PREPARATION OF SILVER COLLOIDAL SOLUTION COATED CERAMIC FILTER AND ITS ANTIMICROBIAL ACTIVITY

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Abstract

In this research work, the silver colloidal solution was synthesized by using silver nitrate and watery extract of bamboo leaves as reducing agents. The optimum ratio of red clay, brown clay and rice husk (6:3:1 w/w) were used for preparing porous ceramic filters. Silver colloidal solution was coated on prepared ceramic filter and silver coated filter, was obtained. EDXRF and SEM were used to examine the silver percent content of coated and uncoated ceramic filters. EDXRF analysis showed that silver (0.166 %) was present in coated filter and absent in uncoated filter. The antimicrobial activities of uncoated filter and coated filter by agar well diffusion method were tested on *Bacillus pumilus, Bacillus subtilis, Candida albicans, Escherichia coli, Pseudomanas fluorescens and Staphylococcus aureus strains*. The coated filter showed high antimicrobial activities on six microorganisms but not on the uncoated filter. Based on the results, prepared silver coated ceramic filters may be used as ecofriendly, environmental friendly and most effective filter material for water treatment due to its antimicrobial activities.

Keywords: silver colloidal solution, ceramic filter, antimicrobial activity, bamboo leaves, watery extract

Introduction

The World Health Organization (WHO) assessed in 2000 that 1.1 billion peoples do not have access to 'improved drinking water sources'. Consumption of unsafe water continues to be one of the major causes of the 2.2 million diarrhoeal disease deaths occurring annually, mostly children in developing countries. According to the WHO a short-term solution to meet the basic need of safe drinking water can be found in household water treatment and safe storage (HWTS). An appropriate technology complies with WHO guidelines on the quality and quantity of water. It ensures the guarantee that water for personal or domestic use is safe and therefore free from microorganisms, chemical substances and hazards that constitute a threat to a person's health (Halem, 2006). People have to collect their own water outside their own water outside their homes and then store the water in the household due to the lack of water supply, and contaminations could occur during the water collection, transport, and storage, which cause a high chance of water-borne disease infection (Mohamed, 2018).

Silver nanoparticles (AgNPs) can be easily incorporated into drinking water purifiers so as to deliver safe and clean water at low cost. Nevertheless, the large demands in nanoparticles availability and high microbial loading during disinfection of drinking water still limits AgNPs either for household (point-of-use) water treatment or when specialized treatment is required (Simeonids *et al*., 2016). Deposition of AgNPs in the bacterial cell surface can affect cell membrane permeability. Nanoparticles can destroy both bacterial cell wall and cell membrane well (Likus, 2013). There have been several reports on the use of AgNPs in the field of medicine. The AgNPs have been used as therapeutic agents, as glyconano sensors for disease diagnosis and as nano carriers for drug delivery (Srikar *et al*., 2016).

Ceramic-water filtration by using ceramics is an inexpensive and effective type of filtration method that relies on the small pore size of ceramic material to filter dirt, debris, and bacteria out of water. Typically bacteria, protozoa, and microbial cysts are removed but the filters are not

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effective against viruses since they are small enough to pass through to the other "clean" side of the filter. Ceramic when combined with silver impregnated carbon is called sterasyl that is ideal for filtering microbiologically unsafe water; however sterasyl does not remove fluoride. The only disadvantage of ceramic materials is the brittle nature which may develop hairline cracks during handling (Padmaja *et al*., 2007). In the present investigation an attempt is made to prepare a silver colloidal solution coated ceramic filter and it can be used as a filter for microbiologically unsafe water.

Materials and Methods

Preparation of Silver Colloidal Solution

2:1 (v/v) ratio of 3 mM silver nitrate solution and bamboo leaves extract were mixed and stirred for 1 h with a magnetic stirrer. The reduction reaction was completed after 2 days with the appearance of a reddish brown colour which confirms the formation of a silver colloidal solution.

