ANTIMICROBIAL ACTIVITY OF PVA MEDIATED ZINC-STRONTIUM FERRITE COMPOSITES

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Abstract: Zinc strontium ferrite composites with different ratios (0.95:0.05 and 0.5:0.5) of zinc ferrite and strontium ferrite were synthesized by the co-precipitation technique. Polyvinyl alcohol was used as a surfactant. The formation of polycrystals of zinc strontium ferrite composites was confirmed via X-ray diffraction studies. The crystallite sizes of the sample, determined by Scherrer's equation was found to be in nanoscale. The antimicrobial activity of the synthesized sample in screening two gram-negative bacteria, two gram-positive bacteria, and two fungi was analyzed using the Kirby-Bauer test.

Keywords: Composites; Co-precipitation; surfactant; Antibacterial; Antifungal; Kirby-Bauer test

1. INTRODUCTION

Zinc ferrite is a soft ferrite with a cubic spinel structure (Fd_3m symmetry) [1]. Its antibacterial activity against gram-negative bacteria (Escherichia coli and Pseudomonas aeruginosa) and gram-positive bacteria (Staphylococcus aureus and Bacillus subtilus) have been studied by several researchers [2–4]. The antifungal activity of zinc ferrite against Candida albicans has also been examined [5]. Reports are available on the antibacterial activity of strontium hexaferrite too. Strontium hexaferrite acts as a strong antibiotic against the gram-negative bacterium, Escherichia coli, and the gram-positive bacterium, Micrococcus luteus [6]. Strontium hexaferrite has a hexagonal structure with P63/mmc symmetry and is a hard ferrite [7]. Zinc-strontium ferrite composite is relatively less explored. The photocatalytic and microwave absorption application of these composites has been studied [8-12]. However, the antimicrobial property of zinc-strontium ferrite composite has not been investigated to the best of our knowledge. Antimicrobial resistance is a persisting problem,

that instigates the need for new antibiotics [13]. In the present study, we have reported the antibacterial activity of zinc-strontium ferrite composite against the gram-negative bacteria - Escherichia coli and Pseudomonas aeruginosa and gram-positive bacteria - Staphylococcus aureus and Bacillus cereus. The results were compared to a commercial antibiotic namely, amikacin. The antifungal activity of zinc-strontium ferrite composite against Candida albicans and Aspergillus flavus were also studied. The results were compared to a commercial antifungal medication namely, nystatin.

2. EXPERIMENTAL PROCEDURE

2.1. Synthesis

Zinc-strontium ferrite of molecular formula $ZnFe_2O_4/SrFe_{12}O_{19}$ in the ratio 0.95:0.05 (labelled as ZSD) and 0.5:0.5 (labelled as ZSC) were synthesized via co-precipitation technique. In the synthesis of ZSD, 0.95 M of zinc chloride and 0.05 M of strontium chloride were used as precursors. In the synthesis of ZSC, 0.5 M of zinc chloride and 0.5 M of strontium chloride were used as precursors. In both cases, 1 M of ferric chloride was also included as a precursor. 0.5g of PVA was added to the precursor solution and stirred thoroughly while heating to a temperature of 60ºC. PVA was added to the solution to act as a surfactant. Sodium chloride was used as a precipitating agent. 8 M sodium chloride solution was added in drops to the precursor solution until a pH of 7 was attained, and the reaction was maintained for 2 hours. The desired product was obtained in powder form. It was repeatedly washed with water and finally with acetone and collected via centrifuging. The collected sample was dried aerobically and was then annealed at 800ºC and finely crushed.

