

Deactivation and Regeneration of Environmentally Exposed Titanium Dioxide (TiO₂) Based Products

Testing Report

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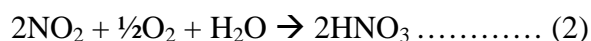
1. INTRODUCTION

1.1 Background

The Environmental Protection Department (EPD) of the HKSAR Government commissioned the Chemistry Department of The Chinese University of Hong Kong (CUHK) to determine the deactivation and regeneration properties of this kind of environmentally exposed titanium dioxide (TiO₂) based paving blocks after 4-month and 12-month site exposure at five different pedestrian roads in Causeway Bay (Departmental Order Ref. No.: E183413), and to provide laboratory analytical support and help interpret exposure data on photocatalytic paving blocks to examine its property.

In Hong Kong, large traffic volume and poor air pollutants dispersion due to high-rise buildings lead to low air quality, especially in crowded districts such as Causeway Bay. Advanced photocatalytic oxidation technique is a way to degrade or oxidize various pollutants such as nitrogen oxides (NO_x)^{[1][2]}. Last year, the study of “Ambient Air Treatment by Titanium Dioxide (TiO₂) Based Photocatalyst in Hong Kong (Tender Ref. AS 00-467)” was conducted. In order to determine the durability of the catalysts, TiO₂ coated paving blocks were tested after extensive use. The deactivation and re-activation of the catalyst were investigated. Photocatalytic oxidation of NO_x was used to evaluate the photocatalytic activity of the paving blocks.

Titanium dioxide capacity in oxidizing pollutants arises from the generation of high oxidizing power hydroxyl radicals (•OH) under UV radiation (wavelength < 387.5 nm)^[3]. The generated •OH can then oxidize pollutants on the catalyst surface and generate less harmful products^{[4][5]}. Oxidation of NO_x leads to the formation of NO₃⁻ on the surface of catalyst by way of NO₂^{[6][7]}.



1.2 Objectives of study

The objective of this study is to evaluate the photocatalytic activity in NO_x removal of the used TiO₂ coated paving blocks to see whether the catalyst would be deactivated after extensive use. Their activities will also be determined after being washed to see if washing with water can regenerate the catalytic activity. The photocatalytic activities of catalysts exposed at different locations will be compared to determine the environmental factors affecting the activity of the photocatalytic products.

2. PROJECT DESIGN & STUDY METHODOLOGY

2.1 Product information

This is a paving block with a layer of titanium dioxide on top surface. The blocks that we used were white, red or black in color.

Type	Paving block
Size	200mm (L) x 100mm (W) x 60mm (H)
Material and Appearance	<ul style="list-style-type: none">➤ Mainly made of concrete and coated with a thin TiO₂ layer on the top surface➤ Rough surface
Country from	Japan



[Picture 1] Paving blocks with TiO₂

2.2 Project design

2.2.1 Treatment of paving blocks

A total of 64 TiO₂ coated paving blocks were used in this study. Four of the pieces were used as a control and they were kept in a clean environment. Another 60 pieces were paved on the pedestrian roadsides of five different locations in Causeway Bay, with twelve pieces at each location. As shown in [Picture 2], the paving blocks were placed across the pedestrian walkways where daily human intrusion is allowed. After 4-month exposure, 6 pieces from each site were collected and their photocatalytic activities were measured. After a 12-month exposure, another 6 pieces from each site were collected and tested. Their photocatalytic activities were compared with that of those without

exposure. Each block was labeled and its treatment and description were shown in [Table 2a, 2b & 2c]



[Picture 2] Blocks were paved across a pedestrian walkway.