Figure 1 Silver colloidal solution

Preparation of Porous Ceramic Filters

The 60 % of red clay, 30 % of brown clay and 10 % rice husk were mixed with weight by weight ratio. 30 mL of distilled water was added to the clay mixture and thoroughly mixed to obtain until paste. And then, the resulting clay paste was put into plastic mold and pressed to obtain ceramic filters. The filters were dried for 2 days in air and heated at 800 ˚C for 2 h.

Coating of Porous Ceramic Filter with Silver Colloidal Solution

The filter was immersed in 25 mL of silver colloidal solution for 1 h. After that, the filter was removed from the silver colloidal solution and dried at room temperature. Figure 2 (b) shows the prepared silver coated porous ceramic filter.

(a) (b)

Figure 2 Porous ceramic filters (a) uncoated filter and (b) coated filter

Characterization of Ceramic Filters by Modern Techniques

EDXRF analysis

The energy dispersive X-ray fluorescence spectrums (EDXRF) of composite beads were recorded on Perkin Elmer 700, EDXRF spectrometer.

SEM analysis

A scanning electron microscope (JSM-5610 Model SEM, JEOL-Ltd., Japan) was used to record the micrograph images of uncoated filter and coated filter.

Antimicrobial activity using agar well diffusion method

The agar plates containing tested organisms were punched to make the wells (8 mm in diameter) using sterile cork borer and filled with the stock solution (0.2 mL) and then these plates were incubated at room temperature for 24 h. After incubation, the diameters of the growth inhibition zones surrounding the wells were measured in mm. These zones indicated the presence of antimicrobial activities which inhibit the growth of tested organisms selectively (Collins, 1965).

Results and Discussion

Visual Observation of Silver Colloidal Solution

The silver colloidal solution prepared by using 3mM of silver nitrate solution and bamboo leaves extract was confirmed by changing in colour from pale yellow to reddish brown due to the formation of silver colloidal solution. Figure 1 shows the silver colloidal solution.

Characterization of Uncoated Filter and Coated Filter

EDXRF analysis

The chemical compositions of minerals that present in the uncoated and coated filter were determined by EDXRF and their compositions are shown in Table 1. Their respective spectra are described in Figures 3 and 4. According to EDXRF analysis, silver is absent in uncoated filters and present in coated filters.

