required amount of the catalyst to the water sample and stirred well for ∼1 h, followed by filtration to remove the catalyst particles, before the ready cult was added to it.

3. Results and discussion

3.1. SEM results

The Ag nano-particles are generated electro-chemically by passing a dc current (40 V) through silver electrodes dipped in distilled water (50 ml). The effect of run time (duration of passage of the current) on the size of the particles generated is examined by carrying out SEM analysis of the Ag solutions thus obtained. Table 1 presents the Ag particle size obtained from SEM analysis at different run times. It can be seen that just a 5 min time is sufficient enough to generate the Ag particles in the nano-range in 50 ml water when a 40 V dc current is applied and beyond this time agglomeration of particles seem to take place producing Ag particles of bigger size. Fig. 1 represents the SEM micrograph of nano-size Ag particles in water generated by electro-chemical method after a run time of 5 min. The figure clearly shows the formation of nano-particles of Ag in the range of 50–200 nm.

During the electrolysis run, as the size of the particle (Ag) increases, the distance between the particles decreases which results in the increase in the current (mA) (initial current of 5 mA has been increased up to 8 mA). It is reported that the aqueous solution containing the silver particles (nano-range) by electro-chemical method to be in the range of 10–20 ppm of Ag [13]. For supporting Ag particles on activated carbon by this method, it is thus assumed that the concentration of Ag is ∼10 ppm. Based on this assumption, a 2 wt.% of Ag deposited on activated carbon (AgC-EC) has been prepared by suspending ∼5 g of carbon in the distilled water with vigorous stirring and maintaining 40 V dc current through the silver electrodes, for sufficient amount of time.

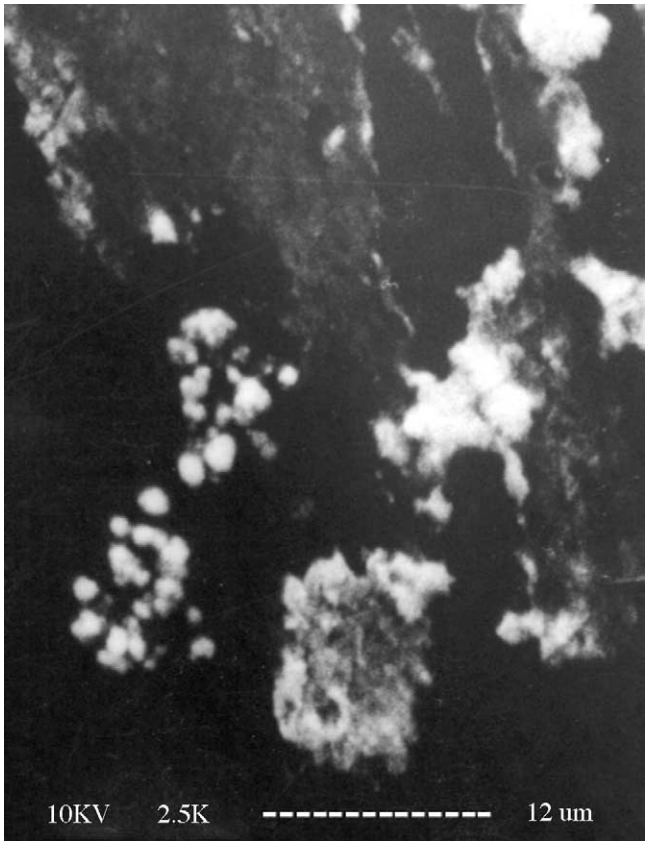

Fig. 1. Scanning electron micrograph of silver nano-particles in water generated by electro-chemical method.