2.2. Kirby-Bauer test

Kirby-Bauer test, also known as disc diffusion test is a commonly used antibiotic susceptibility test. This test was used in the analysis of the antimicrobial properties of the synthesized samples. In this test, an agar medium of pH 7.2 was prepared and poured into a petri dish to a depth of 4 mm and dried at 4ºC. Within a week of agar medium preparation, the agar plates are inoculated with a bacterial suspension of moderate turbidity and allowed to dry. Antibiotic discs to be studied were impregnated on the bacterial suspension. The reference antibiotic used in the study was also impregnated alongside. The plate was then incubated aerobically for 16 hours at 35ºC. Zones of bacterial inhibition were formed around the antibiotics. The diameter of the inhibition zones was measured and reported. The reference antibiotic used in the study is amikacin. A similar procedure was adopted for the analysis of the antifungal activity of the synthesized zinc-strontium composites. The reference antifungal used in the study was nystatin.

3. RESULTS AND DISCUSSION

3.1. X-ray Diffraction (XRD)

The X-ray diffraction pattern of the synthesized samples (Fig. 1) was obtained via X'Pert Pro X-ray diffractometer. The pattern revealed the formation of crystalline zinc strontium composites with discrete phases of $ZnFe_2O_4$ and $SrFe_{12}O_{19}$. The Bragg peaks corresponding to zinc ferrite obtained at 29.9º, 35.2º, 36.9º, 42.8º,53.1º, 56.5º, 62.1º, and 73.5º and strontium ferrite obtained at 31.7º, 33.1º, 40.9º, 54º and 64.1º were indexed using JCPDS files 96-900-5103 and 24-1207 respectively [8], [14]. The crystallite size of the samples ZSD and ZSC, calculated using Scherrer's relation are 61.83 nm 104.6 nm respectively. The structure and morphology of the samples are discussed in our previous paper [15].

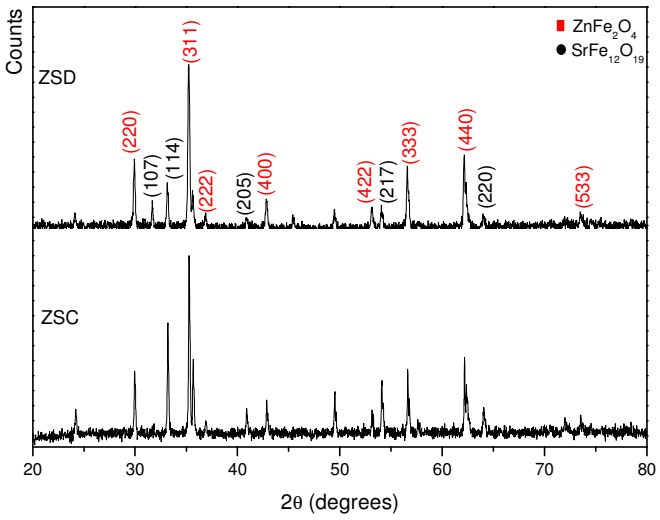

Fig. 1: XRD pattern of zinc-strontium ferrite

3.2. Antibacterial activity against gram-negative bacteria

The inhibition zones measurement of Escherichia coli and Pseudomonas aeruginosa due to the samples ZSD, ZSC, and amikacin are tabulated in table 1 and pictorially represented in fig. 2. It is observed that the synthesized samples show greater efficiency in screening Pseudomonas aeruginosa compared to Escherichia coli. It is also noticed that the antibacterial activity of zinc strontium ferrite increased with an increase in the strontium ferrite composition of the composite. ZSC exhibited a greater potential compared to amikacin in killing the Pseudomonas aeruginosa.