[Table 1] The schedule of paving and collection of blocks

26 Sept 2001	Paving 60 blocks in Causeway Bay
25 Jan 2002	Collecting 30 blocks after 4-month exposure
30 Sept 2002	Collecting 30 blocks after 12-month exposure

Site description

Location 1 (L1)

- Jaffe Road, Causeway Bay
- Next to Sino Plaza



[Picture 3] Picture of Location 1

Location 2 (L2)

- Jaffe Road, Causeway Bay
- In front of a sushi shop



[Picture 4] Picture of Location 2

Location 3 (L3)

- Lockhart Road, Causeway Bay
- In front of Kyoto Plaza



[Picture 5] Picture of Location 3

Location 4 (L4)

- Lockhart Road, Causeway Bay
- Next to MTR station Exit C
- Near a restaurant



[Picture 6] Picture of Location 4

Location 5 (L5)

- Lockhart Road, Causeway Bay
- Near Causeway Bay Plaza (Phase II)
- Next to a car park



[Picture 7] Picture of Location 5

[Table 2a] The treatment and description of new paving blocks

Sample	Colour	Remarks
New-1	White	Kept in a clean environment
New-2	White	Kept in a clean environment
New-3	White	Kept in a clean environment
New-4	White	Kept in a clean environment

[Table 2b] The treatment and description of 4-month exposed paving blocks

Sample	Location	Position	Colour	Exposed time	Gum	Remarks
1A	1	Near kerb	Black	4 months	N	
1B	1	Near kerb	Black	4 months	N	
1C	1	Middle	Black	4 months	N	
1D	1	Middle	Black	4 months	N	
1E	1	Off kerb	Black	4 months	N	
1F	1	Off kerb	Black	4 months	N	
2A	2	Near kerb	Red	4 months	Y	Broken surface corner
2B	2	Near kerb	Red	4 months	N	
2C	2	Middle	Red	4 months	N	
2D	2	Middle	Red	4 months	Y	1/4 bottom broken
2E	2	Off kerb	Red	4 months	N	
2F	2	Off kerb	Red	4 months	N	
3A	3	Near kerb	Black	4 months	Y	
3B	3	Near kerb	Black	4 months	Y	
3C	3	Middle	Black	4 months	Y	
3D	3	Middle	Black	4 months	N	
3E	3	Off kerb	Black	4 months	N	
3F	3	Off kerb	Black	4 months	Y	
4A	4	Near kerb	Red	4 months	N	
4B	4	Near kerb	Red	4 months	N	
4C	4	Middle	Red	4 months	N	
4D	4	Middle	Red	4 months	N	
4E	4	Off kerb	Red	4 months	N	
4F	4	Off kerb	Red	4 months	N	
5A	5	Near kerb	Black	4 months	N	
5B	5	Near kerb	Red	4 months	N	
5C	5	Middle	Black	4 months	N	
5D	5	Middle	Red	4 months	N	
5E	5	Off kerb	Black	4 months	Y	
5F	5	Off kerb	Red	4 months	N	

[Table 2c] The treatment and description of 12-month exposed paving blocks

Sample	Location	Position	Colour	Exposed time	Gum	Remarks
1G	1	Near kerb	Black	12 months	N	Thin TiO ₂ scratched coz construction
1H	1	Near kerb	Black	12 months	N	Thin TiO ₂ scratched coz construction
1I	1	Middle	Black	12 months	Y	-
1J	1	Middle	Black	12 months	N	-
1K	1	Off kerb	Black	12 months	N	-
1L	1	Off kerb	Black	12 months	N	-
2G	2	Near kerb	Red	12 months	N	-
2H	2	Near kerb	Red	12 months	Y	-
2I	2	Middle	Red	12 months	N	-
2J	2	Middle	Red	12 months	N	-
2K	2	Off kerb	Red	12 months	Y	-
2L	2	Off kerb	Red	12 months	N	-
3G	3	Near kerb	Black	12 months	N	-
3H	3	Near kerb	Black	12 months	N	-
3I	3	Middle	Black	12 months	Y	-
3J	3	Middle	Black	12 months	Y	-
3K	3	Off kerb	Black	12 months	N	-
3L	3	Off kerb	Black	12 months	N	-
4G	4	Near kerb	Red	12 months	N	-
4H	4	Near kerb	Red	12 months	N	-
4I	4	Middle	Red	12 months	N	-
4J	4	Middle	Red	12 months	N	-
4K	4	Off kerb	Red	12 months	N	-
4L	4	Off kerb	Red	12 months	N	-
5G	5	Near kerb	Black	12 months	N	2 small broken holes
5H	5	Near kerb	Black	12 months	N	-
5I	5	Middle	Black	12 months	N	-
5J	5	Middle	Red	12 months	N	-
5K	5	Off kerb	Red	12 months	N	-
5L	5	Off kerb	Black	12 months	N	-