3.2. X-ray diffraction

Fig. 2 depicts the XRD patterns of AgC catalysts, i.e., AgC-EC (dried) and AgC-IMP (reduced). The XRD pattern of impregnated Ag over active carbon is recorded for the

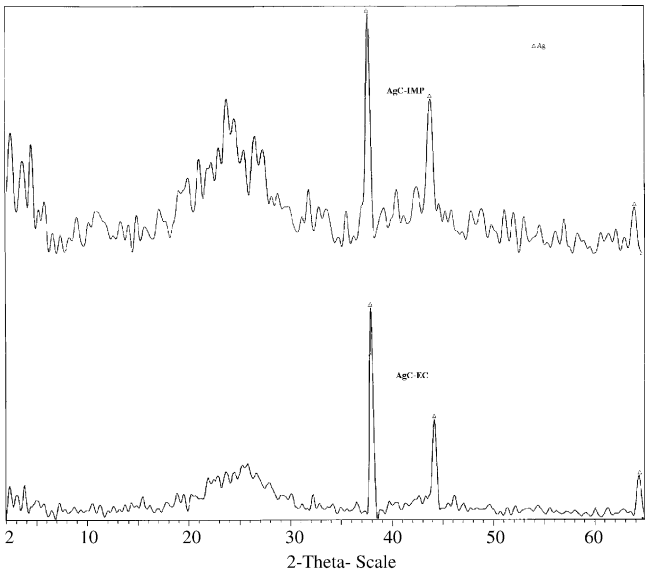

Fig. 2. X-ray diffraction patterns of AgC catalysts.

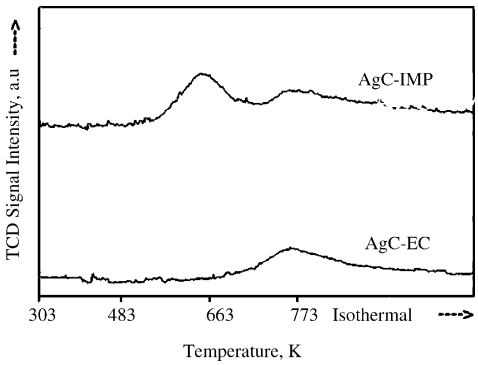

Fig. 3. Temperature programmed reduction profiles of AgC Catalysts.

reduced form of the catalysts where as the pattern of Ag/C catalyst prepared by electro-chemical deposition method is of the dried form. The two catalysts showed amorphous carbon phase and silver in metallic phase [Ag with d values 2.36_x, 2.04_4, 1.25_3 – ASTM card no. 4–783]. The pattern of AgC-EC clearly shows that the dried form of the catalyst itself is in metallic form and thus need not be reduced any more. On the other-hand, the impregnated catalyst has to be reduced in H_2 flow for at least 2 h at 250 °C to get the metallic phase of Ag.

3.3. TPR results

The TPR patterns of dried Ag catalysts viz., AgC-EC and AgC-IMP are presented in Fig. 3. The TPR pattern of AgC-EC catalyst exhibit only a single reduction peak centered at T_{max} of 740 K that which is also observed in TPR pattern of the other catalyst, AgC-IMP. This signal may be attributed to the gasification of the support, active carbon. It is reported to be due to the reaction of carbon with hydrogen resulting in the formation of methane confirmed by the coupled FID analysis technique [14] and is represented as follows:

$$C + H_2 \rightarrow CH_4$$

No other peaks corresponding to reduction of oxidic species of Ag are observed in the TPR pattern of AgC-EC catalyst. This clearly suggests that silver is already in the metallic form in this catalyst. It can be further confirmed from the TPR pattern of conventionally prepared AgC-IMP catalyst which showed a low temperature reduction peaks centered at T_{max} of ∼600 K. This reduction signal is originated due to the reduction of Ag precursors, possibly either the reduction of $AgNO_3$ precursor or the reduction of Ag_2O. It is reported by Gang et al. [15] in the H_2-TPR carried out on silver catalysts pretreated in oxygen below 100 °C after reduction at 500 °C for 2 h to have observed the existence of three peaks at 80, 140 and 460 °C. They attributed it due to molecularly adsorbed oxygen, to surface adsorbed atomic oxygen and the high temperature one assigned to the bulk-dissolved oxygen, which is the most difficult one to be reduced, respectively. Boccuzzi et al. [16] have shown in the TPR patterns of Ag/Ti fresh samples, that a broad and asymmetric peak at T_{max} = 383 K is ascribed to the reduction of oxygen species on finely dispersed silver and to the reduction of Ag_2O. Also, Paryjczak et al. [17] have ascribed a double peak at 370–500 K observed in the TPR study carried out by them over 4 wt.% Ag on γ-$Al_2O_3$to be due to different oxide species of Ag. Based on these reports it seems that the reduction signal observed in the TPR pattern of AgC-IMP sample in this study correspond to the reduction of $AgNO_3$ precursor and/or the reduction of silver oxide. Thus it clearly indicates that silver is in reduced form in AgC-EC where as in oxidic form or in unreduced state in the impregnated catalyst.

