NEW MESH MATERIALS COATED WITH PHOTOCATALYST (TiO_2)

H. Toyoda[*] and K. Abe[†]

[*†]Taiyo Kogyo Corporation
3-20 Shodai-Tajika Hirakatashi OSAKA 573-1132, Japan

[*]Th000902@mb.taiyokogyo.co.jp
[†]Ak02939@mb.taiyokogyo.co.jp

Key words: façade, mesh, photocatalyst, TiO_2, PVC, PTFE, industrial applications.

Summary: *Two kinds of new mesh materials treated with titanium dioxide (TiO_2) photocatalyst: polyvinyl chloride (PVC)-coated polyester fiber mesh and polytetrafluoroethylene (PTFE)-coated glass fiber mesh are developed for architectural façade usage. TiO_2 treatment shows excellent self-cleaning and air purification functions under outdoor conditions with sunlight (UV) and rain.*

1 INTRODUCTION

Use of mesh material covering over the outside wall of building façade gives a unique appearance by a moderate cost. Furthermore, covering of a whole building with mesh material suppresses the penetration of solar radiation and results in decrease of internal temperature of the building, which may be an effective way of energy saving.

Usually PVC-coated polyester fiber mesh or PTFE-coated glass fiber mesh is being used. These meshes sometimes get dirt in the outdoor applications.

Taiyo Kogyo has already developed various TiO_2 coated fabrics for architectural membrane structures since 1998. Such TiO_2 coated fabrics show excellent self-cleaning property compared with fluorpolymer coated ones, e.g., polyvinyl fluoride (PVF) or polyvinylidene fluoride (PVDF) [1-3] coated one.

The mechanism of self-cleaning for the membrane coated with TiO_2 can be explained by both decomposition of dirt through photo-redox reactions and washing-out effect of a photo-induced hydrophilic TiO_2 surface [4].

In this report we have applied such technology to mesh materials to use for architectural façade.

New mesh materials show excellent self-cleaning and air purification performances.

2 EXPERIMENTAL

2.1 Specimens

2.1.1 PVC-coated polyester fiber mesh (PVC/PES)

PVC/PES was prepared as follows. Here we inserted a protective-adhesive layer between PVC layer and TiO_2 layer with a specific ratio of TiO_2, because PVC is decomposed by the photo-redox reaction of TiO_2. As for the TiO_2 top coating, anatase TiO_2 powder is bound to the substrate with an inorganic binder.

2.1.2 PTFE-coated glass fiber mesh (PTFE/GLS)

PTFE/GLS was prepared as follows. Since the fluoropolymer is inert to photocatalytic function of TiO_2, TiO_2 powder was mixed with the fluoropolymer dispersion and then a PTFE/GLS was dipped in the dispersed solution directly and thereafter the mesh was sintered above the melting point of the fluoropolymer.

2.2 Measurements

2.2.1 Self-cleaning performance of TiO_2 coated materials

Decomposition activity index (*R*) of specimens was measured by the JIS R 1703-2. Self cleaningperformance of specimens was evaluated by the outdoor exposure test.

2.2.2 Air purification performance of TiO_2 coated materials

Removal capability of NOx, acetaldehyde and toluene was measured by the JIS R 1701-1 to evaluate air purification performance of TiO_2 coated materials.
Table 1 shows the test condition of air purification performance of TiO_2 coated materials.

Table 1: Test conditions of air purification performance of TiO_2 coated materials

Test gas	NO	acetaldehyde	toluene
Test temprature（℃）	25		
Size of test piece（mm）	50 wide,100 long（2 pieces）		
Fraction of water vapor (vol %)	1.56		
Content of supply gas (ppm)	1.0	5.0	1.0
Flow rate of gas (L/min)	1.5	0.5	0.5
UV irradiance (mW/cm^2)	1		
UV irradiance time (min)	300	180	180

3 RESULTS AND DISCUSSION

Figure 1 shows the pictures of PVC/PES after the outdoor exposure test for 12 months. The right is TiO_2 coated material and the left is non-TiO_2 coated one. Non-TiO_2 coated material changed to black due to dirt adhesion, while TiO_2 coated one maintained white color. Change in ΔE due to dirt adhesion can be used as a measure for the evaluation of self-cleaning property.

The results of color difference (ΔE) after the outdoor exposure test are shown in Table 2. It is clearly shown that ΔE of TiO_2 coated material hardly changes compared with the one of Non-TiO_2 coated one.

Figure 2 shows the pictures of PTFE/GLS after the outdoor exposure test for 4 months. The left is TiO_2 coated material and the right is non-TiO_2 coated one. The same tendency as the previous result of PVC/PES can be seen.

PVC/PES and PTFE/GLA with TiO_2 coating exhibit excellent self-cleaning property.