Site Map of blocks placing locations



(Scale 1:2000)

From CENTAMAP web page ----- <http://www.centamap.com>

2.2.2 Laboratory testing of photocatalytic activities in NO_x removal

The photocatalytic activities in NO_x removal of the collected blocks were tested with the method described below. On return to the laboratory, the blocks were washed with deionized water and cleaned with a brush. Firstly, the blocks were brushed gently in water to remove big particles and residues on the surface. Then, each blocks was immersed in 3.5L deionized water for two hours. After the washing process, some dust and solid particles were washed out but gums and greasy substances still remained on the surfaces. The washed blocks were dried in room temperature and their activities were tested again.

The testing protocol for air purification ability of photocatalytic material

A) Introduction

The testing protocol for analyzing nitrogen oxides (NO_x) removal ability of photocatalyst was

designed mainly based on the technical report proposed by The National Institute of Advanced Industrial Science and Technology of Japan^[8]. As the photocatalytic process of oxidation of NO_x follows the reaction sequence: NO → NO₂ → HNO₃, for simplicity, the removal of NO_x can be tested by using (nitrogen monoxide) NO as the pollutant source.

B) Setup of Test Rig

A continuous supply of NO gas was used for the evaluation of pollutant removal capability of a photocatalytic material. This experimental setup was a simulation of the outdoor environment where a continuous pollutant source was generated as a result of the vehicular emissions. The testing system consisted of a testing-gas supply, a photo-reactor, a UV light source, and the NO_x measurement equipment. Since low concentrations of NO was tested, the system should be constructed with materials of low NO adsorption capacity and high resistant to ultra-violet (UV) radiation. A schematic diagram of the setup is shown in [Figure 1].

