chemistry proceedings

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*Proceedings Paper*

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

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† Presented at the 25th International Electronic Conference on Synthetic Organic Chemistry, 15–30 November 2021; Available online: https://ecsoc-25.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 containing CaO and Ag nanoparticles was prepared from silver nitrate and egg shells. After calcination of the egg shells at 900 °C for 5 h, the solid remaining, CaO was cooled, then silver nitrate was added and the mixture was ground to a fine powder, and finally heated at 300 °C for 3 h. The brown solid obtained was characterized by XRD and XRF methods. Afterwards, the prepared Ag/CaO nanocomposite was applied and compared with CaO for antibacterial activity against gram positive and gram negative bacteria. The bacteria were Escherichia coli, *Pseudomonas aeruginosa*, *Klebsiella peneumoniae*, *Staphylococcus aureus*, *Staphylococcus saprophyticus*.

**Keywords:** silver nano particles; CaO; egg shell; nanocomposite; antibacterial

**Citation:** Aghaee, M.; Mantegh I, F. **A** Silver-Egg Shell Nanocomposite Applied **for** Antibacterial Activities. **2021**, 3, x. https://doi.org/10.3390/xxxxx

Academic Editor: Julio A. Seijas

Published: 15 November 2021



## 1. Introduction

Egg shell is considered as a pollution source as well as a source of calcium carbonate [1]. Nowadays, synthetic methods without dangerous solvents is attractive, especially for their environmental benefits. Recently, scientists have concentrated on manufacturing of economic materials through the process of waste recycling.

## 2. Experimental

### *2.1. Preparation of CaO from Chicken 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-NPs@CaO*

The obtained CaO (3 g) was ground in porcelain mortar, then was added 1 g $Ag(NO)_3$, crushed in porcelain. The mixture was placed in furnace at 300 °C for 3 h until a brown solid, Ag@CaO was obtained.

### *2.3. Characterization*

CaO and Ag@CaO pointed in 2.1 and 2.2 were characterized by XRD, XRF and SEM methods.

In XRD patterns, the two characteristic lines of CaO shown in Figure 1, can be seen in the pattern of Figure 2. This is an evidence for the presence of CaO in Ag@CaO.