	Escherichia coli	Pseudomonas aeruginosa
Amikacin	24 mm	23 mm
ZSD	16 mm	22 mm
ZSC	18 mm	25 mm

Table 1. Antibacterial activity of zinc strontium ferrite against gram-negative bacteria

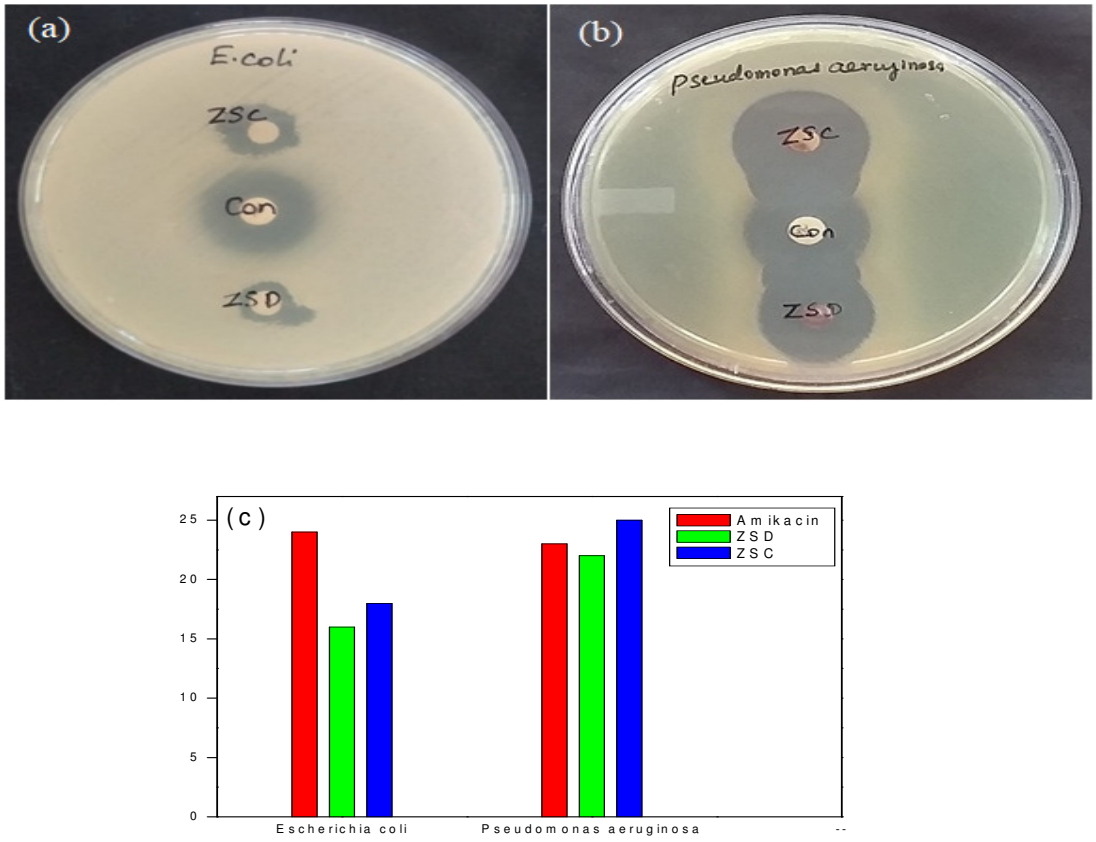

Fig 2. Antibacterial activity of zinc strontium ferrite against gram-negative bacteria

3.3. Antibacterial activity against gram-positive bacteria

The inhibition zones measurement of Staphylococcus aureus and Bacillus cereus due to the samples ZSD, ZSC, and amikacin are tabulated in table 2 and pictorially represented in fig. 3. It is observed that the synthesized samples show greater efficiency in screening Staphylococcus compared to Bacillus cereus. It is also noticed that the antibacterial activity of zinc strontium ferrite decreased with an increase in the strontium ferrite composition of the composite. The synthesized samples exhibited a greater potential compared to amikacin in killing the Staphylococcus aureus.