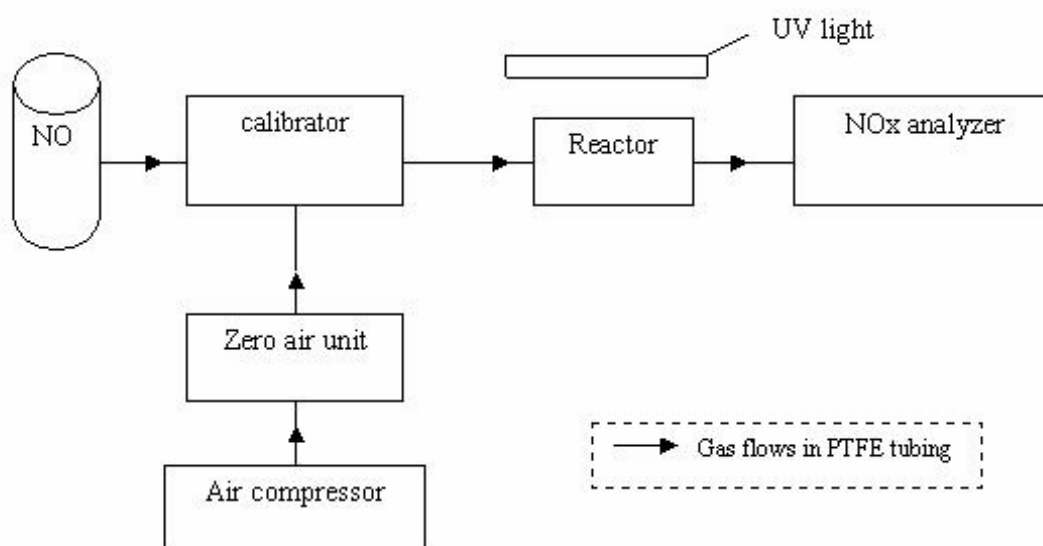


Figure 1 : A schematic diagram of the setup

An initial NO concentration of 1000 ppb was used. It was prepared by mixing the known volume of zero and span NO gas. The ambient air was pumped into the air compressor and pushed into the zero air unit (Zero Air Supply including External Air Compressor), which removed NO_x, O₃, SO₂, CO and hydrocarbon to generate pollutant free “zero gas”. The calibrator (a Multi-gas Calibration System) was used to obtain the span gas by mixing NO/N₂ mixture with the air from the zero air unit to designate the NO concentration. After that, the adjusted NO was continuously supplied to the reactor on the top of which a UV light source.

Reactor

The test piece was placed in the reactor horizontally and parallel to an optical window, through which the UV light penetrated (e.g. quartz and borosilicate glass). The sample was placed to face the UV light source with an air gap of 5 mm in width. Stainless steel was used for manufacturing the reactor as it adsorbed very trace amount of the polluted gas and has high tolerance to radiation near UV.

UV light source

The UV light source consisted of two 15-W 365-nm UV black light lamps. The distance between the light source and the reactor was adjusted so that the test piece can be evenly irradiated with an illumination intensity of about 0.9 mW/cm^2 . A calibrated UV meter was used to measure the illumination intensity. The reactor was shielded from external light during the measurement.

NO_x analyzer

A NO_x analyzer (a USEPA designated chemiluminescent NO/NO₂/NO_x analyzer) was connected to the reactor for measuring NO_x concentrations. The analyzer was first calibrated using zero gas and appropriate NO_x standards.

C) Testing method

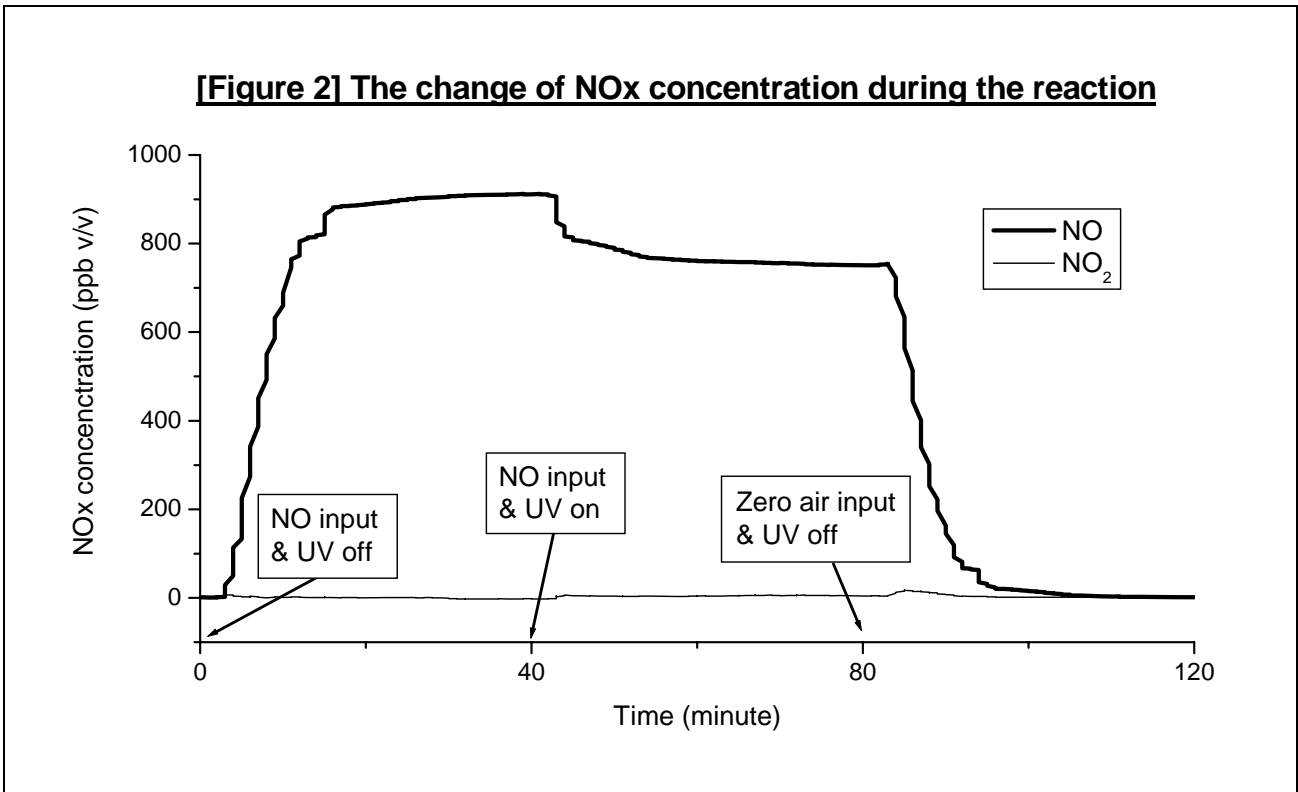
The calibrator was adjusted to generate NO concentration of 1.0 ppm v/v, with relative humidity of around 75% and temperature of $23.0 \pm 3.0 \text{ }^\circ\text{C}$. The temperature, relative humidity and UV intensity (365 nm) in the reactor were measured and recorded.

