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Preparation of PEO/CuO–In_2O_3 Nanocomposites' Films for Antibacterial Fields

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Films of pure PEO, PEO/CuO and PEO/CuO–In_2O_3 nanocomposites are prepared for antibacterial applications. The films are fabricated by using casting method. The samples of PEO/CuO–In_2O_3 nanocomposites are tested for gram-positive organisms (*Bacillus cereus*) and gram-negative organisms (*Salmonella*). As shown, the PEO/CuO–In_2O_3 nanocomposites have good activity against gram-positive organisms and gram-negative organisms.

Плівки чистого поліетиленоксиду (ПЕО), нанокомпозитів ПЕО/CuO та ПЕО/CuO–In_2O_3 підготовлено до антибактерійних застосувань. Плівки виготовляються методом лиття. Зразки нанокомпозитів ПЕО/CuO–In_2O_3 тестуються на грампозитивні організми (*Bacillus cereus*) і грамнеґативні організми (*Salmonella*). Як показано, нанокомпозити ПЕО/CuO–In_2O_3 мають хорошу активність по відношенню до грампозитивних організмів і грамнеґативних організмів.

Key words: In_2O_3, PEO, nanocomposites, films, antibacterial agents.

Ключові слова: In_2O_3, поліетиленоксид, нанокомпозити, плівки, антибактерійні засоби.

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1. INTRODUCTION

Nanocomposites of polymers and inorganic nanoparticles (INPs) have attracted increasing interest due to their value-added applications derived from their unique opto-electric, magnetic, electrical, thermal, and antibacterial properties [1]. Polymer nanocomposite materials are of great scientific and technological interest due to their unique optical, electronic, and mechanical properties. These materials are used in different applications like optoelectronic devices, magnetooptic data storages, reflective materials, and photovoltaic cells [2].

Inorganic–organic nanocomposites have gained a technological robust in the field of linear optics, nonlinear optics and solar cells owing to their outstanding properties and novel applications. Combining one or more metal-oxide nanoparticles (MO NPs) with one or more polymer composites leads to a new class of state-of-art nanocomposites. Particularly, the incorporation of polymers with MO NPs such as ZnO, CuO, ZnS, SiO_2, TiO_2 and Al_2O_3 has been demonstrated to nanocomposites exhibiting excellent electrical, optical and mechanical properties. Polymer composites developed several striking properties such as easy processing, resistance to deformations and organic functionalities. Moreover, MO NPs are well known to possess attractive properties such as stiffness, transparency, good thermal and chemical stabilities. Nanocomposites synthesized by blending polymers with MO NPs exhibit properties of both components to yield multifunctional materials with new or enhanced properties overtaking each single-component independently. Recently, considerable interest has been focused on nanocomposite thin films due to their physical properties and applications in optical lenses, UV shielding, light-emitting diodes (LED), photodetectors, solar cells, multisensors, organic transformation reactions, super capacitors and corrosion protections [3].

Polymers are versatile materials that have certain unique properties such as low density, flexibility, toughness, easy processability, and low conductivity. However, these properties are still inadequate for efficient industrial applications. Hence, continuous research efforts are in progress to develop new polymeric materials with advanced properties. The desired properties can be obtained by adding filler (organic and inorganic materials) to the polymer matrix [4].

The In_2O_3 possess a very good magnitude of energy gap equal to about 3.2 eV that does these materials very promising for the optical applications. Particular interest presents nanoparticles of these materials. This is caused by their very specific crystal-chemical structure [5]. The bacterial infection is threatening the health of humans and any living species, on the other hand, the infecting bacteria pollute the water, soil, and the environment, eventually leading to the death of animals and plants. Therefore, until now, antibacterial agents have attracted a great deal of attentions and many of them have been developed. The excessive use of antibiotics has resisted the bacteria against their drugs, causing a serious public health problem [6]. This paper aims to prepare PEO, PEO/CuO and PEO/CuO–In_2O_3 nanocomposites' films for antibacterial applications.

