Deodorizing Properties of Photocatalyst Textiles and Its Effect Analysis

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Abstract

In this paper, yarns of photocatalyst modified polyester staple fiber, cotton and blended yarn of bamboo fiber and photocatalyst modified polyester were selected. Series of woven fabric were manufactured. The photocatalyst fiber contents of woven fabrics were changed from 0% to 100% with 20% gap, that is 0%, 40%, 60%, 80% and 100%. The deodorant performance of these fabrics were tested and analyzed, it can be concluded that when the content of the photocatalyst is 80% or 100%, the fabrics owns better deodorant; when the photocatalyst content in fabric is 40% or 60%, it has the deodorantion properties but the effect was not good. It can be shown from this experimental study that the deodorizing fabrics can be considered to develop if only the content of photocatalyst is above the 80%.

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1. Introduction

Photocatalyst is a nanoscale metal oxide materials (titanium dioxide is often used). It is coated on the substrate surface of material and it owns strong catalytic degradation function in the influence of light. It degrades toxic and harmful gases effectively in the air. The most important is that it can remove odor and stains, etc. In the light, nano-titanium dioxide crystal surface can regenerate hydroxyl groups and absorb oxygen, and the adsorbed oxygen molecules can capture the external excited electrons to form active...
negative oxygen on which can oxidize and decompose organic and harmful gases. It was Japan that applied the properties of the photocatalyst into the textile at first. Fiber test site of Qi country in Japan developed photocatalyst fabric using photocatalytic deodorizing agent[3]. After that the field was researched increasingly in our country. This test had a detailed discussion for the performance if photocatalyst fabric had the deodorizing performance.

The fabric were woven with different photocatalyst fiber contents in this paper, the deodorizing performances of fabrics were discussed according to the absorbed ammonia content of photocatalyst fabrics in the light. (Ammonia is a typical representative of odor gas and it is suitable for a deodorant test because of strong pungent odor and good volatility [5]). In the study, the material of photocatalyst fabric was the modified polyester photocatalyst fiber with a honeycomb structure, and it combined nano-TiO2 and polymer materials by modern composite technology, then distributed nano-titanium dioxide into fibers by melt spinning. We hope that the photocatalyst fiber can be applied into home textile, garment textiles and industrial textiles through the study.

2. Experiment

2.1. Samples

In the paper, these five samples are woven with the same weave structure, yarn fineness, warp and weft density but different raw materials. Their basic weave is five satin and the fineness of warp and weft yarns both are 11.8tex. The fabrics have different content of photocatalyst fibers and the increased gradient is about 20%.

In this test we used four kinds of raw materials.

A1—100% cotton fiber
A2—40 photocatalyst polyester / 60 bamboo fiber
A3—60 photocatalyst polyester / 40 bamboo fiber
A4—100% photocatalyst polyester fiber

Warp density —420 pick.cm⁻¹           Weft density —390 pick.cm⁻¹

The detailed specifications are listed in Tab 1.

Tab. 1 Series of fabrics distribution of raw materials and the content of photocatalyst

| Samples | Raw Materials | The content of photocatalyst(%) |
|---------|---------------|--------------------------------|
|         | Warp yarn     | Weft yarn                      |
| 1#      | A1            | A1                             | 0                  |
| 2#      | A2            | A2                             | 40                 |
| 3#      | A3            | A3                             | 60                 |
| 4#      | A4            | A3                             | 80                 |
| 5#      | A4            | A4                             | 100                |

2.2. Experimental

Ammonia (0.88g/ml); Solid Sodium Hydroxide; Surface Plate; Cylinder; 60W Fluorescent Lamp; Indoor Air Detector; Ammonia Rapid Detection Tube; Hose; Reagent.
2.3. Test methods

Small climate chamber method. When we made the experiment by small climate chamber method, in order to ensure the same experimental conditions, every sample was served the same ammonia, same content of solid sodium hydroxide, the same time of 12h and same fluorescent lights.