For controlling the microorganisms in raw water, it is assumed that silver should be in metallic form so that it can take dissolved oxygen from water. Thus for the catalyst AgC-EC, no pretreatment is needed for controlling the microorganisms in water. Whereas the silver catalyst prepared by conventional impregnation technique requires reduction prior to use in controlling microorganisms in water because silver is in oxidic form and also $AgNO_3$ precursor in the catalyst may leach into the water there by causing depletion of concentration of silver in the catalyst.

3.4. Activity test

The *E. coli* lacZ gene encoding ß-galactosidase (ß-gal) is the classical histochemical reporter gene [18]. It can be detected using a variety of substrates, all of which have galactose linked through a ß-D-glycosidic linkage to a moiety whose properties change upon liberation from galactose [19]. Several substrates yield colored or fluorescent soluble products, which are useful when quantifying ß-gal activity [20,21] or visualizing transduced cells live in vivo [22–24]. The fluorescent products can even be used to kill cells in vivo [23]. However, for localization of cells containing transduced lacZ, chromogenic substrates that yield a precipitated product are desirable [25–27]. The most common such substrate is an indole derivative, 5-bromo-4-chloro-3-indolyl-ß-D-galactoside [28].

When ß-gal cleaves the glycosidic linkage in X-gal, a soluble, colorless indoxyl monomer is produced. Subsequently, two of the liberated indoxyl moieties form a dimer, which is non-enzymatically, oxidized (Fig. 4). The resultant halogenated indigo is a very stable and insoluble blue compound [28]. The dimerization and oxidation reactions require transfer of an electron, which is facilitated by electron acceptors of the proper redox potential [29]. The ferric and ferrous ions included in most X-gal reaction buffers provide this function [30].

The scheme presented in Fig. 4 shows the action of X-gal in detecting the presence of microorganisms, which is evidenced from the blue coloration, found after incubation. The Readycult containing X-gal is mixed in the raw water sample to be tested along with required amount of catalyst stirred well for an hour and incubated for 24 h. The resulting bluish-green coloration of the brath indicates the presence of

