chemistry proceedings

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Proceeding Paper

A Modified Silver-Egg Shell Nanocomposite Applied for Antibacterial Activities †

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† Presented at the 26th International Electronic Conference on Synthetic Organic Chemistry; Available online: https://ecsoc-26.sciforum.net.

Abstract: Bacterial infections have one of the extensive impacts on public health. Therefore, finding compounds with antibacterial properties could serve as an effective method. A nanocomposite, Ag/CaO was prepared from silver nitrate and egg shells. After calcination of egg shells, the remaining solid, CaO was cooled, then silver nitrate was added and the mixture was ground to a fine powder, and finally heated to 300 °C. The brown solid obtained was characterized by XRD, SEM and XRF methods. The prepared Ag/CaO was exmained for antibacterial activity against gram-positive and gram-negative bacteria including keleb pneumonia, staphylococcus aureus, Esherichia coli. This work has a similar paper published in 25th ECSOC 2021, but now we made two changes including the amount of silver nitrate and calcium oxide in the synthesis route, and the size of the first synthesized nanocomposite by grinding with a ballmill, and then we examined these two substances against the bacteria. In fact, changing the amount of silver, known as the antibacterial metal, was compared to the changing the size of the nanocomposite, which could have more antibacterial effect.

Keywords: nanocomposite; green chemistry; antibacterial; egg shell; CaO

Citation: Aghaee, M.; Manteghi, F. A Modified Silver-Egg Shell Nanocomposite Applied for Antibacterial Activities. *Chem. Proc.* **2022**, *4*, x. https://doi.org/10.3390/xxxxx

Academic Editor(s):

Published: 15 November 2022

1. Introduction

Egg shell is considered as a pollution source as well as a source of calcium carbonate [1]. Todays, synthetic methods without dangerous solvents is attractive, particularly for their environmental advantages. It is important to prepare materials that have antibacterial properties and that these materials being not harmful to the environment and the synthesis method used being compatible with the life cycle.

2. Experimental

2.1. Preparation of CaO from Egg Shell

CaO was prepared from collected egg shells after washing carefully, drying in room temperature, grinding in a porcelain mortar, and then calcination at 900 °C for 5 h [2]. As a final step, it was cooled down to room temperature. The obtained CaO was used for antibacterial activity.

2.2. Preparation of Ag-NP@CaO(1)

The obtained 3 g CaO was ground in a porcelain mortar, then was added to 1 g $AgNO_3$, and crushed again to get a fine uniform powder. The powder mixture was placed in furnace at 300 °C for 3 h until a brown solid, Ag@CaO was obtained [3].

2.3. Preparation of Ag-NP@CaO(2)

The obtained 2 g CaO was ground in a porcelain mortar, then was added to 2 g $AgNO_3$, and crushed in the mortar. The mixture was placed in furnace at 300 °C for 3 h until a brown solid, Ag@CaO(2) was obtained.

2.4. Preparation of Ag-NP@CaO(3)

Ag-NP@CaO(1) was ground in a ball mill for 20 min and was considered for studying its morphology and size.

2.5. Characterization:

All materils including CaO, Ag-NP@CaO(1), Ag-NP@CaO(2), Ag-NP@CaO(3) were characterized by XRD, XRF and SEM methods.

In XRD patterns, the three characteristic lines of CaO shown in Figure 1, can be seen that are present also in Figure 2, Ag-NP@CaO(1) nanocomposite synthesized with 3 g of calcium oxide and 1 g of silver nitrate and Figure 3 Shows that increasing of silver nitrate compared to calcium oxide and the synthesis of CaO and $Ag(NO)_3$ with an equal ratio of them, which can be seen in the figure, the changes can be seen well.

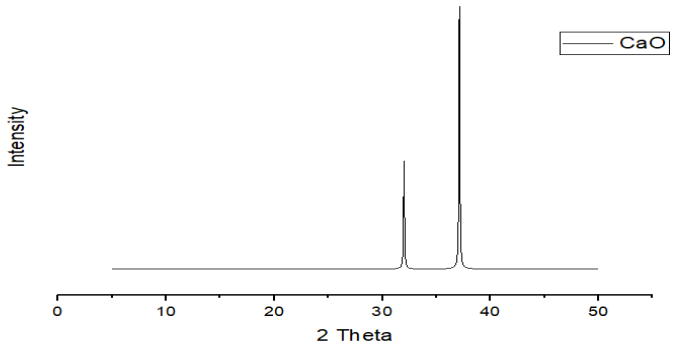

Figure 1. XRD pattern of pure CaO.

