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Antimicrobial Properties of Some Zinc Compounds

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It was revealed that the antimicrobial activity of nanodispersed zinc oxide depends on the particle shape. The greatest antibacterial activity of rod-shaped particles from all other studied shapes was shown. Zinc salicylate was synthesized and found to have biological activity against certain microorganisms.

Index Terms: antimicrobial activity, nanoparticles, zinc oxide, zinc salicylate.

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I. INTRODUCTION

The search for new compounds with high biological activity is an urgent task, since many microorganisms have become accustomed to most medications. Along with the synthesis of new organic molecules with high biological activity, it is worth paying attention to a number of inorganic compounds, in particular, zinc compounds.

The purpose of this paper was to identify the biological activity of zinc oxide and salicylate. There are several reasons for choosing these compounds. On the first hand, zinc oxide has long been known to be used in various medical preparations, but its biological activity has not been sufficiently studied. On the second hand, there is a drug on the Russian market that contains a mixture of zinc oxide and salicylic acid. The study of the biological activity of zinc salicylate, rather than a mixture of individual components, has scientific significance.

II. EXPERIMENTAL

Synthesis of zinc salicylate ($Zn(Sal)_2$) and nanodispersions of zinc oxide with different particle shapes were carried out according to the methods developed earlier [1, 2] and described in [3].

IR spectra were obtained with a SolidSpec-3700 spectrophotometer.

Antimicrobial activity was evaluated using standard microbiological analyses methods.

III. RESULTS AND DISCUSSION

Despite the long-known antimicrobial properties of zinc compounds, there are a number of factors that prevent the effective use of zinc compounds for the treatment of skin diseases and injuries. This can include the low solubility of zinc oxide, as well as the susceptibility to hydrolysis of a number of zinc salts.

The use of salicylic acid for the production of zinc salts has a range of advantages, since the salicylate anion has its own pharmacological activity (analgesic, anti-inflammatory, antiseptic, keratolytic).

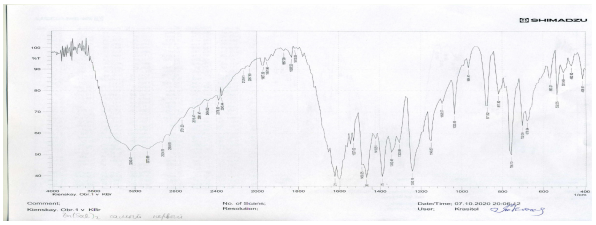
Comparison of methods for the synthesis of zinc salicylate described in [2, 3] showed that the method proposed by the patent author [2] is more preferable. According to this method, not only the main product yield is higher, but also the purity of the prepared zinc salicylate. Therefore, based on this method, zinc salicylate was obtained according to the following reactions:

$$Zn(NO_3)_2 + K_2CO_3 \rightarrow ZnCO_3 + 2KNO_3 \quad (1)$$

$$2SalH + ZnCO_3 \rightarrow Zn(Sal)_2 + CO_2 + H_2O \quad (2)$$

Fig. 1 shows the IR spectrum of zinc salicylate recorded in KBr tablets.

Figure 1. IR spectrum of zinc salicylate synthesized by the method [1].

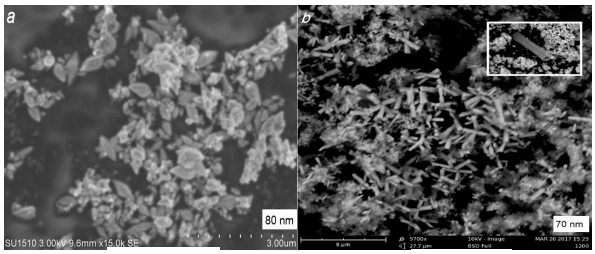


It should be noted that this salt is highly soluble in water, practically does not undergo hydrolysis, and for the study of biological activity ($Zn(Sal)_2$) molecular solutions were used. As opposed to salt, zinc oxide is insoluble in water, so water nanodispersions were used to study its biological activity.

