APPLYING CYCLODEXTRIN AND ZNO / TIO_2 NANOPARTICLES TO CREATE AN ANTIBACTERIAL AND ODOR-ABSORBING ACRYLIC CARPET

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Abstract

The carpet industry is a vital component of the textile industry, with a distinct added value. Today, extensive research has been conducted on new carpet finishes, and researchers are attempting to develop a new generation of flooring by infusing the carpet with novel properties. Thus, antimicrobial and odor-absorbing carpets were created in this study using cyclodextrin and ZnO / TiO_2 nanoparticles. This was accomplished by spraying dispersed nanoparticles (500 ppm) and cyclodextrin onto the carpet and curing it at temperatures of 50, 90, and 120 ° C. The characteristics of the specimens were then determined using FESEM, ATR-FTIR, water and odor absorption tests, and antimicrobial properties. The results indicate that cross-linking between cyclodextrin and fibers occurs at all three temperatures. The amount of water absorbed decreases as the temperature rises. Additionally, the treated carpets have a high absorption capacity for odors and antibacterial properties. Furthermore, the treated carpet at 90°C exhibits less discoloration, indicating that this temperature is suitable for industrial production.

Objective

Production of an antibacterial and odor-absorbing floor covering through cyclodextrin and ZnO/ TiO2 nanocomposite.

Material and Method

- MATERIAL

Nima Baft Kashan, Co. provided the carpet (acrylic pile/1000 reeds) (Mahoor Carpet brand). Nanopad Sharif Co. provided ZnO/TiO_2 nanocomposite (NP). Merck Compounds offered cyclodextrin (CD), diethylenetriamine (DT), and other chemicals.

- METHODS

Carpet preparation

The carpets (20*20cm^2) were sprayed with a NP/CD/DT solution. The concentration of components were indicated as Table1.

Table 1: Finishing materials for carpet and yarns treatment

Component	Concentration
ZnO/TiO_2 nanocomposite (NP)	500ppm
B-Cyclodextrin(CD)	10(w/v%)
Diethylenetriamine(DT)	2(w/v%)

Cross-linking process

To cross-link nanocomposite and cyclodextrin to the acrylic fibers, curing was done at three distinct temperatures: 50, 90, and 120 °C.

EDX/FESEM

The morphology of the ZnO/TiO_2 nanocomposite and the nanoparticle distribution on carpet fibers were investigated using an energy dispersive X-ray spectrometer (EDX) and a field emission scanning electron microscope (FESEM) (Tescan Mira 3; Czech Republic).

ATR-FTIR

The chemical structure of treated and untreated carpets was studied using attenuated total reflectance-Fourier transform infrared (ATR-FTIR) spectroscopy (PerkinElmer Frontier; USA).

Water absorption

A static immersion test was used to examine the wettability of specimens (BS 34491: 1990).

Antibacterial property

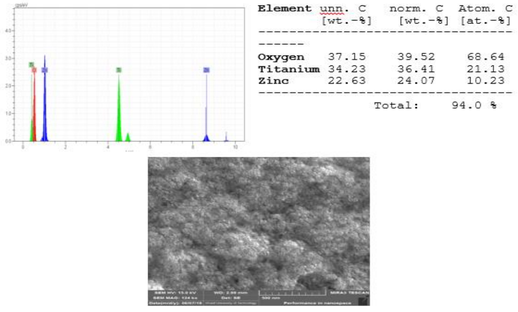
The antibacterial property of treated and untreated carpets was assessed using the colony count test method for textile antibacterial study (AATCC100-2004).

Deodorant Testing method

ISO 17299-1:2014(E) was used to determine the deodorant properties of treated and untreated carpets. Human sensory testing was used in this procedure, and the assessment was graded based on the strength of the smell as judged by the human sense. As a result, the subject selects a value between 0 and 6, with 0 indicating full deodorant and 6 indicating strong odor. According to ASTM E544, different concentrations of n-butanol (12-1550 ppm) were utilized on specimens as a reference for odor generation [7].

Results

-Nanocomposite analysis



Element	unn. C [wt.-%]	norm. C [wt.-%]	Atom. C [at.-%]
Oxygen	37.15	39.52	68.64
Titanium	34.23	36.41	21.13
Zinc	22.63	24.07	10.23
Total:		94.0 %	

Figure 1: EDX, weight percentage of elements and FESEM image of ZnO/TiO_2 nanocomposite

-ATR-FTIR

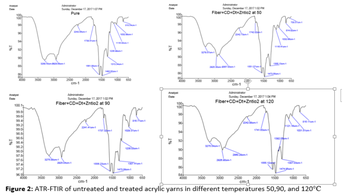


Figure 2: ATR-FTIR of untreated and treated acrylic yarns in different temperatures 50,90, and 120°C

-Water absorption

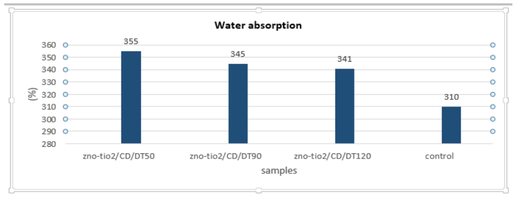


Figure 3: The amount of water absorption of untreated and treated acrylic yarns in different temperatures 50, 90, and 120°C

-SEM observation

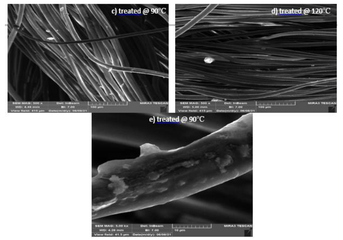


Figure 4: SEM images of untreated (a) and treated acrylic fibers in 50 °C (b), 90°C (c, e), and 120°C (d)

-Antibacterial property

Table 2: Antibacterial activity of ZnO/TiO_2 nanocomposite in acrylic carpets

Sample	Antibacterial property (%)	
	S.aureus	E.coli
Treated carpet @90°C	97.97	99.18
Normal carpet	-	-

=Deodorant property

Table 3: Deodorant activity of ZnO/TiO_2/cyclodextrin/diethylenetriamine@90°C in acrylic carpets

participant	*Treated carpet 10%CD/DI/ZnO/TiO₂*	*Normal carpet*
1	*2*	*5*
2	*2*	*5*
3	*3*	*5*
4	*2*	*5*
5	*3*	*5*
6	*2*	*5*

Conclusion

Carpet is one of the most useful items in the ornamental, decorative, and comfortable aspects of human life. Because of the relevance of carpets, various studies have concentrated on developing multi-functional carpets for various applications. According to this, we attempted to create new carpet with antibacterial and deodorant qualities by cross-linking acrylic fibers with diethylenetriamine, β-cyclodextrin, and ZnO/TiO_2 nanocomposite in this study.

The effects of several temperatures on cross-linking were investigated, and the results confirmed that 90°C is the optimal temperature for the treatment. In addition, around this temperature, the standard carpet finishing (back coating) is applied.

It is possible to do both functional finishing and conventional back coating at the same time. The findings revealed that β-cyclodextrin absorbed odor molecules, ZnO/TiO_2 nanocomposite exhibited strong antibacterial properties, and diethylenetriamine cross-linked with β-cyclodextrin and nanocomposite to acrylic fibers.

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