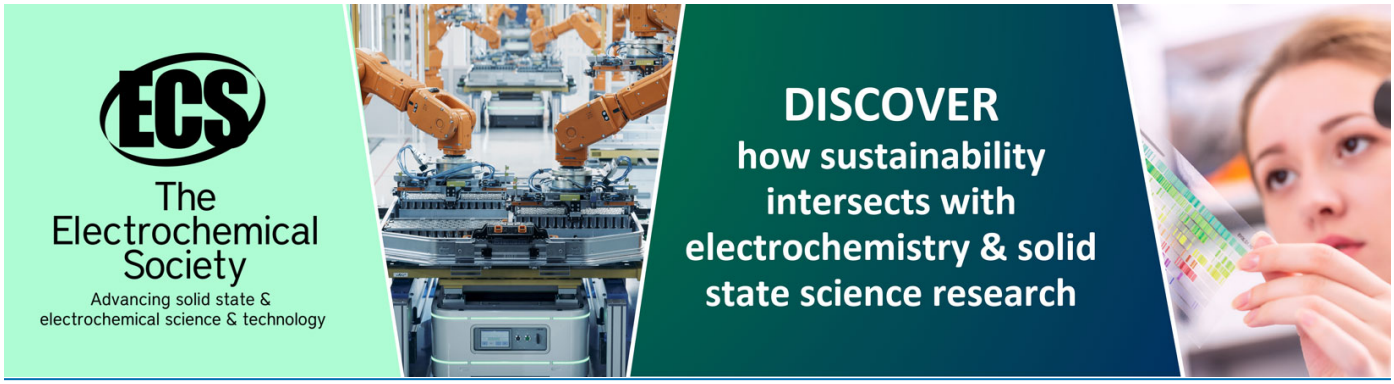
Fibrous materials on polyhydroxybutyrate and ferric iron (III)-based porphyrins basis: physical-chemical and antibacterial properties



Fibrous materials on polyhydroxybutyrate and ferric iron (III)-based porphyrins basis: physical-chemical and antibacterial properties

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Abstract. Ferric iron (III)-based complexes with porphyrins are the homogenous catalysts of auto-oxidation of several biogenic substances. The most perspective carrier for functional low-molecular substances is the polymer fibers with nano-dimensional parameters. Application of natural polymers, poly-(3-hydroxybutyrate) or polylactic acid for instance, makes possible to develop fiber and matrice systems to solve ecological problem in biomedicine The aim of the article is to obtain fibrous material on poly-(3-hydroxybutyrate) and ferric iron (III)-based porphyrins basis and to examine its physical-chemical and antibacterial properties. The work is focused on possibility to apply such material to biomedical purposes. Microphotographs of obtained material showed that addition of 1% wt. ferric iron (III)-based porphyrins to PHB led to increased average diameter and disappeared spindly structures in comparison with initial PHB. Biological tests of nonwoven fabrics showed that fibers, containing ferric iron (III)-based tetraphenylporphyrins, were active in relation to bacterial test-cultures. It was found that materials on polymer and metal complexes with porphyrins basis can be applied to production of decontamination equipment in relation to pathogenic and opportunistic microorganisms.

1. Introduction

Development of polymer modification of biologically active substances is the one of the most promising field of engineering chemistry. It is focused on synthesis of polymer materials with significant biomedical properties. Ferric iron (III)-based complexes with porphyrins are the homogenous catalysts of auto-oxidation of several biogenic substances. In this process the formation of active forms of oxygen as intermediate products of reaction occurs, such as superoxide anion radicals, peroxy and hydroperoxy radicals, hydrogen peroxide. The cytostatic activity of these substances is well known. These radical and ion-radical particles cause oxidative and destructive reactions in cells, which define its antibacterial effect [1, 2]. The most perspective carrier for functional low-molecular substances is the polymer fibers with nano-dimensional parameters. The electrostatic spinning or electrospinning of polymer solution is one of the most updated technologies of obtaining such fibers.

Low cost of equipment, simplicity of instrumentation, variety of technological conditions, and wide range of obtained fibers and materials on their basis are among the advantages of electrospinning [3].

Application of natural polymers, poly-(3-hydroxybutyrate) or polylactic acid for instance, makes possible to develop fiber and matrice systems to solve ecological problem in biomedicine. These materials are biocompatible and have controlled biodegradability without formation of toxic substances [4, 5].

2. Experimental part

2.1. *Materials and Preparation of Samples*

In current work the new material on polyhydroxybutyrate (PHB) fibers and ferric iron (III) complexes with tetraphenylporphyrins basis was obtained. The structural formula of ferric iron (III)-based porphyrins is presented in Figure 1