A micrograph of zinc oxide particles of various shapes is shown in Fig. 2. The ZnO particle size does not exceed 60 nm in both cases.

The study of the zinc salicylate biological activity showed that zinc salicylate increases the metabolic and proliferative activity of rat fibroblasts comparable to zinc acetate. At the same time, zinc salicylate at a concentration of 0.5 mmol / L has a greater effect on the migration activity of fibroblasts in the first 12 hours after scarification damage than zinc acetate. Thus, the result of using zinc salicylate as a wound healing agent was the increasing the metabolic and proliferative activity, as well as in increasing the migration activity of fibroblasts and protecting cellular lipids from damage. Currently, research on the development of a wound-healing drug based on zinc salicylate in the form of a gel is proceeding.

Figure 2. Micrographs of wedge-shaped ZnO particles (a) and rod-shaped finely dispersed ZnO particles (b) obtained by scanning electron microscopy.



(a) (b)

Successful experiments on rats described above suggested that the antimicrobial activity of zinc compounds can also influence wound healing.

The following strains of microorganisms were used as a test cultures: *Staphylococcus aureus subs. aureus* FDA

209P, *Escherichia coli* ATCC 25922, *Candida albicans* ATCC 885-653, *Bacillus subtilis* VKPM B-13183, *Pseudomonas aeruginosa* VKPM B-8243.

To determine the antimicrobial activity, prepared suspensions of test organisms in an amount of 0.1 mL were introduced into Petri dishes on the surface of a dense nutrient medium and evenly distributed over the surface with a sterile spatula. Disks were prepared from sterile filter paper with a diameter of 0.6 cm, impregnated with samples and applied to the surface of the culture medium with sown test cultures. To ensure the diffusion of the sample's active components into the culture medium, Petri dishes were left for 1 h at room temperature, then placed in a thermostat and incubated at 37°C for 24 hours. After incubation, zones of inhibition of microorganisms test cultures growth were measured in a thermostat.

The zinc oxide nanodispersions with particles of various shapes were prepared as a samples. The content of zinc oxide was constant everywhere and was 0.1% by weight. For comparison, a coarse suspension of zinc oxide with a particle size of 40-50 microns was used.

The results are presented in Table I.

Table I. Size of the test organisms growth inhibition zone

Test-organisms	Inhibition zone size, mm		
	Tapered particles ZnO	Rod-like particles ZnO	Coarse dispersion of spherical particles ZnO
St. aureus	—	15-20	—
P.aeruginosa	5	8	—
E. coli	—	—	—
B. subtilis	10	10-15	2-4
C.albicans	—	—	—

Analysis of the results of this table leads to the conclusion that: firstly, zinc oxide does not show activity to *E.coli* and *C.albicans*; secondly, rod-shaped particles are more active.

At the final stage of these studies, a comparative evaluation of the antimicrobial activity of all the compounds and compositions considered here, namely: zinc salicylate, salicylic acid, and a mixture of salicylic acid with zinc oxide. It was found that at comparable concentrations, neither salicylic acid nor a mixture of salicylic acid with coarse zinc oxide exhibit more pronounced antimicrobial activity than nanodispersions of zinc oxide with rod-shaped particles. On the contrary, aqueous solutions of zinc salicylate (0.5% by weight) demonstrated inhibition of the growth of gram-positive bacteria *Bacillus subtilis* and *Staphylococcus aureus*, which makes it possible to consider zinc salicylate a promising compound for the development of antimicrobial drugs based on it.

CONCLUSION

Thus, it was found that zinc compounds (highly dispersed zinc oxide and zinc salicylate) are promising compounds for the development of antimicrobial compositions based on them. It should be considered that the antimicrobial activity of zinc oxide depends on both the shape and size of the particles.

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