PREPARATION AND CHARACTERIZATION OF ZnO-CONTAINING UV-CURABLE ANTIBACTERIAL COATINGS

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Abstract: *Chitosan is a natural carbohydrate that is extracted from the shells of seafood, such as crabs and shrimp. Chitosan has antiviral, antibacterial and antifungal properties. Chitosan is advantageous in terms of its non-toxicity, biodegradability and biocompatibility. For this reason, chitosan is a natural biopolymer used in many industrial areas such as food, medicine, pharmaceuticals, cosmetics, agriculture. ZnO nanoparticles are nontoxic inorganic oxides that have been extensively used as antibacterial agents in the industry and academic studies. In this study, acrylate functionality was first added to chitosan, and then a control formulation was prepared by mixing it with other acrylate group containing monomers. Then the prepared ZnO nanoparticles were included in the control formulation. The prepared formulation was applied to the polycarbonate surface by spraying method and left to dry for 3 minutes under UV rays. The structural, thermal and antibacterial properties of the obtained biocompatible coating were examined and it was observed that the coating showed antibacterial properties.*

Keywords: *Antibacterial coating, ZnO nanoparticles, chitosan, UV-curable*

INTRODUCTION

Chitosan is a linear aminopolysaccharide obtained by deacetylation of chitin. Chitin, on the other hand, is a natural biopolymer that is abundant in the shells of shellfish and is the most abundant on earth after cellulose [1-3]. Chitosan has excellent chemical and biological properties. The biocompatibility, biodegradability, non-allergy, film-forming capacity and antibacterial activity are the most attractive properties of chitosan. Therefore, chitosan can be used in many fields such as food, cosmetics, water treatment, membranes, environmental protection material development, biomedicine, tissue engineering and packaging [1,4-8]. Nanocomposites have unique properties and wide application potential in various fields. Therefore, there has been a significant increase in the number of academic articles on nanocomposites in recent years [9-12].

In this study, ZnO nanoparticle was synthesized as relevant literature and chitosan is modified with 2-isocyanatoethylmethacrylate. we investigate the antimicrobial activity of the prepared coating.

EXPERIMENTAL

The synthesis of ZnO particles

ZnO nanoparticles was synthesized as indicated in the relevant literature.[13,14] 4.5 g of zinc acetate and 1.5 gram hexamethylenetetramine were dissolved in 100 ml of destilled water and pH of the solution was adjusted. The mixture was stirred for 30 minutes. The mixture at about 100 °C was refluxed for 24 h and then filtered. The precipitate was heated at 450°C. ZnO nanoparticles were solidly obtained.

The modification of chitosan

1 g chitosan were dissolved in 100 ml destilled water and then added 5 mL 2-isocyanatoethyl methacrylate and refluxed at 100 °C for 12 h. The mixture was recrystallised using sodium hydroxide solution and then washing with distilled water several times. Modification route to chitosan is given in Figure 1.

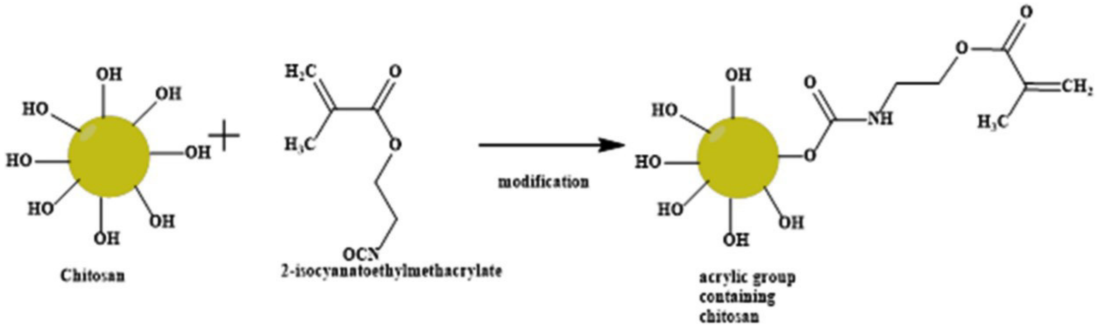

Figure 1: Modification route to chitosan

The preparation of the coatings

The formulation table of the prepared coating was given in table 1.