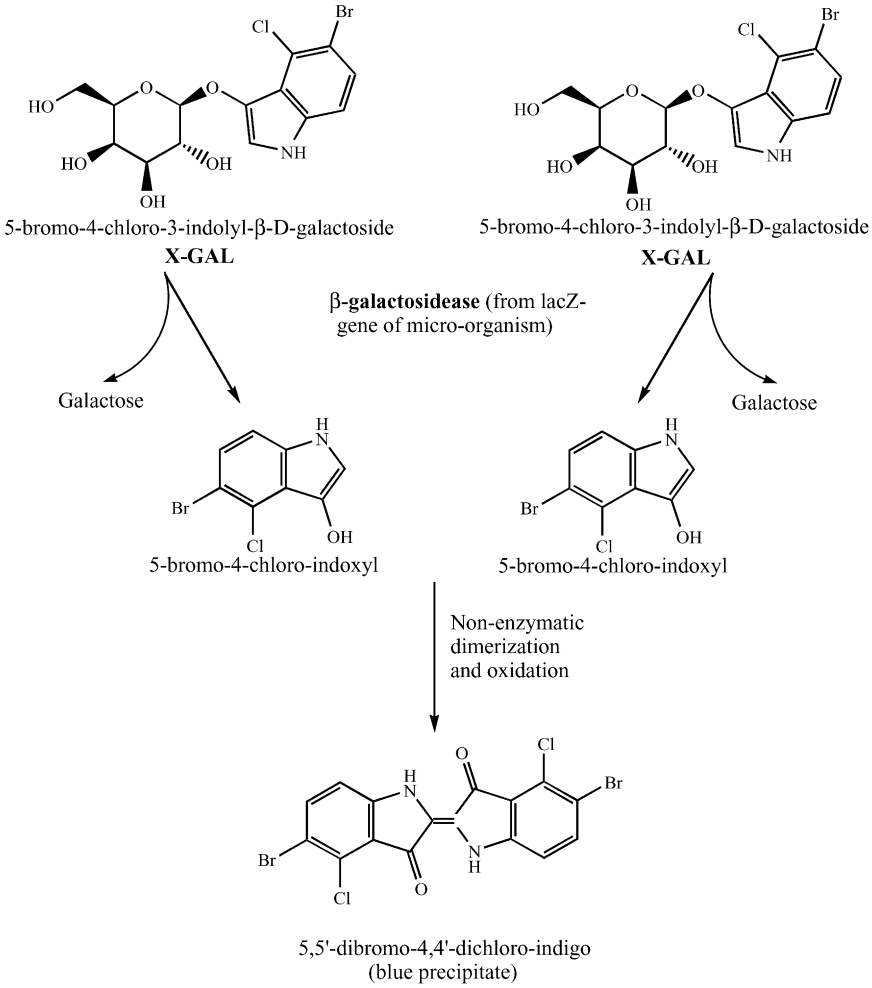

Fig. 4. Scheme showing the action of X-gal (from Readycult reagent) in detecting the microorganisms in water.

microorganisms and the absence of any coloration show the effectiveness of Ag catalyst in controlling the microorganisms. Since, if the microorganism is killed by the action of Ag, then there is further reaction of ß-galactosidase present in the microorganism with X-gal responsible for the coloration of the brath.

IPTG, isopropyl ß-D-thiogalactopyranoside is a chemical analogue of galactose, which cannot be hydrolyzed by the enzyme ß-galactosidase. Therefore, it acts as an inducer for activity of the lac operon of the microbe by binding and inhibiting the lac repressor without being degraded and is hence often used in conjunction with a ß-galactosidase substrate such as X-gal.

MUG, 4-methyl lumbelliferyl-ß-D-glucuronide trihydrate is a fluorescent substrate for ß-D-glucuronidase (GUS) encoded by the gusA gene isolated originally from *E. coli*. Cleavage of the substrate MUG by a ß-glucuronidase activity leads to the generation of the fluorigenic product 4-MU, 7-hydroxy-4-methyl coumarin, which can be visualized or detected by irradiation with UV-light.

A report [31], discuss three mechanisms of deactivation that silver utilizes to incapacitate disease-causing organisms. They are catalytic oxidation, reaction with cell membranes, and binding with the DNA of disease organisms to prevent unwinding. Among all the metals, silver is unique in its affinity towards oxygen. It is reported that atomic oxygen has an almost prefect fit in the octahedral holes of gold, silver [32] and copper. However, in gold the electron cloud of oxygen tends to be expelled by lattice oxygen of gold atoms and this block the movement through holes. Copper, on the other hand forms the oxide providing an impossible barrier. Silver offers so little repulsion to oxygen that only a small amount of thermal energy is required to readily move the atomic oxygen through the silver lattice [33].

Silver in its atomic state, has the capacity to absorb oxygen and act as a catalyst to bring about oxidation. Atomic (nascent) oxygen absorbed onto the surface of silver ions in solution will readily react with the sulfhydryl (–S–H) groups surrounding the surface of bacteria or viruses to remove the hydrogen atoms (as water), causing the sulfur atoms to form an R–S–S–R bond; blocking respiration and causing the bacteria to expire. Micro-crystals of silver have a tendency to lightly bound nascent oxygen (with a binding energy of only 40 kcal/mol) and these species readily oxidizes bacteria or

Table 2
Effect of Ag concentration in water on the destruction of coliforms

S. no.	Catalyst code	Volume of 10 ppm Ag aq. solution (ml)	Volume of raw water (ml)	Total coliforms status (A: absence, P: presence)
1	Without catalyst	–	50	P
2	Ag solution (10 ppm)	10	40	P
3	Ag solution (10 ppm)	20	30	P
4	Ag solution (10 ppm)	30	20	A
5	Ag solution (10 ppm)	40	10	A