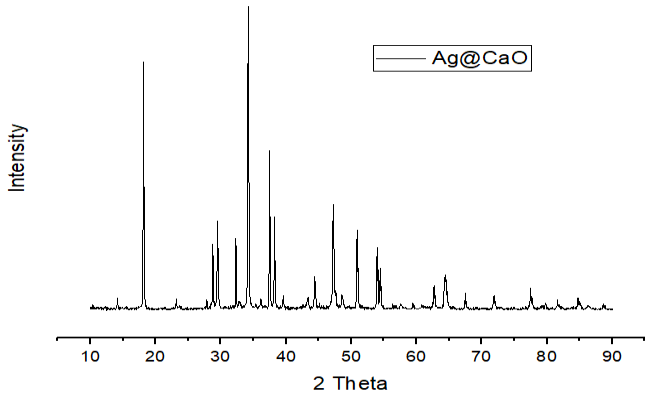

Figure 2. XRD pattern of Ag@CaO(1).

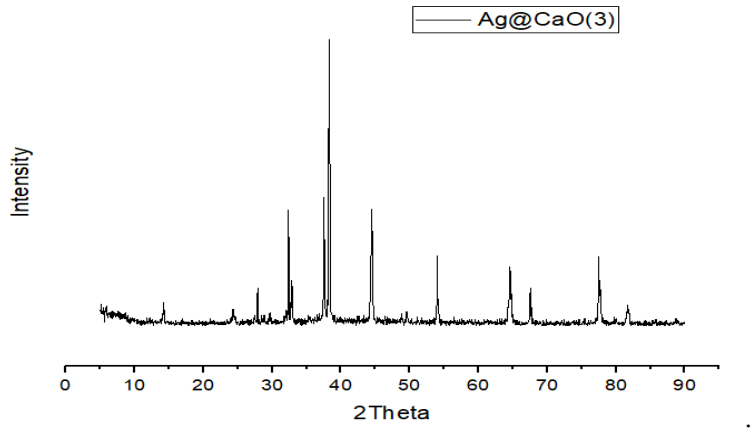

Figure 3. XRD pattern of Ag@CaO(2).

In XRF analysis of CaO, shown in Table 2, we can see percentage of pure CaO equal 97.7% and XRF analysis of Ag@CaO(1) is given in Table 2 that shows 15.67% Ag in the composite. In Table 3, which shows the synthesis with increasing the percentage of silver nitrate compared to calcium oxide, which has an equal ratio of these two substances, the amount of silver has reached 46.9% in the Ag@CaO(2).

Table 1. The XRF results of CaO as weight percentage of oxides of elements.

Elements	Na_2O	MgO	Al_2O_3	SiO_2	P_2O_5	SO_3	K_2O	CaO	TiO_2
wt %	>>	2.224	>>	-	-	>>	-	97.776	-
Elements	Fe_2O_3	V_2O_5	MnO	Cr_2O_3	Ba	Sr	Zn	Ba	Pb
wt %	-	-	-	-	-	-	-	-	-
Elements	F	Zr	Cl	Ce	Co	Mo	Ca	Cu	Ho
wt %	-	-	-	-	-	-	-	-	-

Table 2. The XRF results of Ag@CaO(1) as weight percentage of oxides of elements.

Elements	Na_2O	MgO	Al_2O_3	SiO_2	P_2O_5	SO_3	K_2O	CaO	TiO_2
wt %	-	1.026	-	-	0.245	-	-	83.058	-
Elements	Fe_2O_3	V_2O_5	MnO	Cr_2O_3	Ag	Sr	Zn	Ba	Pb
wt %	-	-	-	-	15.670	-	-	-	-
Elements	F	Zr	Cl	Ce	Co	Mo	Ca	Cu	Ho
wt %	-	-	-	-	-	-	-	-	-

Table 3. The XRF results of Ag@CaO(2) as weight percentage of oxides of elements.

Elements	Na2O	MgO	Al_2O_3	SiO_2	P_2O_5	S	Ti_2O	CaO	TiO_2
wt %	-	0.46765	-	-	0.12405	<<	-	52.387	-
Elements	Fe	V_2O_5	MnO	Cr_2O_3	Ba	Sr	Zn	Se	Pd
wt %	<<	-	-	-	-	<<	-	-	-
Elements	Ag	ZrO	Cl	V	Co	Mo	Ce	Cu	LOI
wt %	46.917	-	-	-	-	-	-	0.10474	-

The SEM micrographs of four samples, CaO, Ag@CaO(1), Ag@CaO(2), Ag@CaO(3) are shown in Figure 4. The flake morphology of CaO can be clearly observed in Figure 4 and can be seen that the edges of flakes become round, but in Ag@CaO, the Ag particles are settled on the planes of CaO. In Ag@CaO(3) only a ball mill grinding was used and the same composite (1) was placed in the ball mill for 15 min and the particle size approached from 7.559 nm to 6.735 nm and in Ag@CaO(2), a 1:1 ratio of silver nitrate and calcium oxide was applied and the nanocomposite has a more slightly amorph shape.

