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Fabrication and Characterization of Novel Cement Mortar/(PVP–CMC–Y_2O_3) Nanocomposites for Antifungal and Antibacterial Agents

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Synthesis of novel cement mortar/polymer nanocomposites for antifungal and antibacterial applications is investigated. The blend solution of polyvinyl pyrrolidone (PVP) and carboxymethyl cellulose (CMC) with various ratios of yttrium oxide (Y_2O_3) nanoparticles is prepared with content of 1 wt.% by weight of cement. The (PVP–CMC–Y_2O_3) nanocomposites are used with cement to fabricate the mortar/(PVP–CMC–Y_2O_3) nanocomposites for biomedical applications. The cement mortar/(PVP–CMC–Y_2O_3) is tested against Aspergillus, Lactose organisms and Proteus organisms. Results show that the inhibition zones increase as Y_2O_3 nanoparticles' ratios increase.

Досліджено синтезу нових цементних розчин/полімер-нанокомпозитів для протигрибкових та антибактерійних застосувань. Суміш розчину полівінілпіролідону (PVP) і карбоксиметилцелюлози (CMC) з різними співвідношеннями наночастинок оксиду Ітрію (Y_2O_3) готується з вмістом 1 ваг.% за вагою цементу. Нанокомпозити (PVP–CMC–Y_2O_3) використовуються з цементом для виготовлення нанокомпозитів розчин/(PVP–CMC–Y_2O_3) для біомедичних застосувань. Цементний розчин/(PVP–CMC–Y_2O_3) тестується проти аспергіллуса, лактозних організмів і організмів протея. Результати показують, що зони гальмування

збільшуються в міру збільшення співвідношення наночастинок Y_2O_3.

Key words: antifungal agent, antibacterial agent, yttrium oxide, cement mortar, nanocomposites.

Ключові слова: протигрибковий засіб, антибактеріальний засіб, оксид ітрію, цементний розчин, нанокомпозити.

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1. INTRODUCTION

The introduction of nanoparticles or lamellar solids materials in mortars and concrete to enhance it mechanical characterization has been generally tested in present concrete technology. The modern studies on nanoparticles and nanotechnology explain using these nanomaterials in different fields such as automobile industry, medicine, energy, construction, *etc.* This is related to the particular appearances of mater at the nanosize. Building materials can be considered as beneficiaries of the investigations and their applications that will enhance the properties of concrete and insulating materials [1].

Nanoparticles, including metals and metals oxides, can be used and applied in cosmetics, electronics, agriculture, food industry, and building materials. The manufactures of cement mortars and concretes are mainly important branches in building materials [2].

In the present time of multidrug resistance, in which viruses, fungi, parasites and bacteria are gaining resistance to various antimicrobial agents, it is becoming especially complex for health care staff to treat patients [3]. Antimicrobial agents are of high importance in several commercial fields such as environmental one, textiles packaging industries and medical products, *etc*. However, random use of antibiotics leads to resistance of bacteria to the antimicrobial drugs. Nanomaterials with their huge surface area-to-volume ratio have been studied to be expected candidates used for antimicrobial agents.

Metal oxides nanoparticles have huge applications in many fields ranging from water treatment, medicine, engineering, cosmetics, *etc*. [4]. Yttrium oxide (Y_2O_3) is one of the mainly promising substances for the synthesis of chemical catalysis and optoelectronic applications. Y_2O_3 is a distinguished material due to its properties of good thermal stability of high dielectric constant in a powder state. Y_2O_3 may be used as high-activity additive and useful composite similar to yttria-stabilized zirconia films. In addition, Y_2O_3 is generally used as a host substance for different rare earth dopants and is of attention for potential area in biological imaging [5].

2. MATERIALS AND METHODS

Nanocomposites/mortar is prepared according to the ASTM C373 with ratio 1:3 for cement/sand. The solutions of nanocomposites are fabricated with content 1 wt.% from weight of cement. The solution of polymers is prepared with content (50 wt.% PVP with 50 wt.% CMC).

The yttrium oxide (Y_2O_3) nanoparticles were added to solution of polymers with ratios 1, 2 and 3 wt.%. The solutions of PVP–CMC–

TABLE 1. The chemical analysis of the used cement (according to IQS No. 472/1984).