Table 3
Comparison of activities of AgC-EC and AgC-IMP in controlling the microorganism

S. no.	Catalyst	Catalyst weight (g)	Volume of water (ml)	Total coliforms status (A: absence, P: presence)
1	AgC-EC	1	50	A
2	AgC-EC	0.5	50	A
3	AgC-EC	0.2	50	A
4	AgC-IMP	1	50	A
5	AgC-IMP	0.5	50	P
6	AgC-IMP	0.2	50	P

viruses, resulting in complete disintegration [1]. There are many forms of silver viz., silver salts, organic precursors of silver, metallic form of silver on carbon, which may exhibit microscopic particle size and show germicidal, antibiotic and other effects, but are not always found to be safe and are less effective than the silver generated by electro-deposition method. In the case of silver nano-particles in water solution generated by electrolytic method, ∼30 ml of such solution is required to deactivate bacteria in a 20 ml raw water (Table 2). Moreover, it is very difficult to separate the Ag particles in the solution and to reuse them. Thus this Ag solution deposited on active carbon seems to be more advantageous particularly in reusing the catalyst. Silver particles produced by this method are ideal sized and provide the greatest biological benefit and are proved to be non-toxic as well. The biological activities of AgC-EC and AgC-IMP, the two different types of silver catalysts used, are presented in Table 3 clearly shows the difference and superiority of the AgC-EC system in controlling the microorganisms. Although the impregnated Ag catalyst (AgC-IMP) showed anti-bacterial activity, they are needed in high concentration, i.e., only if taken ≥1 g amount (in ∼50 ml raw water) can effectively control microorganisms in water. Also, more importantly these catalysts have to be pretreated subjecting to reduction in H_2 flow at 523 K for at least 2 h to get metallic silver particles on active carbon prior to their application. Thus, again AgC-EC catalyst prepared by electro-chemical deposition method, which contains silver already in metallic form, is advantageous over the impregnated catalyst as the pretreatment is not required. Moreover, even ∼0.2 g of this catalyst is sufficient enough or effective in controlling the microorganisms in water.

4. Conclusions

1. The catalytic ability of the silver deposited on carbon by electro-deposition route is more effective than that of silver deposited on carbon by conventional impregnation technique in controlling the microorganisms in water.
2. The electro-deposition method is easier and less expensive.
3. Silver is deposited in metallic form directly in this method, which is more cost effective as the pretreatment processes viz., calcinations and/or reduction can be avoided.
4. This method yields smaller particles (nano-particles) which increases the intrinsic activity (activity per site) and hence superior activity compared to the catalysts prepared by conventional method. The high intrinsic activity of this catalyst is evidenced from its effectiveness in controlling the microorganism in water with lower weight.
5. The electro-deposition method can also be extended to make other supported catalysts like Cu, Ni to increase the catalytic activity in various other reactions too.

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References

[1] C.F. Heinig, Composition for bacterial treatment of water, US Patent No. 4,608,247 (26 August 1986).
[2] H. Oka, T. Tomioka, S. Ueda, et al., Inactivation of enveloped viruses by a silver-thiosulfate complex, Metal-Based Drugs 1 (5–6) (1994) 511.
[3] C.L. Fox, B.W. Rappole, W. Stanford, Control of pseudomonas infection in burns by silver sulfadiazine, surgery, Gynecol. Obstetrics 128 (1969) 1021.
[4] T. Tokumaru, Y. Shimizu, C.L. Fox, Antiviral activities of silver sulfadiazine and ocular infection, Res. Commun. Chem. Pathol. Pharmacol. 8 (1) (1984).
[5] G.V. James, Water Treatment, 4th ed., CRC Press, Cleveland, OH, 1971, 38 pp.
[6] E. Habenschaden, Sterilization of water with Katadyn ceramic filters, Sonderdruck aus Pharma International (1988).
[7] J.D. Collins, Laboratory Manager, Ionics, Inc., Bridgeville, PA, September 1995, Private communication.
[8] M.S. Antelman, Silver (II, III) Disinfectants, Soap/Cosmetics/Chemical Specialties, March 1994, p. 52.
[9] R.O. Becker, J.A. Spadaro, Treatment of orthopedic infections with electrically generated silver ions, J. Bone Joint Surgery 60A (1978) 871–881.
[10] R.O. Becker, Proceedings of the International Conference on Gold and Silver in Medicine, The Silver Institute, Washington, DC, Effect of electrically generated silver ions on human cells, 1987, p. 227.