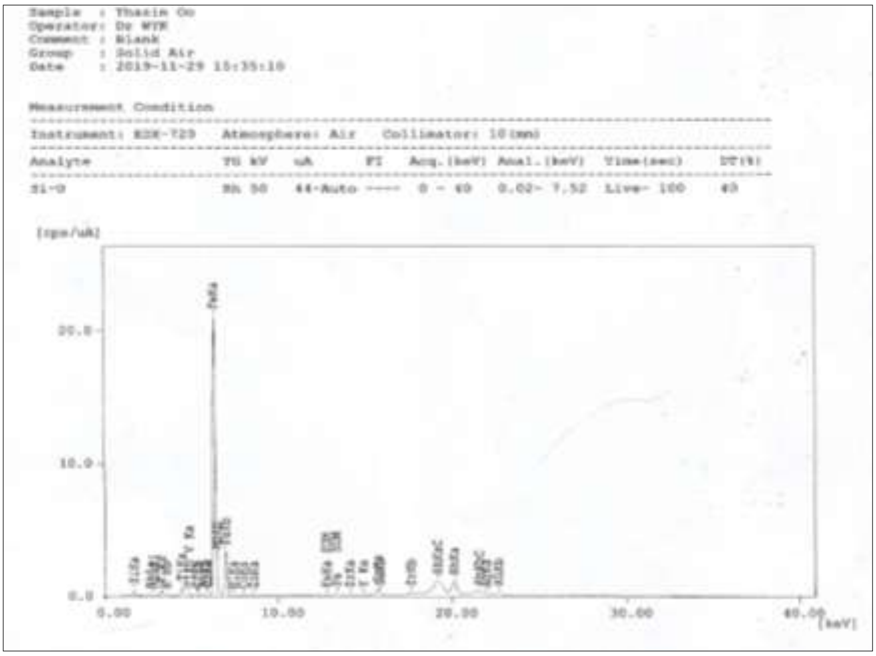


Figure 3 EDXRF spectrum of uncoated filter

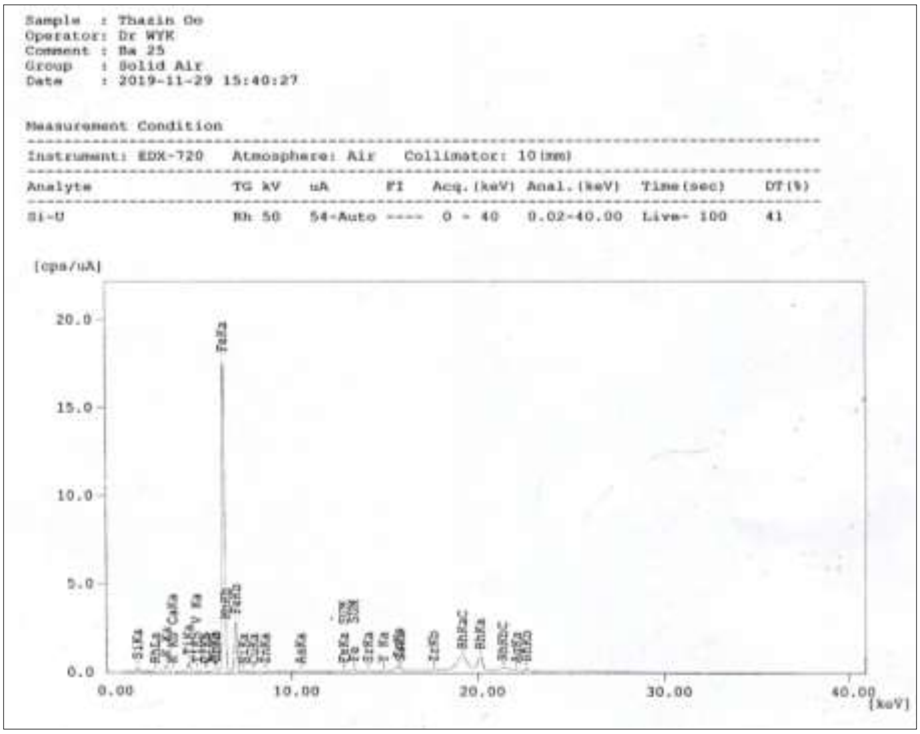


Figure 4 EDXRF spectrum of coated filter

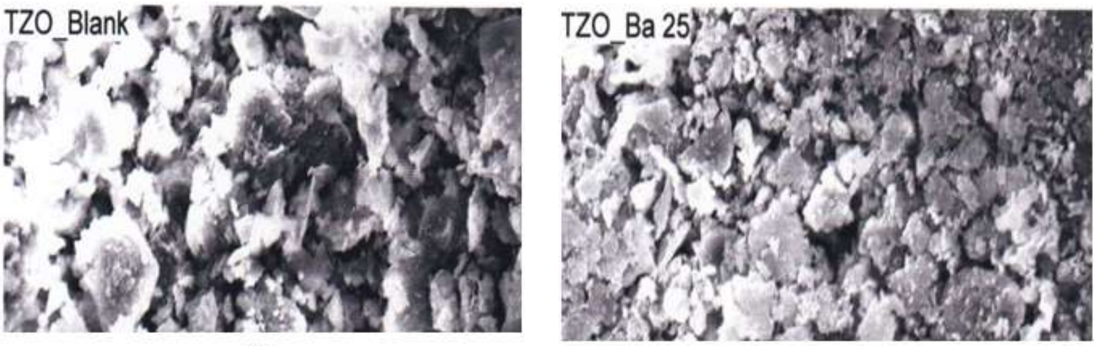
Table 1 Elemental Analysis of Uncoated and Coated Filter

Elements	Relative abundance (%)	
	Uncoated filter	Coated filter
Si	62.123	58.572
Fe	28.816	31.151
K	6.004	6.613
Ti	2.084	2.198
Mn	0.247	0.249
Zr	0.231	0.205
Ag	**ND**	**0.166**
Cr	0.131	0.129
Ni	0.062	0.072
Zn	0.053	0.062

ND – not detected

SEM Analysis

SEM micrographs of silver coated and uncoated filters were described in Figures 5 (a) and (b). It can be seen that uncoated and coated filters have different morphologies. The pores are indicated by black areas in the micrograph of the uncoated filter. In the SEM micrograph of the coated filter, there was a lack of the black areas due to the presence of silver. In Figure 5 (a) the black areas showed the pores of the uncoated filter.