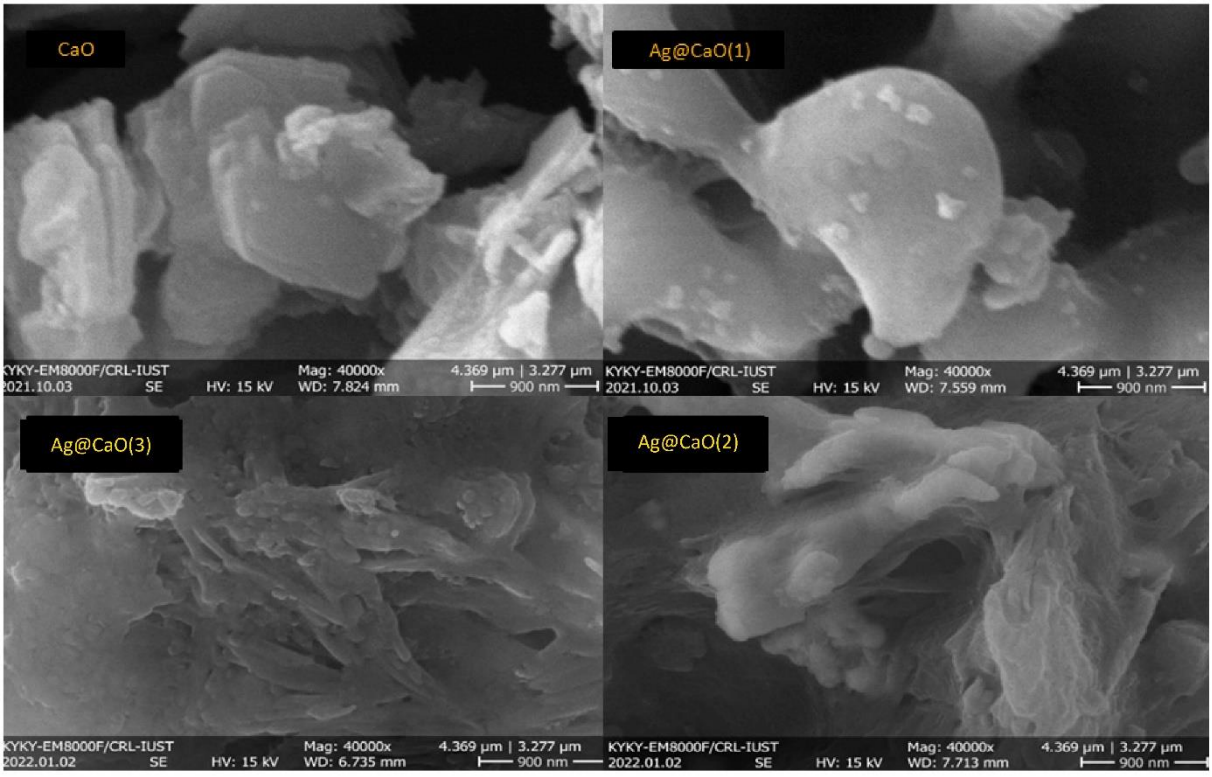

Figure 4. The SEM images of CaO and Ag@CaO(1), Ag@CaO(2), Ag@CaO(3) nanocomposite.

2.6. Antibacterial Activity

Antibacterial activity of CaO [4,5], Ag@CaO(1), Ag@CaO(2), Ag@CaO(3) composite against gram positive and gram negative bacteria were tested. The bacteria include Keleb peneumonia, Staph coccus aureus, and Esherichia coli. The results are shown in Figure 5a–c and summarized in Table 4. In all cases, it can be seen that how the inhibition zone diameter of Ag@CaO(1), Ag@CaO(2), Ag@CaO(3) nanocomposite is changed.

Table 4. The behavior of CaO and from Ag@CaO(1), Ag@CaO(2), Ag@CaO(3) against some bacteria as the diameter of inhibition zone.