	Staphylococcus aureus	Bacillus cereus
Amikacin	21 mm	26 mm
ZSD	28 mm	20 mm
ZSC	24 mm	13 mm

Table 2. Antibacterial activity of zinc strontium ferrite against gram-positive bacteria

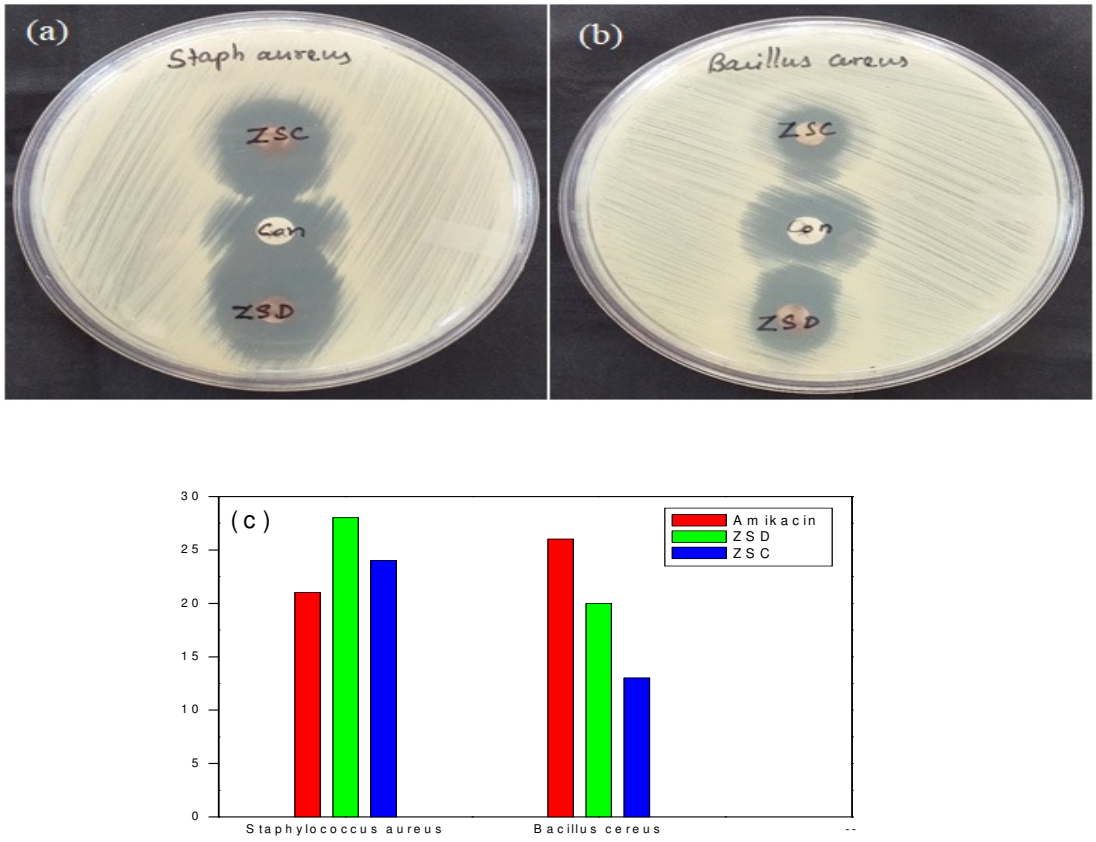

Fig 3. Antibacterial activity of zinc strontium ferrite against gram-positive bacteria

3.4. Antifungal activity

The inhibition zones measurement of Candida albicans and Aspergillus flavus due to the samples ZSD, ZSC, and nystatin are tabulated in table 3 and pictorially represented in fig. 4. The synthesized samples show good antifungal activity against both the fungi. The antifungal activity of zinc strontium ferrite is observed to decrease with an increase in the strontium ferrite composition of the composite. However, the diameter of inhibition zones produced by both ZSD and ZSC is greater compared to that of nystatin.