Oxide	Value	Limits according to IQS
CaO	61.00	—
SiO_2, %	19.50	—
Al_2O_3, %	3.80	—
Fe_2O_3, %	5.60	—
MgO, %	3.00	≤ 5%
SO_3, %	2.00	≤ 2.5% if $C_3A < 5\%$
Loss on ignition, %	3.65	< 4%
Total, %	98.55	—
Free lime, %	1.32	—
Insoluble residue, %	1.40	≤ 1.5%
L.S.F.	0.93	0.66–1.02
M.S.	2.07	—
M.A.	0.68	
C_3S, %	55.52	—
C_2S, %	14.02	—
C_3A, %	0.59	≤ 3.5%
C_4AF, %	17.04	

TABLE 2. The physical properties of the used cement (according to IQS No.5/1984).

Property		Value	Limits ace ending to IQS
Initial setting time, hour:min		02:27	≥ 00:45
Final setting time, hour:min		03:30	≤ 10:00
Fineness (Blaine) in m^2/kg		307	≥ 250
Compressive strength, MPa at	3 day	17.31	≥ 15.00
	7 day	26.24	≥ 23.00

Y_2O_3 nanomaterials were added to cement to prepare the cement mortar nanocomposites for antifungal and antibacterial agents. Then, these ingredients were mixed for 4 minutes using a spark mixer, and a vibrating machine further mixed the resultant mixtures with a frequency of 200 Hz for another 4 minutes. Finally, the samples were subjected to humid environment for 24 hours and immersed in distilled water for another seven days before testing.

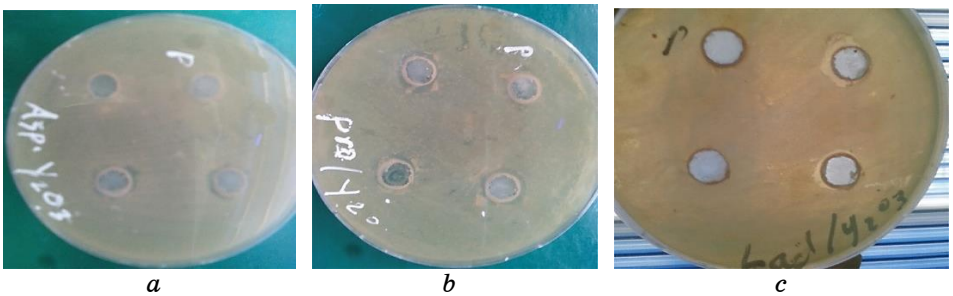
The used cement was analysed according to the Iraqi standard No. 472/1984 as shown in Table 1, and its physical properties according to the Iraqi standard No. 5/1984 is shown in Table 2.

The antifungal and antibacterial agents were tested against fungal (Aspergillus), positive bacteria (Lactose) and negative bacteria (Proteus) by disc diffusion method.

3. RESULTS AND DISCUSSION

The antifungal and antibacterial tests of the mortar samples (cement/PVP–CMC–Y_2O_3 nanocomposites) were tested against fungal (Aspergillus), positive bacteria (Lactose) and negative bacteria (Proteus) as shown in Figures 1–4. The inhibition-zones' areas increase as Y_2O_3 nanoparticles ratios increase. Antifungal effect of cement mortar/nanocomposites is explained by its high surface area. The Y_2O_3 nanoparticles can energetically inhibit the development of fungal strains by interfering cell and effecting deformation in fungal hyphae [6].

The explanation for the antibacterial effect of cement nanocomposites can be related to occurrence of reactive oxygen species produced by Y_2O_3 nanoparticles. The (cement–nanocomposites) mortar goes on to contact with the dead bacteria; in one time, the hydrogen peroxide was produced and, hence, prevents further the action of bacteria and carry on to create and release the hydrogen peroxide to medium. The mechanism, which is possible for action, is as follows: Y_2O_3 nanoparticles in mortar have positive charges, and the mi-



a *b* *c*

Fig. 1. Images of cement–nanocomposites mortar against: (*a*) Aspergillus; (*B*) Lactose; (*c*) Proteus.