Test Bacteria	Inhibition Zone Diameter (mm)			
	CaO	Ag@CaO(1)	Ag@CaO(2)	Ag@CaO(3)
Keleb Peneumonia	8.345	8.866	9.11	9.1
Staph Coccus aureus	13.937	15.928	16.44	16.21
Esherichia coli	15.248	17.819	19.7	18.10

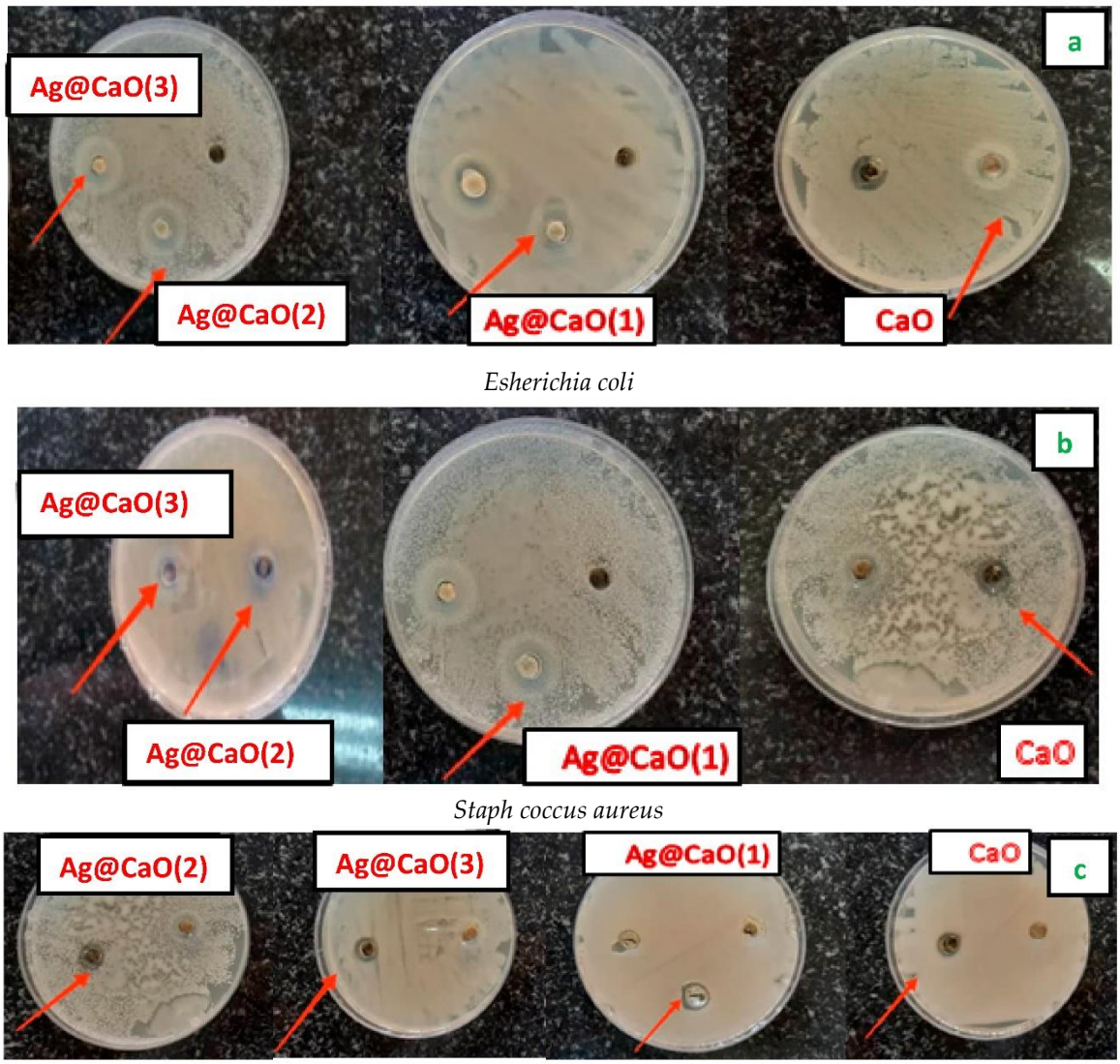

Figure 5. Images of antibacterial test results for gram-negative (**a**,**c**) and gram-positive (**b**) bacteria.

3. Conclusions

In this work, a waste material was converted to a bioactive product against many types of bacteria. Moreover, its composite with metallic silver showed a more effective antibacterial effect. When the synthesized nanocomposite with two different ratios, and its ground form by a ball mill were examined, it was found out that not only the particle sizes changed, but also, they behave differently against 5 types of applied bacteria.

Author Contributions:

Funding:

Institutional Review Board Statement:

Informed Consent Statement:

Data Availability Statement:

Conflicts of Interest:

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