3. Test Results and Analysis

Among the series of fabrics of different content of photocatalyst, the warp and weft materials of 1# were 100% cotton fabric, as the comparison sample. The fabrics of 2# ~ 5# contained different photocatalyst fiber contents. The initial concentration of ammonia inside the box was 1.5mg/m³. The test datas of ammonia concentration were recorded as the following Tab 2.

| Samples | 1#  | 2#  | 3#  | 4#  | 5#  |
|---------|-----|-----|-----|-----|-----|
| Density after 12h (mg/m³) | 1.23 | 1.07 | 0.90 | 0.63 | 0.45 |

It can be seen from Tab.2, with the increasing of photocatalyst content in fabrics, the concentration of ammonia had reduced in the small climate box after 12h, and the reduction of ammonia levels also increased.

From Tab.2, we found that the ammonia content of 1# in the box also reduced, but 1# didn't contained photocatalyst fiber. There are two kinds of relationships between fabric system and ammonia, one is the adsorption and diffusion in the fiber and another is the degradation reaction between photocatalyst-TiO₂ on the fiber surface and ammonia under the light [2]. Obviously, 1# fabric belonged to the first situation that cotton fibers absorbed ammonia and ammonia diffused in pores of the fiber. Moreover, there was people's carelessness or other human operations that made ammonia run away from the climate chamber when added ammonia. Assume that the escape of ammonia and the operation of the fiber were the same in the experiment, it should be considered the reduced amount when the rates of each fabric deodorant were calculated. The amount of reduction was c, c = (1.5 - 1.23)mg/m³ = 0.27mg/m³.

The deodorant rate could be calculated as the following formula (1).

\[ K = \frac{a - b - c}{a} \]  

(1)

K—the deodorant rate;  
\( a \)—initial concentration of ammonia;  
\( b \)—the concentration after the reaction;

According to the formula (1), we can calculate the deodorant rate of the 2#~5# and 1#. Their photocatalyst fiber contents were 0, 40%, 60%, 80%, 100% from 1# to 5#. And the results were as the following Fig.1.
It can be seen from Fig.1, the fabrics of 4#(80%) and 5#(100%) owned better photocatalyst odor effect on ammonia. The deodorant rate can even achieved above 50 % when the contents of photocatalyst is 100%. It can be conclude that the fabrics had good deodorizing effect when the contents of photocatalyst fiber were 80% to 100%. The fabric also had a certain odor performance when the content of photocatalyst fiber was 40% and 60%, but its deodorant effect was not obvious. It could be concluded from this experimental research that the content of photocatalyst fiber was 80% or more, the fabric can be considered for the development of deodorizing fabrics.

4. Conclusions

A series of fabric with different content of photocatalyst fiber were manufactured in the paper, the reduced amount of ammonia content in box were tested after the sufficient effect between the fabric and ammonia through ‘Small climate chamber method’, which can be used to compare the deodorant performance and effect of fabric with different photocatalyst fiber content. It can be concluded from the experiment results:

1) When the content of photocatalyst fiber is 0 and the raw material of fabric is 100 % cotton fiber, the ammonia was absorbed on the surface of fabric or escape in the experiment. So the real deodorant rate of the fabric reacted with ammonia is 0 .

2) As the content of photocatalyst fibers increases, the fabric can absorb more ammonia, the deodorant performance is better and the deodorant effect is also better. When the contents of photocatalyst fiber are 80% and 100%, the fabrics have good deodorizing effect .The deodorant rate has reached 52% when the content of photocatalyst is 100% and the fabric owns the best deodorizing effect.

Though it had proved photocatalyst fabric had some deodorant properties in the experiment, it was still a problem if it could be on mass production. If the property of photocatalyst fabrics was stable, and it could be used on home interior products , these problems shoule be considered carafully now. Except
those, as some relative performance tests on photocatalyst fabric were done, maybe it can be considered to develop functional fabrics and make the photocatalyst more heathful and innocuous be better useful by human beings.

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