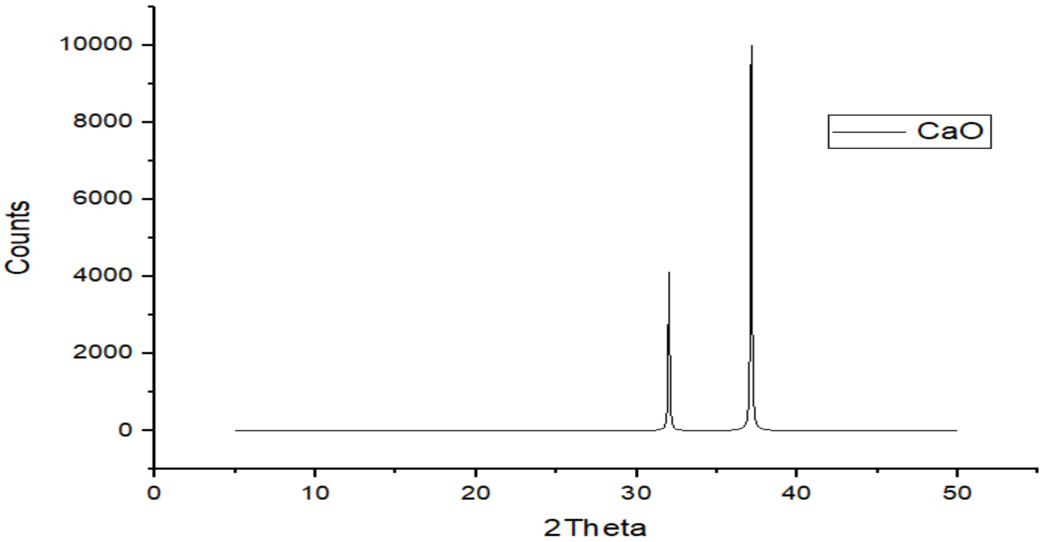



**Figure 1.** XRD pattern of CaO.

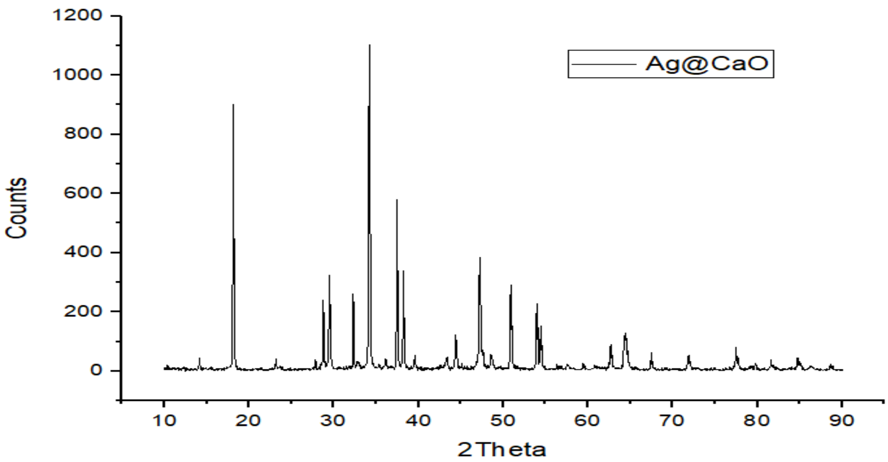



**Figure 2.** XRD Pattern of Ag@CaO.

In XRF analysis of CaO, shown in Table 1, we can see the percentage of pure CaO equal to 97.78% which can be acceptable. The XRF analysis of Ag@CaO is given in Table 2 that shows 15.7% Ag in the composite.

**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 as weight percentage of Ag and CaO.

| 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 % | - | - | - | - | - | - | - | - | - |

The SEM micrographs of the two samples, CaO and Ag@CaO are shown in Figures 3 and 4, respectively. The flake morphology of CaO can be clearly observed in Figure 3. However, in Figure 4, it can be seen that the edges of flakes become more round, but Ag particles are settled on the planes of CaO.