3. MATERIALS AND METHODS

The pure PEO, PEO/CuO and PEO/CuO–In_2O_3 nanocomposites films are prepared by dissolving 1 gm of PEO in 40 ml of distilled water, then added 1.8 wt.% CuO to PEO, and the indium oxide (In_2O_3) was added to the PEO/CuO with ratios of 1.8, 3.6, and 5.4 wt.%. The components were mixed using a magnetic stirrer for 1 h to obtain homogeneous solution. The casting method is used to prepare the PEO/CuO–In_2O_3 nanocomposites in the template (Petri dish has diameter 10 cm). The samples were prepared with thickness 140 μm. Antibacterial activity of PEO/CuO–In_2O_3 nanocomposites tested using a disc diffusion method. The antibacterial activities were done by using gram-positive organisms (*Bacillus cereus*) and gram-negative organisms (*Salmonella*).

4. RESULTS AND DISCUSSION

The distribution of CuO–In_2O_3 nanoparticles in the PEO matrix are shown in Figs. 1, 2. The figures show that the microscopic and SEM images of PEO/CuO–In_2O_3 nanocomposites. As shown in these Figures, the CuO–In_2O_3 nanoparticles are aggregated as clusters at low concentrations, and they form a paths network inside the polymer matrix at high concentrations [7]. These results agree with Refs. [8–12].

The antibacterial activity of PEO/CuO–In_2O_3 nanocomposites against gram-positive organisms (*Bacillus cereus*) and gram-negative organisms (*Salmonella*) are presented in Figs. 3, 4. The inhibition zone diameter rises with rise in the concentrations of CuO–In_2O_3 nanoparticles. The main mechanism that caused the antibacterial activity by the metal-oxide nanoparticles might be through oxidative stress caused by ROS. ROS includes radicals like super oxide radicals (O^{-2}), hydroxyl radicals (^{-}OH) and hydrogen peroxide (H_2O_2) and singlet oxygen ($^1O_2$) could be the reason damaging the proteins and DNA in the bacteria. ROS could have been produced by the present nanocomposites leading to the inhibition of most pathogenic bacteria [13–16].

5. CONCLUSIONS

In present work, the antibacterial application of films of pure PEO, PEO/CuO and PEO/CuO–In_2O_3 nanocomposites has been investigated to use it for biomedical fields.

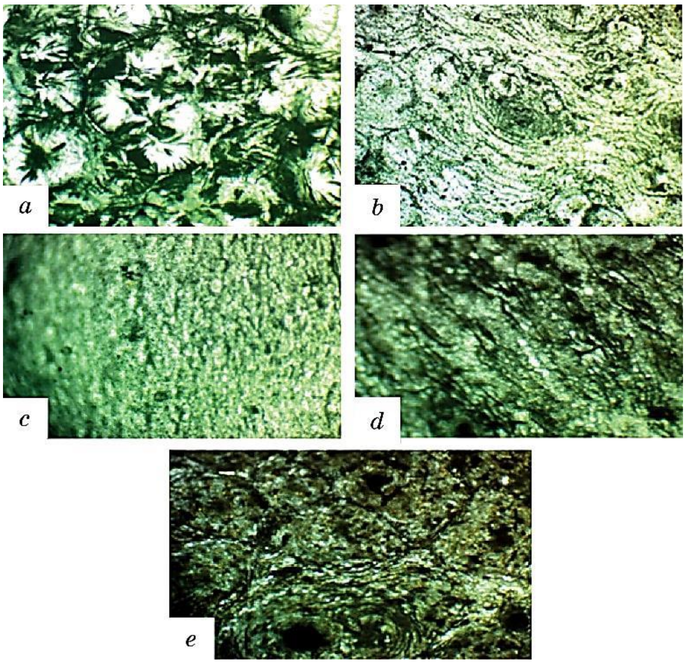

Fig. 1. Microscope images of PEO/CuO–In_2O_3 nanocomposites: *a*—PEO; *b*—1.8 CuO NPs; *c*—1.8 In_2O_3 NPs; *d*—3.6 In_2O_3 NPs; *e*—5.4 In_2O_3 NPs (in wt.%).