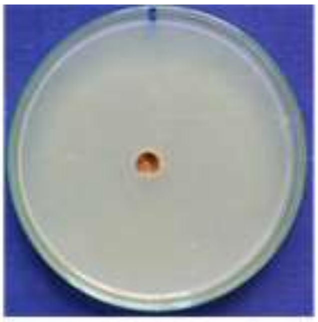
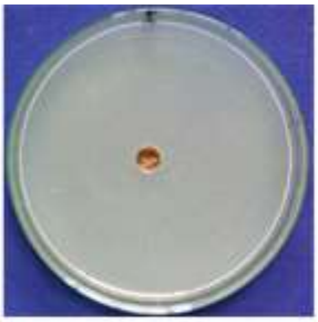
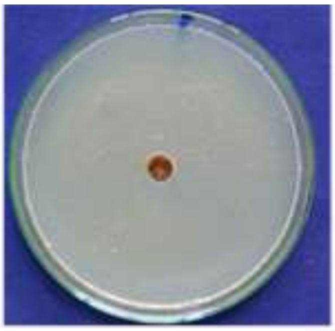


(a) (b)

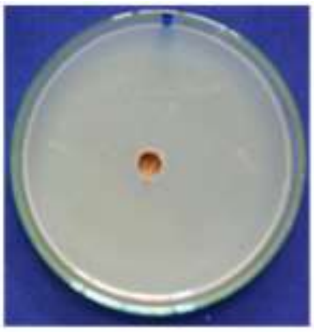
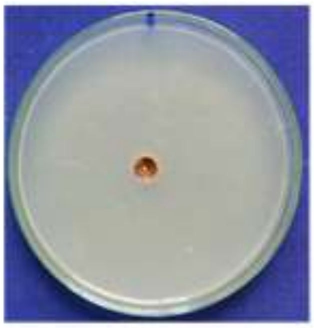
Figure 5 SEM micrographs of (a) uncoated filter (b) coated filter

Antimicrobial Activities of Uncoated and Coated Filters

The uncoated and coated filter exhibited an antimicrobial activity against *Bacillus pumilus*, *Bacillus subtilis*, *Candida albicans*, *Escherichia coli*, *Pseudomonas fluorescens* and *Staphylococcus aureus*. Figure 6 and Table 2 showed the antimicrobial activities of uncoated filters on six microorganisms. Figure 7 and Table 2 showed the antimicrobial activities of coated filters against six microorganisms. According to the test the uncoated filter showed no antimicrobial activities on six microorganisms and the coated filter showed high activity against six microorganisms due to the presence of silver.