The test piece was placed into the reactor. The gap between the glass wall and the test piece was adjusted by placing aluminum plates under the test piece. The glass wall was installed and fixed, ensuring that the chamber was airtight.

At first, NO was allowed to flow into the reactor without illumination at a constant flow rate (6 L/min). For at least 40 minutes, the change of concentration of NO and NO₂ in darkness was measured and recorded. If NO_x (i.e. NO + NO₂) concentration was less than 90% of the supplying concentration (i.e. 900 ppb) after 40 minutes, this process was continued until the NO_x concentration exceeds 90% of the supplying concentration. The light source was then turned on. Similarly, concentration of NO and NO₂ were recorded for 40 minutes or until the optimal removal rate has been reached, whichever was longer.

Finally, the effect of desorption was investigated. Photo-irradiation was stopped and the reactor was re-filled with zero gas under the same temperature, humidity and flow rate. The concentration of NO_x at the reactor outlet was recorded for another 40 minutes. Zero-air supply to the chamber was then stopped and the test piece was removed from the reactor.

The amount of NO_x adsorption by the test rig & test piece in a dark environment, the amount of NO_x removal under UV irradiation and the amount of desorption after the tests were to be determined. The change in NO_x concentration during this process is shown in [Figure 2].



D Expression of the Testing Results

Amount of NO_x adsorption on the test piece

The amount of NO_x adsorption was calculated according to the following equation.

$$Q_{ads} = \left\{ \int ([NO]_0 - [NO])dt - \int [NO_2]dt \right\} \times f / 22.4$$

- Q_{ads} : the amount of NO_x adsorption on the test piece (μmol)
- [NO]₀ : supply concentration of NO (ppmv)
- [NO] : concentration of NO at the reactor outlet (ppmv)
- [NO₂] : concentration of NO₂ at the reactor outlet (ppmv)
- t : processing time for adsorption (min)
- f : flow rate (L/min)

Amount of NO removal by the test piece

The amount of NO removed was calculated according to the following equation.

$$Q_{NO} = (f / 22.4) \int ([NO]_0 - [NO]) dt$$

Q_{NO} : the amount of NO removal (μmol)

t : time of removal operation (min)

Other variables are the same as shown above.

Amount of NO₂ formed by the test piece

The amount of NO₂ production was calculated according to the following equation.

$$Q_{NO_2} = (f / 22.4) \int [NO_2] dt$$

Q_{NO_2} : the amount of NO₂ production (μmol)

Other variables are the same as shown above.