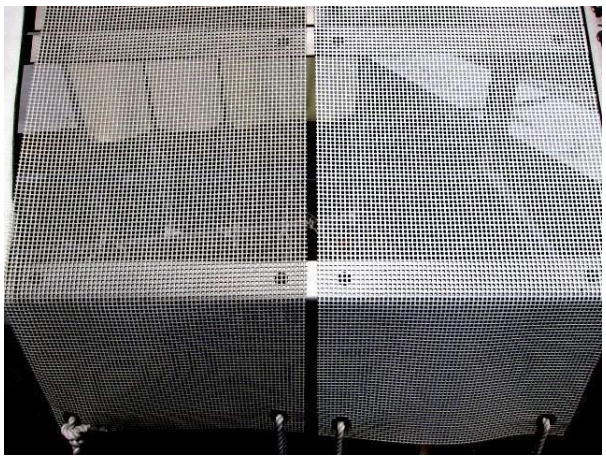

Figure 1: PVC/PES after 12-months outdoor exposure test (Osaka, Japan)
The left: without TiO_2 coating, the right: with TiO_2 coating

Table 2 The color difference (ΔE) measurements of PVC/PES after the outdoor exposure test

Exposure period（months）	Without TiO_2	With TiO_2
1	1.7	2.3
3	3.7	1.9
6	7.2	0.7
12	12.8	1.7

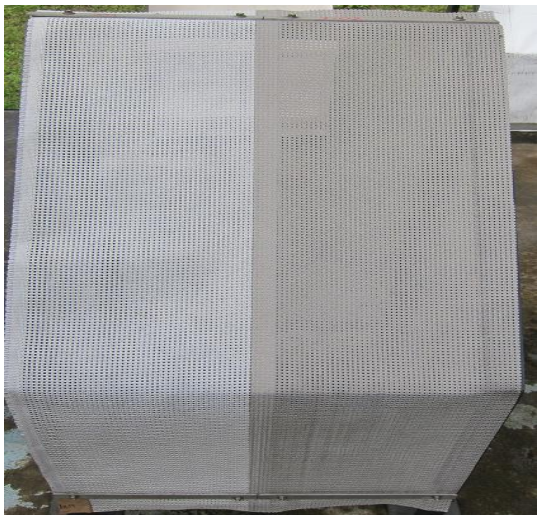

Figure 2: PTFE/GLS after 4-months outdoor exposure test (Taipei, Taiwan)
The left: with TiO_2 coating, the right: without TiO_2 coating

Table 3 shows the results for the photocatalytic performance of TiO_2 coated materials. Decomposition activity index (*R*), i.e., dirt-decomposition ability was 18.1 for PVC/PES and was 26.6 for PTFE/GLS, respectively.

These values satisfy sufficiently the PIAJ (Photocatalysis Industry Association of Japan), criteria which requires the value of more than 5.
Removal amounts of NOx for PVC/PES and PTFE/GLS were 1.2 and 1.1, respectively. These values are much higher than the value above 0.5 of PIAJ criteria.
Furthermore, the measurement values of removal amounts of acetaldehyde and toluene also satisfy sufficiently the value above 0.17 of PIAJ criteria.

Table 3 demonstrates clearly that TiO_2 coated materials show excellent air purification performance.

Table 3 Photocatalytic performance of TiO_2 coated materials

Items	PVC/PES	PTFE/GLS	Criteria of PIAJ
R (nmol/L/min)	18.1	26.6	above 5
Removal amount of NOx（μmol/h）	1.2	1.1	above 0.5
Removal amount of acetaldehyde（μmol/h）	2.5	3.4	above 0.17
Removal amount of toluene（μmol/h）	0.4	0.6	above 0.17

4 CONCLUSIONS

New mesh materials were developed by treating the meshes with TiO_2 photocatalyst. The developed meshes show sufficient photocatalytic performance and air purification performance against NOx and VOC. This means that they are of maintenance-free when used in the outer wall of building façade, moreover they have air cleaning effect. The new developed mesh materials have a great potentiality to solve environmental problems and we will pursue a wide range of applications in the future.

REFERENCES

[1] H.Toyoda and T.Torii, *The 5th Asian Textile Conference, Kyoto, Proceeding 2,* 867, 1999

[2] H.Toyoda,T.Nakata, K.Abe and T.Normura, *3rd International Workshop on the Utilization and Commercialization of Photocatalytic Systems, Coatings for Clean Surfaces, Water and AirPurification, Saarbrücken, Germany, Abstracts of oral presentations,* 2003

[3] H.Toyoda and K.Abe, *Tensinet Symposium 2007, Ephemeral Architecture Time and Textiles,* Politecnico di Mirano BEST Department Faculty of Architecture and Society,345, 2007

[4] A.Fujishima, K.Hashimoto and T.Watanabe, *TiO_2 PHOTOCATALYSIS Fundamentals and Applications,* Bkc.Inc, 1999