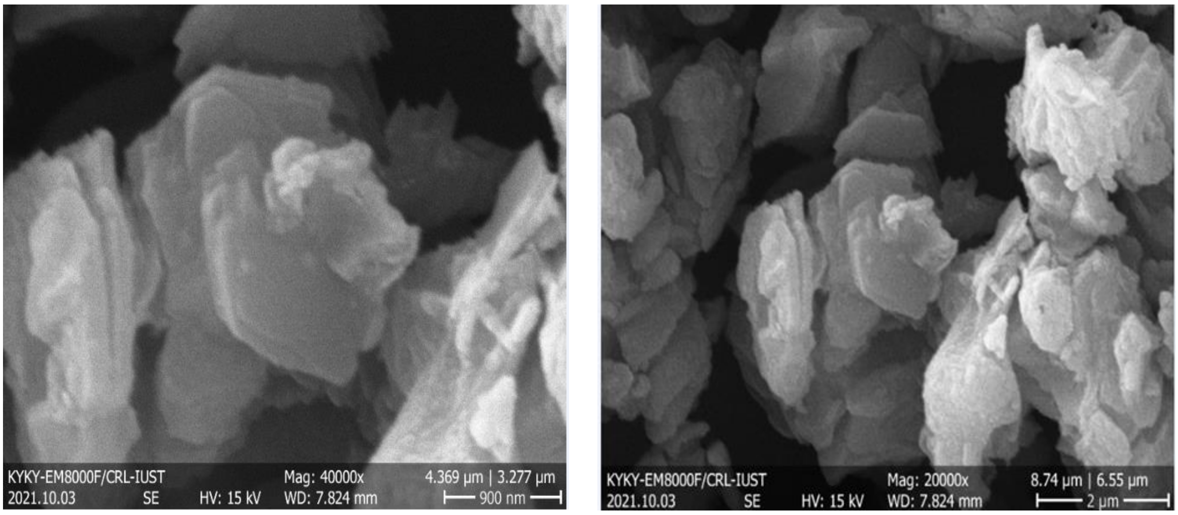



**Figure 3.** The SEM images of Cao.

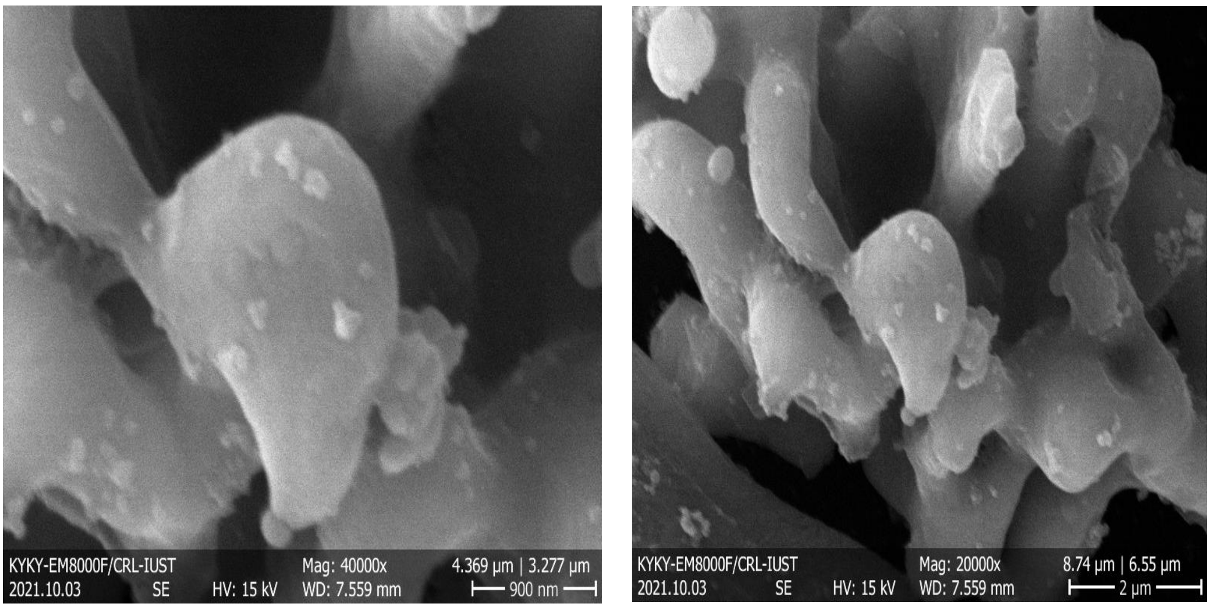


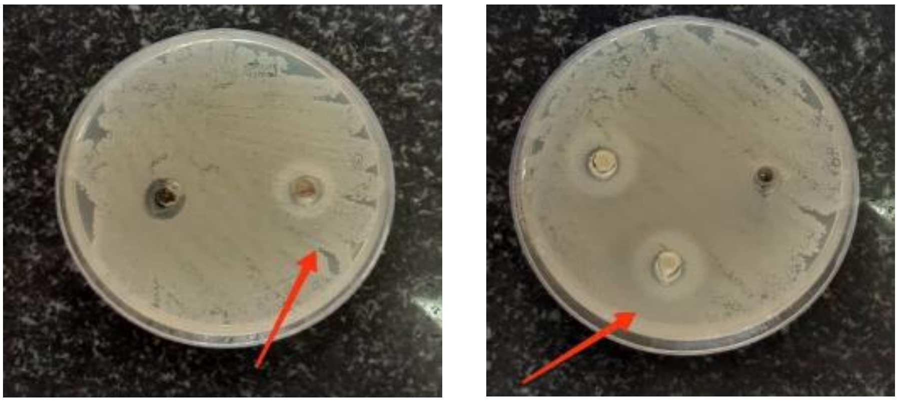

**Figure 4.** The SEM images of Ag@CaO composite.

### *2.4. Antibacterial Activity*

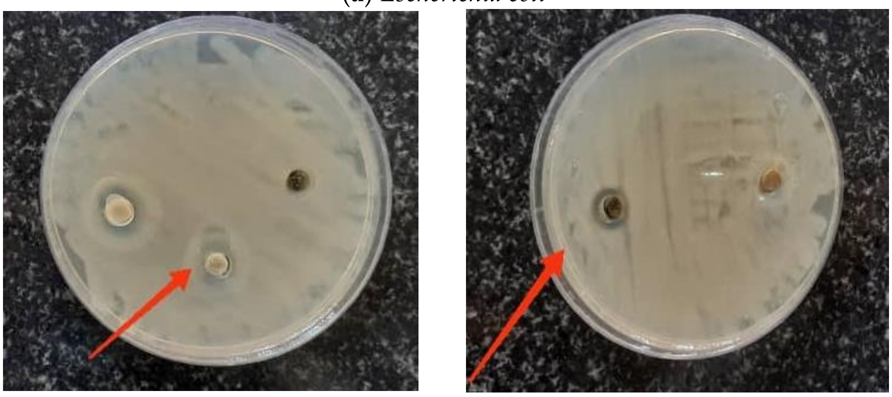
Antibacterial activity of CaO [3,4] and Ag@CaO composite against gram positive and gram negative bacteria were tested. The bacteria include PS. Aeruginosa, Keleb peneumonia, Staph coccus aureus, Staph sapropphyticus and Ecoli. The results are shown in Figure 5a–e and summarized in Table 3. In all cases, it can be seen that the inhibition zone diameter from CaO to CaO@Ag is increased.