Table 1: Formulation Table

	Modified chitosan (g)	ZnO Nanoparticles (g)
F0	1	-
F1	1	0,03

RESULTS and dıscussıon

FTIR analysis

FT-IR spectra of chitosan, modified chitosan and the prepared coatings in the range of 4000-400 cm^{-1} were obtained using Perkin Elmer ATR FT-IR spectrophotometer. FTIR spectra of the prepared coatings, chitosan and modified chitosan are given in Figure 2 and 3. In the FT-IR spectrum of chitosan, a wide band of -OH group is seen at 3353 cm^{-1}. At 1648 cm^{-1} stretching vibration band of amide C=O bond is seen. In addition, -N-H at 1560 cm^{-1} and $-CH_3$ wagging at 1377 cm^{-1} are seen [15]. The FTIR spectra of chitosan and modified chitosan in this study are similar to previous literature [15,16]. FT-IR spectrum of modified chitosan is seen -C==C- band that should be seen at 1630 cm^{-1} so that chitosan with 2-isocyanatoethyl methacrylate is succesfully modified. FTIR spectra of the prepared coating has not observed -C==C- band that should be seen at 1630 cm^{-1} which is characteristic for acrylates, This result demonstrates that the coatings is successfully prepared.

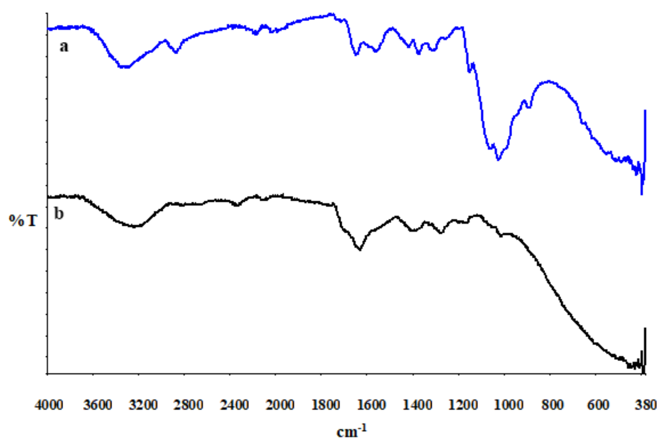

Figure 2: FTIR spectra of a) chitosan and b) modified chitosan

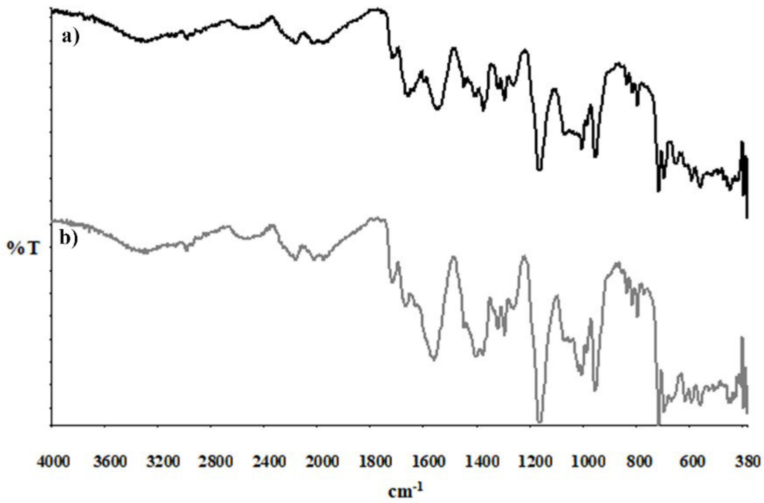

Figure 3: FTIR spectra of a) F0 and b) F1

Size distribution

The size distribution of ZnO nanoparticle was in the range of 43.9 and 54.7 nm and the mean diameters measured with the zeta-sizer were 48.4 nm. The results are similar to previous literature [13,14]. Size distribution of the obtained ZnO nanoparticles is given Figure 4.

