SYNTHESIS OF PULLULAN-BASED SILVER NANOPARTICLES AND THEIR ANTIMICROBIAL ACTIVITY FOR PREVENTION OF FOOD SPOILAGE

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In this work we investigated the synthesis and antimicrobial properties of a pullulan based silver-nanoparticles. Pullulan is nontoxic and biodegradable polysaccharide, therefore has wide applications, from food, as additive, to environmental remediation agents [1].

Introduction

Nanoparticles can be usually synthesized in different ways: by physical, chemical and biological methods. The aim of the presented work was the synthesis of silver nanoparticles by periodate oxidized polysaccharide, pullulan, that produced by the yeast-like fungus *Aureobasidium pullulans*, strain CH-1 (IChTM, Collection of Microorganisms). It is a linear α–D-glucan having D-glucopyranose units connected by (1,4)- and (1,6)-glucosidic linkages. The maltotriose repeating units, connected by (1-6)-α-D-linkages (Fig. 1), maltotetraosyl units (about 7%) being randomly inserted in the polymer chain are the main structural characteristics of this polysaccharide [2,3]. Potential application of pullulan through various chemical modifications obtaining new biologically active derivatives is very relevant.

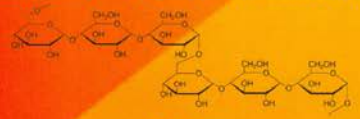

Fig. 1 Pullulan

Polyaldehyde derivatives of pullulan were obtained by reaction with periodate salts in aqueous solution. In the polyaldehydes thus prepared the aldehyde content can be varied in a wide range, depending on the reaction conditions. Pullulan contains three different anhydroglucoside moieties in the repeating unit and it contains different types of vicinal diol groups, therefore, periodate oxidation of this glucan results in different types of dialdehyde structure (Fig. 2).

Ad Am Bm Cm

Fig. 2. Different places of oxidation in a periodate-oxidized pullulan
Am, Bm and Cm are singly oxidized units, Ad is a doubly oxidized unit.

Aim

The aim of the present work was test synthesis of pullulan-based silver nanoparticles of periodate oxidized pullulan and silver ions with the aim of broadening knowledge in this area. Thus obtained silver nanoparticles can be used in many applications, including the food industry.

Material and methods

Pullulan-based silver nanoparticles of oxidized pullulan and silver ions were synthesized by reducing silver nitrate salts with 1% solution of periodate oxidized pullulan by heating at temperature of 121 °C.

After cooling at room temperature the solution was used for the characterization of obtained nanoparticles.

References

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[3] M. Dj. Radulović, O. G. Cvetković, S. D. Nikolić, D. S. Djordević, D. M. Jakovljević, M. M. Vrvić, *Biores. Technol.* 99 (2008) 6673-6677.

Results and Discussion

The aqueous silver ions were reduced to metallic silver by reaction with periodate oxidized pullulan. Formation of nanoparticles was visually monitored by changing the color of the solution from colorless to yellow brown. Ultraviolet visible absorption spectra (UV-Vis) of these solutions (Fig. 3) showed sharp absorption maxima at range 400-440 nm, relating to the plasmon resonance of silver ions.

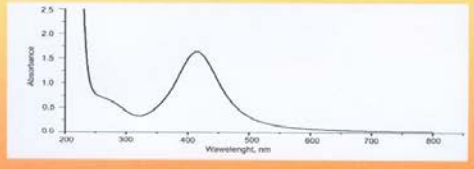

Fig. 3. UV-Vis spectrum of the solution of pullulan-based silver nanoparticles

The characterization of obtained products was performed by scanning electron microscopy (SEM) and energy dispersive spectrometry (EDX), too (Fig. 4. a, b).

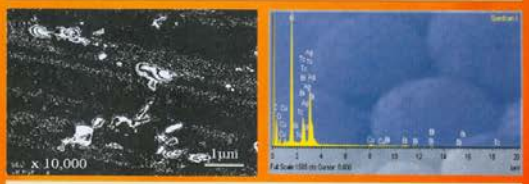

Fig. 4. SEM micrograph (a) and EDX spectrum (b) of dried sample nanoparticles obtained by reducing silver nitrate with periodate oxidized pullulan

Antimicrobial activity of silver nanoparticles

The antibacterial activity of silver nanoparticles was tested using the strain of *Micrococcus lysodeikticus*, and it was shown significant activity against them (Fig. 5).

Fig. 5. Results of antibiogram test of pullulan-based silver nanoparticles using the strain *Micrococcus lysodeikticus*

* Diameter of inhibition zone increases with the greater degree of oxidation of the pullulan chain (range 10% - 70%), i.e. higher number of the -CHO groups affects on an increased formation of nanoparticles by reduction of silver salt to nano Ag^0.

Conclusion

The synthesized pullulan-based silver nanoparticles is promising candidate for a wide range applications, among them is very important food industry, as food packaging products, as barrier materials and antimicrobials for prevention of food spoilage.

Acknowledgement: This work was supported by the Ministry of Education and Science, Republic of Serbia, Project No. III 43004.