**Table 3.** The behavior of CaO and Ag@CaO against some bacteria as the diameter of inhibition zone.

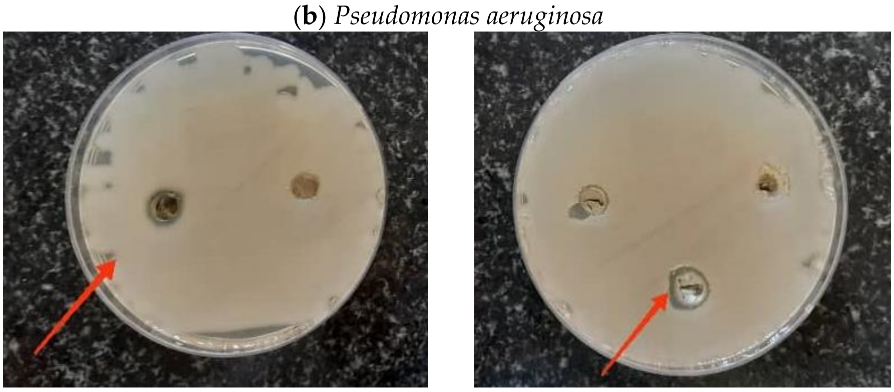
| Bactery | Inhibition Zone Diameter(mm) | |
|---|---|---|
| | CaO | Ag@CaO |
| *Pseudomonas aeruginosa* | 8.770 | 18.038 |
| *Klebsiella peneumoniae* | 8.345 | 8.866 |
| *Staphylococcus aureus* | 13.973 | 15.928 |
| *Staphylococcus saprophyticus* | 8.790 | 11.565 |
| *Escherichia coli* | 15.248 | 17.819 |



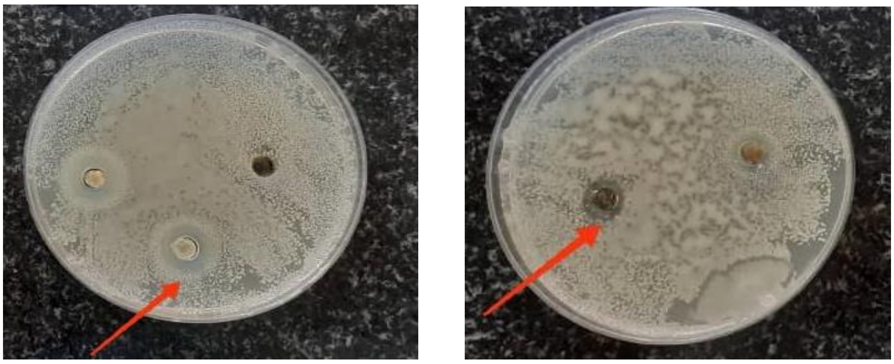
(**a**) *Escherichia coli*



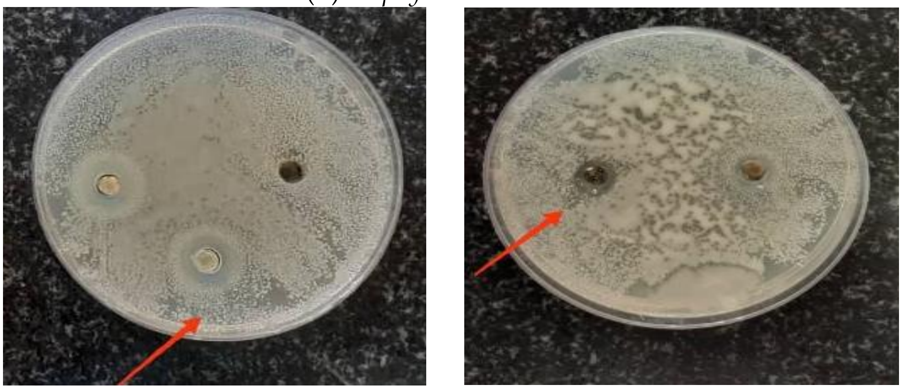
(**b**) *Pseudomonas aeruginosa*



(**c**) *Klebsiella peneumoniae*



(**d**) *Staphylococcus aureus*



(**e**) *Staphylococcus saprophyticus*

**Figure 5.** Images of antibacterial test results for gram-negative (**a**–**c**) and gram-positive (**d**,**e**) bacteria on pure CaO (left) and Ag@CaO composite (right).

## 3. Conclusions

In this work, a waste material was converted to a bioactive product against many types of bacteria. Moreover, its composite with silver showed a more successful antibacterial effect.

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