	Candida albicans	Aspergillus flavus

Nystatin	16 mm	13 mm
ZSD	18 mm	15 mm
ZSC	17 mm	14 mm

Table 3. Antifungal activity of zinc strontium ferrite

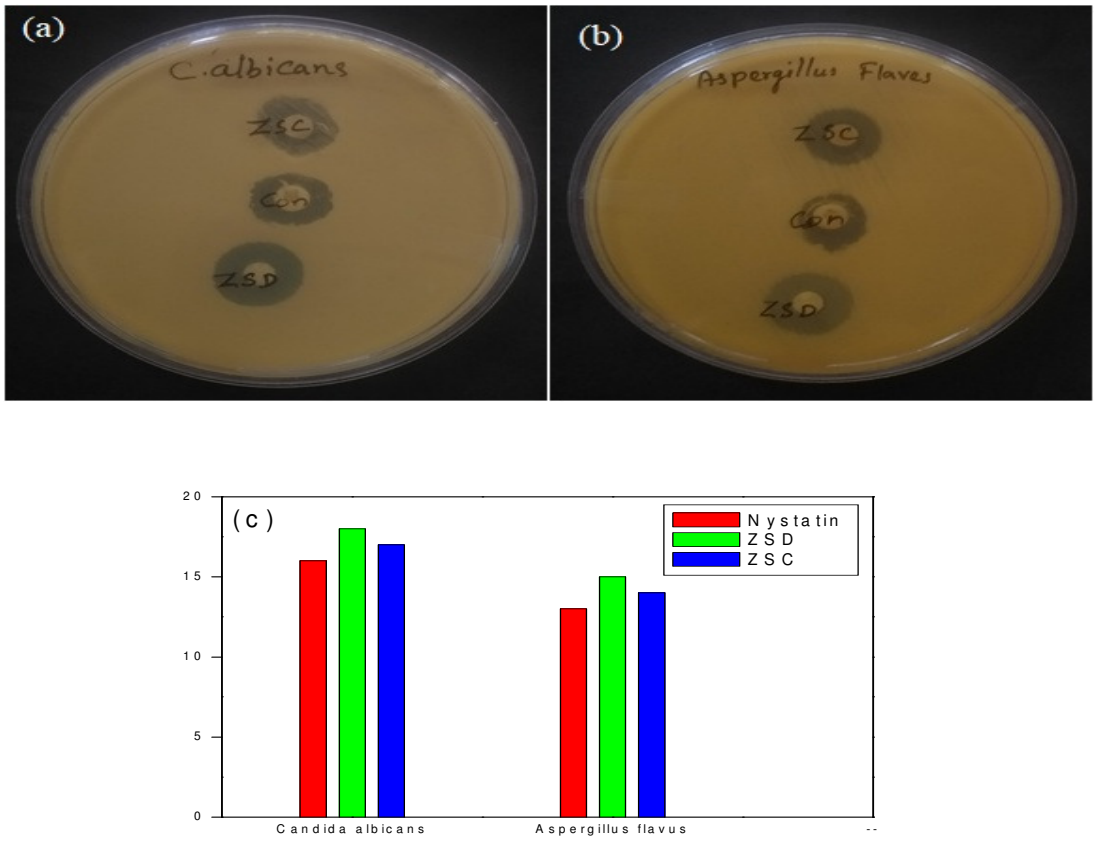

Fig 4. Antifungal activity of zinc strontium ferrite

4. CONCLUSION

The antimicrobial activity of synthesized zinc strontium ferrite composites (ZSD and ZSC) was studied against Escherichia coli, Pseudomonas aeruginosa, Staphylococcus aureus, Bacillus cereus, Candida albicans, and Aspergillus flavus, using the Kirby-Bauer test. The zinc strontium ferrite samples exhibited excellent antibacterial activity against the gram-positive bacterium, Staphylococcus aureus, and good antibacterial activity against the gram-negative bacterium, Pseudomonas aeruginosa. However, the synthesized samples did not show remarkable antibacterial activity in screening the gram-positive bacterium, Bacillus cereus, and the gram-negative bacterium, Escherichia coli. The samples also exhibited good antifungal activity against both the fungi - Candida albicans and Aspergillus flavus.

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