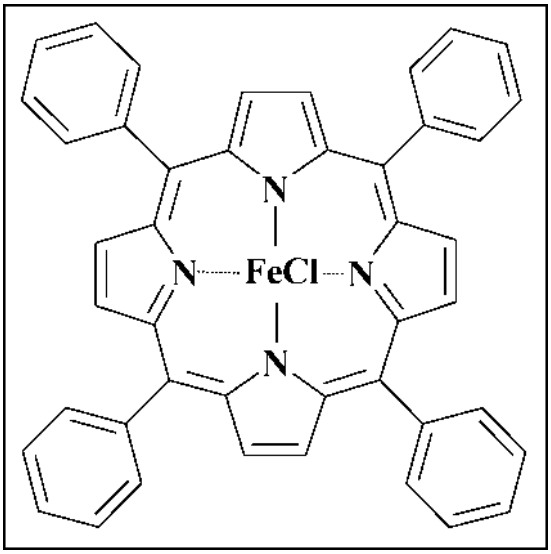


Figure 1. Ferric iron (III) complex with tetraphenylporphyrin

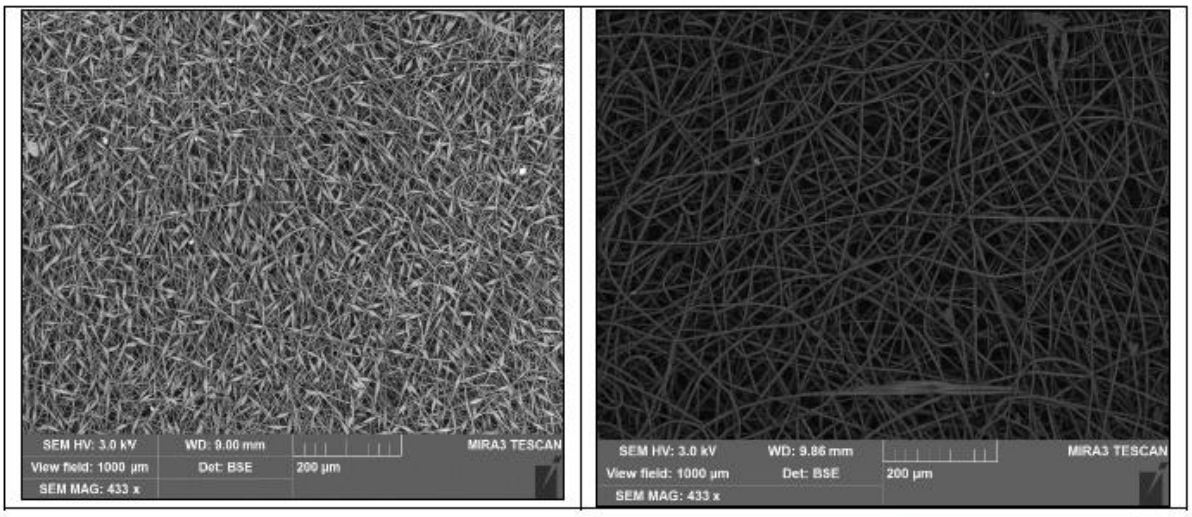
Ultrathin fibers of PHB fibers with addition of 1,3 and 5 % wt. of ferric iron (III)-based porphyrins (in relation to content of PHB in solution) were obtained by electrospinning method in chlorophorm solution. The single-capillary installation EFW-1 (Russia) was used with voltage 11kV. The distance between electrodes was 15 cm. The concentration of polymer in spinning solution was 7% wt. The dynamic viscosity of solution was 0,9 Pa*s and volumetric flow rate of spinning solution was (10-12)*10^5 g/s.

2.2. *Measurements*

The morphology of fibrous materials was examined by electronic microscopy method with using of electronic microscope Hitachi TM-1000 (Japan). Biocidal activity was determined by diffusion into agar medium, containing test-cultures. The parameter was defined by diameter of bacteriostasis zones. Test-cultures of *Staphylococcus aureus* P209 and *Escherichia coli* 1257 with different dilution were used in current work. Test- cultures of microorganisms were cultivated in beef-extract agar at temperature 37°C during 24 hours, then wipe samples from fibrous material were made. These samples were placed in test pit with the diameter 3 mm. Inoculations were incubated within 24 hours at temperature 37°C. Then the measurements of bacteriostasis zones were made.

3. Results and discussion

In dependence to characteristics of spinning solution and technological parameters of electrospinning, the fibers with different diameter, density, geometry can be obtained [3, 5]. In Fig. 2a and 2b the microphotographs of nonwoven fabric on PHB with addition of 1% wt. ferric iron (III)-based porphyrins are shown. As it is seen, for initial PHB significant number of spindly thickenings was observed. The most common reason of thickenings is disturbance of steady state of spinning solution outflow cause of insufficient conductivity of spinning solution or its suboptional viscosity [3]. As it is seen in Fig. 2a for single fiber the sequence of cylindrical fibers with the diameter of 1-3 μm and spindly elements with maximum diameter ~10 μm and length 20-30 μm was observed. With the addition of 1% wt. ferric iron (III)-based porphyrins average diameter of such fibers increased insignificantly 2-4 μm, but spindly structures practically disappeared. Only single local thickenings on fibers were observed. Possibly, this effect is explained by increased conductivity of spinning solution in presence of polar molecules of ferric iron (III)-based porphyrins. Following increase of concentration of ferric iron (III)- based porphyrins in spinning solution caused disappearance of thickenings on fibers. Thus, it was concluded that ferric iron (III) complex with tetraphenylporphyrin can be used as technological additive, which increases conductivity of spinning solution of PHB in chlorophorm.



(a) (b)

Figure 2 (a). Electron microphotographs of fibrous material on PHB basis (b). Microphotograph of fibrous material on PHB and ferric iron (III)-based porphyrins basis

Biological tests of nonwoven fabrics showed that fibers, containing ferric iron (III)-based tetraphenylporphyrins, were active in relation to bacterial test-cultures. It was found that materials on polymer and metal complexes with porphyrins basis can be applied to production of decontamination equipment in relation to pathogenic and opportunistic microorganisms.

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