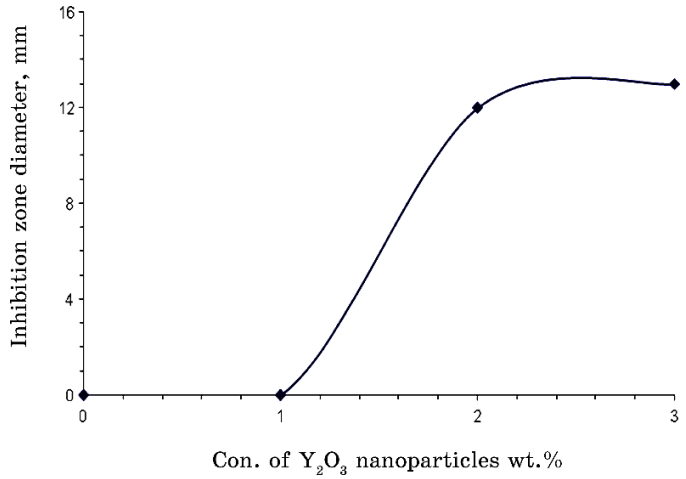


Fig. 2. Antifungal agent of (cement–nanocomposites) mortar against Aspergillus.

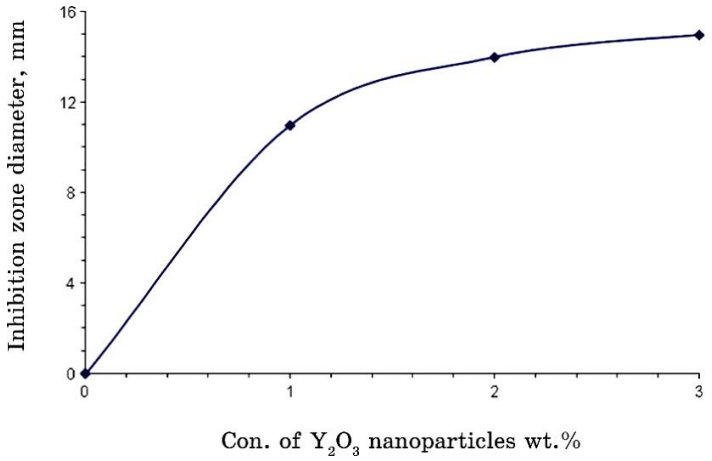


Fig. 3. Antibacterial agent of (cement–nanocomposites) mortar against Lactose.

crobes have negative charges and, hence, produce the contact between the Y_2O_3 and the bacteria. When the contact was created, the bacteria become oxidized that leads it to the die [7–10].

4. CONCLUSIONS

The cement–nanocomposites mortar samples are fabricated against Aspergillus organisms, Lactose organisms and Proteus organisms.

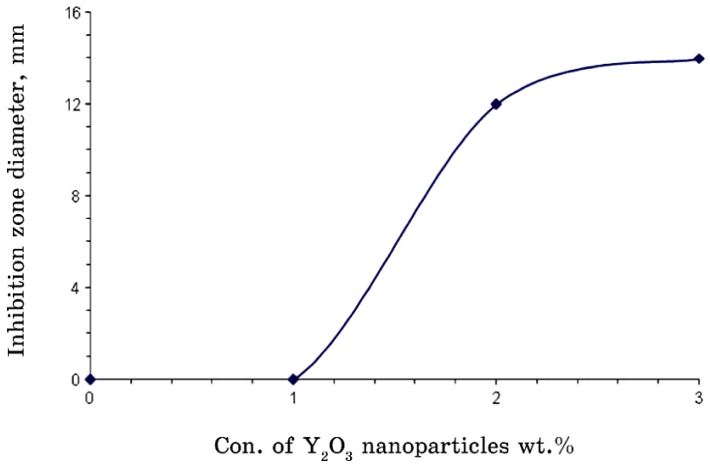


Fig. 4. Antibacterial agent of (cement–nanocomposites) mortar against Proteus.

The areas of inhibition zones of antifungal and antibacterial tests rise as the Y_2O_3 nanoparticles ratios raise.

The prepared samples of cement–nanocomposites mortar have good antifungal and antibacterial effects.

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