Amount of NO_x desorbed from the test piece

The amount of NO_x desorbed was calculated according to the following equation.

$$Q_{des} = (f / 22.4) \{ \int [NO] dt + \int [NO_2] dt \}$$

Q_{des} : the amount of NO_x desorbed from the test piece (μmol)

t : time of desorption operation (min)

Other variables are the same as shown above.

Net amount of NO_x removed by the test piece

The net amount of NO_x removed was calculated by the following equation.

$$Q_{NO_x} = Q_{ads} + Q_{NO} - Q_{NO_2} - Q_{des}$$

Q_{NO_x} : the amount of NO_x removal by the test piece (μmol)

The amount of NO_x removed per hour per unit surface area (mg/hr/m^2) of the sample was used for expressing the catalytic activity of the sample. It was calculated as shown below:

$$\frac{(\text{net amount of NO}_x \text{ removed in mmol}) (\text{molecular weight of NO}_x \text{ i.e. } 30)}{(\text{removal operation time in hour}) (\text{area of sample in m}^2)}$$

3. RESULTS & DISCUSSION

The NO_x removal activities in term of amount of NO_x removed in one hour per unit area (mg/hr/m²) of new and used paving blocks are calculated and shown in [Table 3a & 3b].

[Table 3a] The activities of paving blocks (New blocks)

Sample no.	NO _x removal rate (mg/hr/m ²)
New-1	5.39
New-2	5.44
New-3	4.77
New-4	5.93
<i>Average</i>	5.38

[Table 3b] The activities of paving blocks (Exposed blocks)

Sample no	NO _x removal rate (mg/hr/m ²)		Sample no.	NO _x removal rate (mg/hr/m ²)	
	4 month-unwashed	4 month-washed		12 month-unwashed	12 month-washed
1A	1.94	2.26	1G	0.82	0.59
1B	1.55	1.60	1H	1.65	1.58
1C	1.34	0.90	1I	1.41	1.70
1D	1.59	1.64	1J	1.85	2.02
1E	3.22	3.34	1K	2.43	2.69
1F	2.34	3.46	1L	2.53	2.55
2A	1.74	1.48	2G	2.84	2.61
2B	1.99	2.03	2H	2.58	2.18
2C	1.96	1.56	2I	2.44	2.12
2D	1.52	1.28	2J	1.49	1.24
2E	3.02	3.30	2K	1.54	1.47
2F	2.39	2.30	2L	0.92	1.13
3A	1.19	1.40	3G	4.18	4.02
3B	1.93	1.83	3H	3.89	4.19
3C	3.46	2.96	3I	3.32	3.20
3D	3.02	2.75	3J	3.90	4.22
3E	2.34	2.45	3K	1.95	2.21
3F	2.21	2.86	3L	2.12	1.75
4A	2.23	2.17	4G	1.04	1.31
4B	1.19	0.93	4H	0.63	0.85
4C	1.53	1.22	4I	1.25	1.08
4D	1.24	1.70	4J	1.84	1.67
4E	1.40	1.68	4K	1.38	1.07
4F	1.85	1.40	4L	1.19	1.44
5A	2.81	2.64	5G	2.60	3.03
5B	2.37	2.01	5H	3.04	3.10
5C	2.05	2.07	5I	2.44	2.80
5D	1.20	1.16	5J	1.10	1.44
5E	2.48	2.30	5K	1.11	1.82
5F	3.03	2.86	5L	1.74	1.74

Effect of exposure on NOx removal activity

Independent T-test is used to determine if there are mean differences between activities of new and exposed (unwashed) blocks. The results are shown in [Table 4]. The activities of new and exposed blocks are significantly different for both 4-month and 12 month exposure. For blocks with 4-month exposure, their activities dropped by 36% to 78%, while the activities dropped by 22% to 88% for 12-month exposure blocks compared with that of new blocks.