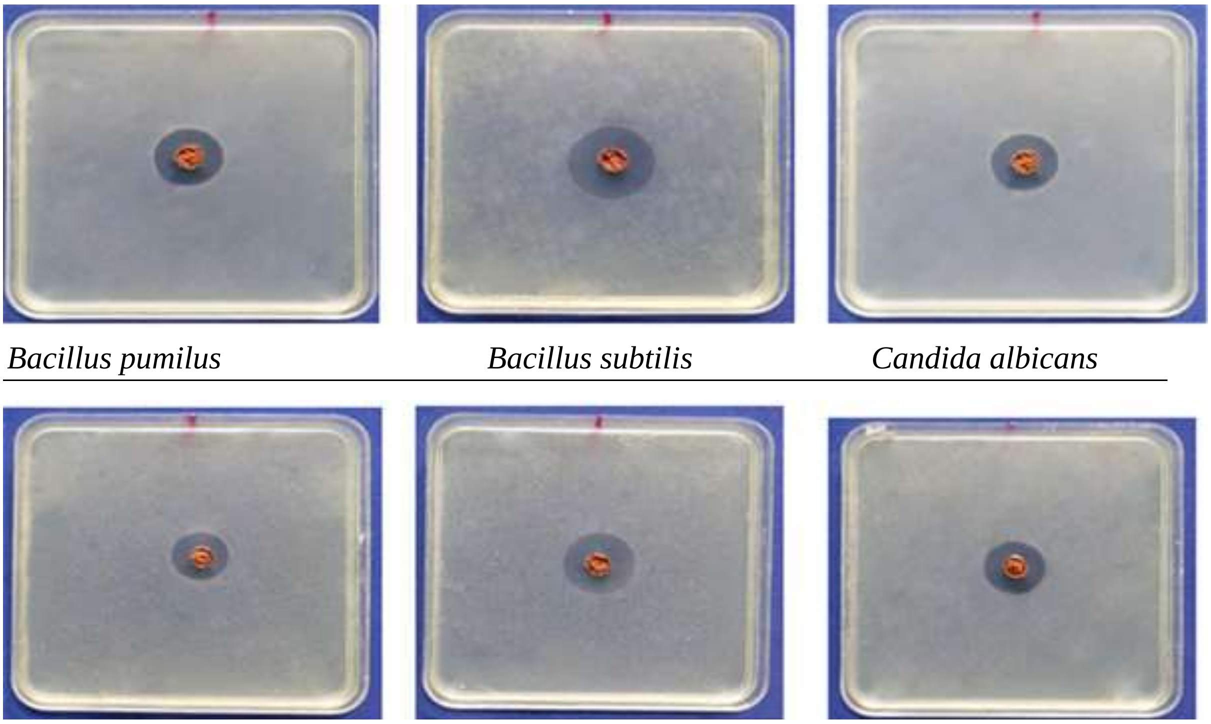




Bacillus pumilus *Bacillus subtilis* *Candida albicans*

Escherichia coli *Pseudomonas fluorescens* *Staphylococcus aureus*

Figure 6 Antimicrobial activities of uncoated filter



Bacillus pumilus *Bacillus subtilis* *Candida albicans*

Escherichia coli *Pseudomonas fluorescens* *Staphylococcus aureus*

Figure 7 Antimicrobial activities of coated filter

Table 2 Antimicrobial Activities of Coated and Uncoated Filters

Organisms	Inhibition zone diameter (mm)	
	Uncoated filter	Coated filter
Bacillus pumilus	–	22 (+++)
Bacillus subtilis	–	26 (+++)
Candida albicans	–	22 (+++)
Escherichia coli	–	20 (+++)
Pseudomonas fluorescens	–	24 (+++)
Staphylococcus aureus	–	26 (+++)

Diameter of Agar Well – 8 mm
No activity (-)
10 mm ~ 14 mm - mild activity (+)
15 mm ~ 19 mm - medium activity (++)
20 mm ~ above - high activity (+++)

Conclusion

Silver colloidal solution was successfully prepared from silver nitrate solution by bamboo leaves extract as reducing agent. Porous ceramic filters were prepared by using optimum ratios of red clay, brown clay and rice husk with 6:3:1 w/w at 800˚C. Silver colloidal solution coated and uncoated ceramic filters were examined by EDXRF and SEM analyses. EDXRF analysis revealed that silver was found to be 0.166 % in a coated filter. According to SEM analysis, SEM micrographs of uncoated and coated filters have different microstructures. The morphology of coated filters showed a distribution of silver particles on pores of ceramic surfaces. And also an antimicrobial activity test was performed by using an uncoated filter and coated filter. Concerning the antimicrobial activities, uncoated filter did not show activity but coated filter showed high activity against six microorganisms. Therefore, the prepared silver colloidal solution coated filters are nontoxic, simple and cost-effective ceramic filters and it can be used for filtering microbiologically unsafe water.

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