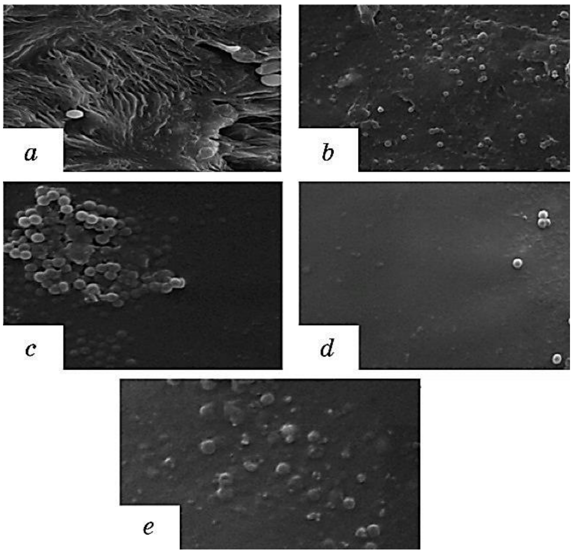

Fig. 2. SEM images of PEO/CuO–In_2O_3 nanocomposites: *a*—PEO; *b*—1.8 CuO NPs; *c*—1.8 In2O3 NPs; *d*—3.6 In2O3 NPs; *e*—5.4 In2O3 NPs (in wt.%).

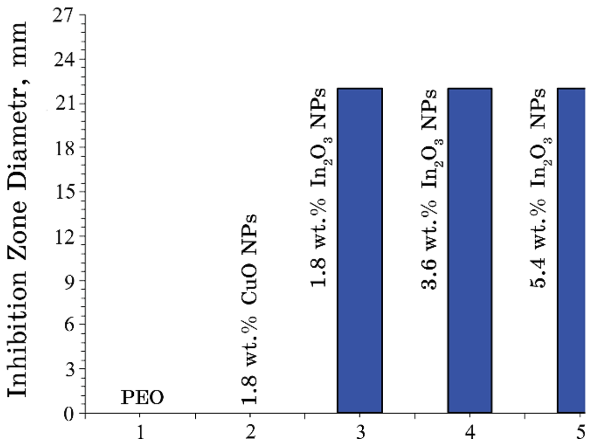

Fig. 3. Antibacterial activity of PEO/CuO–In_2O_3 nanocomposites against gram-positive organisms (*Bacillus cereus*).

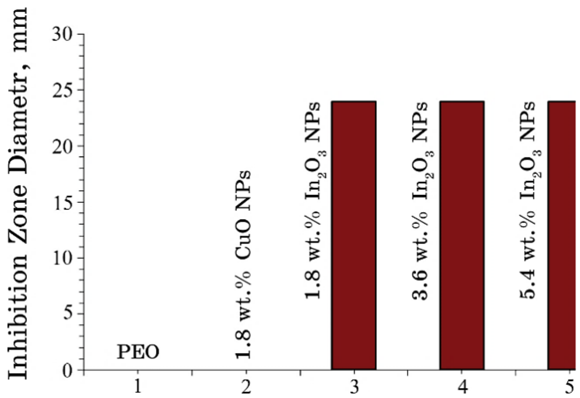

Fig. 4. Antibacterial activity of PEO/CuO–In_2O_3 nanocomposites against gram-negative organisms (*Salmonella*).

The PEO/CuO–In_2O_3 nanocomposites films were tested for gram-positive organisms (*Bacillus cereus*) and gram-negative organisms (*Salmonella*). The results showed that the PEO/CuO–In_2O_3 nanocomposites have good activity against gram-positive organisms and gram-negative ones.

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