[Table 4] T-test results for difference between activities of new and exposed blocks

Null hypothesis (H ₀): No difference between activities of new and exposed blocks		
	<i>4-month exposure</i>	<i>12-month exposure</i>
Mean activity of new blocks	5.38	5.38
Mean activity of exposed blocks	2.07	2.04
Significance level	0.1	0.1
T-value (t)	-10.9030	-7.608
P-value (p)	1.78×10^{-12}	9.36×10^{-9}
Decision of rejecting H ₀	Reject	Reject

Deactivation of TiO₂ based paving blocks may be due to a decrease in the catalytic surface area. Dust and dirt, oil and grease, discarded chewing gums, and scratches were found on used paving blocks.

Effect of exposure time on NOx removal activity

Independent T-test is used to determine if there are mean differences between activities of 4-month exposed and 12-month exposed (unwashed) blocks. From the results shown in [Table 5], there is no significant difference between the activities of 4-month exposed and 12-month exposed blocks.

[Table 5] T-test results for difference between activities of 4-month and 12-month exposed blocks

Null hypothesis (H ₀): No difference between activities of 4-month and 12-month exposed blocks	
Mean activity of 4-mth exposed blocks	2.07
Mean activity of 12-mth exposed blocks	2.04
Significance level	0.1
T-value (t)	-0.1433
P-value (p)	0.8865
Decision of rejecting H ₀	Not reject

Although the activities of the used paving blocks were worse than that of the unused ones, the catalytic activities of the former did not diminish upon prolonged usage. This may be contributed by the heavy rainfall in September 2002 at the end of which the samples were collected and the street

cleansing with degreasing agent.

Rainfall record from Hong Kong Observatory

Date	Total rainfall (mm)
Oct 2001	10.7
Nov 2001	4.3
Dec 2001	44.6
Jan 2002	25
Feb 2002	4.6
Mar 2002	238.7
Apr 2002	12.4
May 2002	275.6
Jun 2002	237.6
July 2002	320.8
Aug 2002	365.9
Sept 2002	723

Effect of washing on activity recovery

Paired T-test is used to determine if there are mean differences between activities of unwashed and washed exposed blocks. The results are shown in [Table 6]. The activities of washed blocks are not statistically different from that of unwashed blocks for both 4-month and 12 month exposure.

[Table 6] T-test results for difference between activities of unwashed and washed exposed blocks

Null hypothesis (H_0): No difference between activities of unwashed and washed exposed blocks		
	<i>4-month exposure</i>	<i>12-month exposure</i>
Mean activity of unwashed blocks	2.07	2.04
Mean activity of washed blocks	2.05	2.09
Significance level	0.1	0.1
T-value (t)	0.3047	-1.0389
P-value (p)	0.7628	0.3074
Decision of rejecting H_0	Not reject	Not reject

Washing the blocks with water is not an effective way to regenerate their activity in harsh practical environment that daily human intrusion is allowed. Other researchers proposed that washing with water alone can recover catalytic activity^{[9][10]}. However, in their study, their samples were not exposed to practical environment. The deactivation of samples in their study was merely due to the accumulation of nitric acid, which is easily removed by water, on catalyst surface. The blocks used in this study were exposed to a harsh but practical environment to examine the real-life application. If the catalytic surface is partially covered by an adhesive and water insoluble contaminant, washing alone may not be sufficient to resume their activities. Street cleansing with degreasing agent may be needed in order to sustain their activities.

Effect of exposed location on NOx removal activity

One-way ANOVA is used to determine if there are mean differences among the activities of blocks (unwashed) placed at different locations. The results are shown in [Table 7]. The results confirm that the exposed location affects the NOx removal activity. The activities of the blocks exposed at Location 3 deteriorated least while that at Location 4 deteriorated most. The ascending order of deterioration of blocks exposed at different locations is as follow: Location 3 (in front of a plaza) < Location 5 (next to a car park) < Location 2 (in front of a sushi shop) < Location 1 (in front of a plaza) < Location 4 (near a restaurant).