[11] National Sanitation Foundation/International, Ann Arbor, MI, Standard #50 on Circulation System Components for Swimming Pools, Spas, or Hot Tubs; Section 16 on Copper-Silver Ion Purification Systems.
[12] A.H. Padmasri, A. Venugopal, J. Krishnamurthy, K.S. Rama Rao, P. Kanta Rao, J. Mol. Catal. A 181 (2002) 73.
[13] Robert Jordan, Medipatch, http://www.cyberpet.com/cyberdog/articles/health/coloid.htm.
[14] S. Chandra Shekar, J. Krishna Murthy, P. Kanta Rao, K.S. Rama Rao, J. Mol. Catal A 191 (2003) 45.
[15] L. Gang, B.G. Anderson, J. van Grandelle, R.A. van Santen, Appl. Catal. B: Env. 40 (2003) 101.
[16] F. Boccuzzi, A. Chiorino, M. Manzoli, D. Andreeva, T. Tabakova, L. Ilieva, V. Iadakiev, Catal. Today 75 (2002) 169.
[17] T. Paryjczak, J. Goralski, K.W. Jozwiak, React. Kinet. Catal. Lett. 16 (1981) 147.
[18] J.R. Beckwith, Lac: the genetic system, in: J.H. Miller, W.S. Reznikoff (Eds.), The Operon, Cold Spring Harbor Laboratory, Cold Spring Harbor, New York, 1980.
[19] K. Wallenfels, R. Weil, , in: P.D. Boyer (Ed.), In the Enzymes, vol. 7, 3rd ed., Academic Press, New York, 1972, 617 pp.
[20] R.E. McCaman, E. Robins, J. Neurochem. 5 (1959) 32.
[21] J. Miller, Experiments in Molecular Genetics, Cold Spring Harbor, New York, 1972.
[22] M.A. Krasnow, S. Cumberledge, G. Manning, L.A. Herzenberg, G.P. Nolan, Science 251 (1991) 81.
[23] S. Nirenberg, C. Cepko, J. Neurosci. 13 (1993) 3238.
[24] S. Lin, S. Yang, N. Hopkins, Dev. Biol. 161 (1994) 77.
[25] S.J. Holt, D.G. O'Sullivan, Studies in enzyme cytochemistry. I. Principles of cytochemical staining methods, Proc. Roy. Soc. (London) 148B (1958) 465.
[26] B.H. Learse, , in: B.L. Courne, L.F. Canielli (Eds.), Azo Dye Methods in Enzyme Histochemistry in International Review of Cytology, vol. III, Academic Press, New York, 1954.
[27] B. Pearson, P.L. Wolf, J. Vazquez, Lab Investig 12 (1963) 1249.
[28] S.J. Holt, P.W. Sadler, Studies in enzyme cytochemistry. III. Relationships between solubility, molecular association and structure in indigoid dyes, Proc. Roy. Soc. (London) 148B (1958) 495.
[29] S. Cotson, S.J. Holt, Studies in enzyme cytochemistry. IV. Kinetics of aerial oxidation of indoxyl and some of its halogen derivatives, Proc. Roy. Soc. (London) 148B (1958) 506.
[30] Z. Lojda, Histochemie 22 (1970) 347.
[31] R.L. Davies, S.F. Etris, Catal. Today (1997) 36.
[32] R.A. Outlaw, M.R. Davidson, Small ultra-high vacuum compatible hyper thermal oxygen atom generator, Vacuum Sci. Technol. A 12 (1994).
[33] M.E. Eberhart, M.J. Donovan, R.A. Outlaw, Ab initio calculations of oxygen diffusivity in Group IB transition metals, Phys. Rev. 46 (1992) 12744.