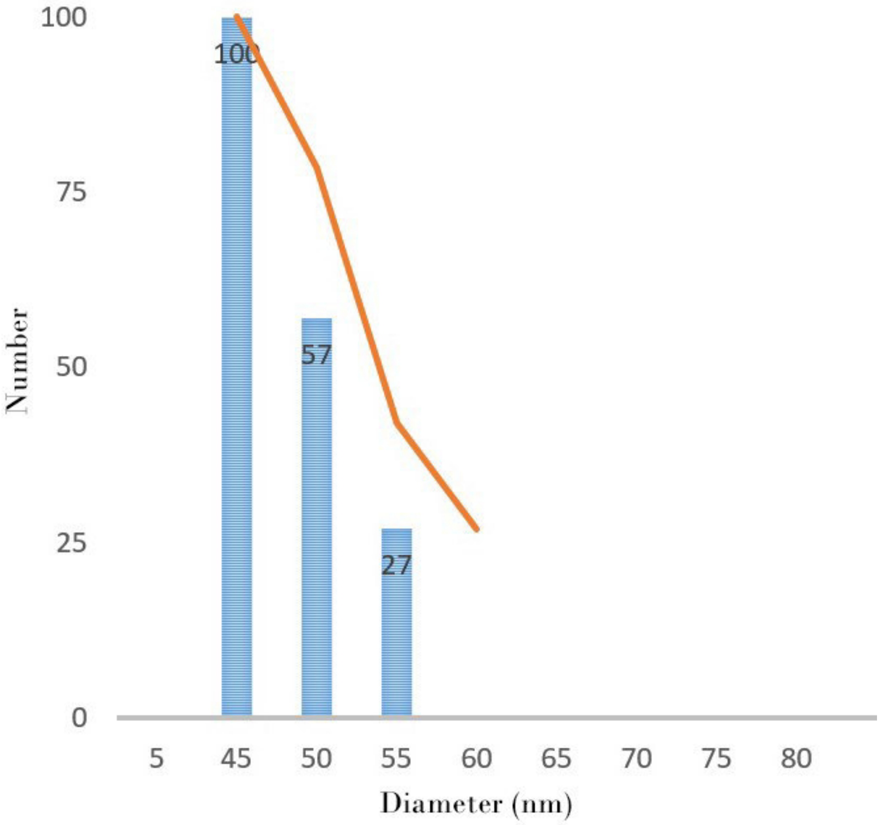

Figure 4: Size distribution of ZnO nanoparticles

SEM analysis

SEM images of prepared coatings are given Figure 5. As seen Figure 5, Results are consistent with the literature [17].

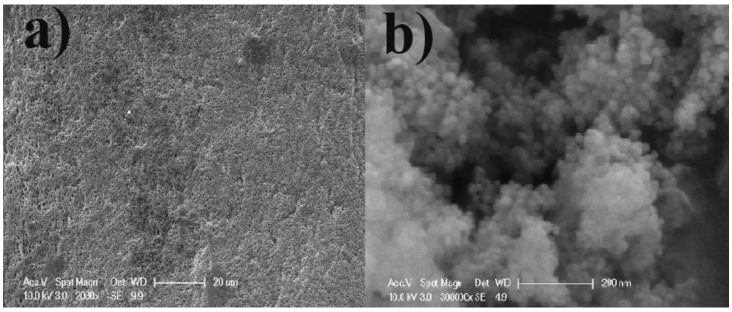

Figure 5: SEM images a) F0 coating and b) F1 coating

Antibacterial activity

Antimicrobial activity of prepared coatings against S. aureus, Gram-positive pathogen bacteria and E. coli, Gram-negative pathogen bacteria is shown in Tables 2 Both F0 sample and F1 sample were observed to have inhibitory effects against E. coli and S. aureus. Because chitosan and ZnO nanoparticles have antimicrobial activities.

Table 2: Antimicrobial activity (inhibition zone diameter in centimeter)

Sample	*E. coli*	*S. aureus*
F0	0.9	0.6
F1	1.1	0.9

CONCLUSIONS

ZnO nanoparticles and acrylic group containing chitosan were successfully synthesized. The synthesized ZnO nanoparticles had an average size of 48.4 nm. The synthesized acrylic group containing chitosan was characterized by FTIR spectroscopy. The prepared coatings show anti-bacterial activity. Therefore it is thought the obtained coatings can use food packaging.

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