[Table 7] ANOVA results for difference among activities of blocks exposed at different locations

Null hypothesis (H ₀): No difference among activities of blocks exposed at different locations	
Mean activity of blocks at L1	1.89
Mean activity of blocks at L2	2.04
Mean activity of blocks at L3	2.79
Mean activity of blocks at L4	1.40
Mean activity of blocks at L5	2.16
Significance level	0.1
F-value (f)	6.2582
P-value (p)	3.18 x 10 ⁻⁴
Decision of rejecting H ₀	Reject

The blocks exposed at Location 4 are particularly oily and greasy, which may be caused by the activities of the nearby restaurant. The catalyst-coated blocks perform better when they are paved in a site free from or with less contamination.

Effect of exposed position on NOx removal activity

The blocks were classified into 3 classes according to their positions along the walkway. They are near-kerb, middle and off-kerb. One-way ANOVA is used to determine if there are mean differences among the activities of blocks (unwashed) placed in different positions. From the results shown in [Table 8], the positions do not significantly affect the NOx removal activity of paving blocks. The only exception is Location 1, for which the activities of blocks paved off-kerb is higher than that paved at the middle and near-kerb.

[Table 8] ANOVA results for difference among activities of blocks exposed in different positions

Null hypothesis (H_0): No difference among activities of blocks exposed in different positions					
	<i>Location 1</i>	<i>Location 2</i>	<i>Location 3</i>	<i>Location 4</i>	<i>Location 5</i>
Mean activity of blocks paved near-kerb	1.49	2.29	2.80	1.27	2.71
Mean activity of blocks paved at middle	1.55	1.85	3.43	1.47	1.70
Mean activity of blocks paved off-kerb	2.63	1.97	2.16	1.46	2.09
Significance level	0.1	0.1	0.1	0.1	0.1
F-value (f)	11.2651	0.4638	2.0966	0.2264	2.5469
P-value (p)	0.0036	0.6431	0.1789	0.8018	0.1329
Decision of rejecting H_0	Reject	Not reject	Not reject	Not reject	Not reject

For Location 1, the blocks paved off-kerb have significantly higher activities than that paved at the middle and near-kerb. As those blocks were placed right next to a wall, there are less potential to be disturbed and ruined.

Effect of the presence of chewing gums on paving block surface on NO_x removal activity

After the exposure, some discarded chewing gums were found on the surfaces of some blocks. Mostly, these chewing gums only covered not more than 1/10 of the top surface area of the blocks. Independent T-test is used to determine if there are mean differences between activities of exposed (unwashed) blocks with and without gums on the surface. The results are shown in [Table 9]. There is no significant difference between the activities of blocks with and without gums on the surface.

[Table 9] T-test results for difference between activities of blocks with and without gum on surface

Null hypothesis (H_0): No difference between activities of blocks with and without gum	
Mean activity of 4-mth exposed blocks	2.12
Mean activity of 12-mth exposed blocks	2.24
Significance level	0.1
T-value (t)	0.3539
P-value (p)	0.7287
Decision of rejecting H_0	Not reject

Apparently, the loss of surface area due to the accumulation of dust, dirt, oil and grease is as significant as that covered by discarded chewing gums. However, this may be due to small area covered by discarded chewing gums. As the chewing gums mostly only covered less than 1/10 of the top surface area, their influences to the photocatalytic activities of blocks may not be obvious.

4. CONCLUSION

The photocatalytic activity of TiO₂-coated paving blocks decreased significantly after a 4-month exposure in an ambient environment. As photocatalytic oxidation is a surface phenomenon, accumulation of contaminants on the TiO₂-coating surface would compromise its reactivity. The exposed environment (e.g. restaurant and plaza etc) may affect the performance of blocks but the positions across the pedestrian road (i.e. kerb side, middle and near wall) do not significantly affect the NO_x removal activity of paving blocks. Surprisingly, washing with water alone could not effectively recover the activity. This was probably due to the presence of non-polar contaminants such as oil and grease. As the blocks were in a horizontal position, the contaminants would tend to stay on the surfaces together with the rinsing water. Apparently, the loss of surface area due to the accumulation of dust, dirt, oil and grease is as significant as that covered by discarded chewing gums. To fully utilize their NO_x removal power, photocatalytic materials should be used in places with heavy automobile traffic but away from human intrusion.

5. REFERENCES

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