

Light Pipe Combined with Photocatalysis to Decompose Formaldehyde under Sunny Conditions in Beijing

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Abstract: Light pipe technology gives an effective way to transmit sunlight into room. It is much better as an auxiliary lighting method in buildings that are short of daylight. Photocatalytic oxidation is an emerging technology for destruction of dilute air contaminants that is currently under commercial development, which using TiO_2 as photocatalyst. Light pipe combined with photocatalysis technology will bring not only good luminous environment but also better indoor air quality. Light pipe combined with photocatalysis to decompose formaldehyde under sunny conditions in summer was tested in Beijing. The light pipe is a straight light pipe, which is 550mm long, with diameters of 280mm. Degussa P25 titanium dioxide ("Degussa", Germany) as photocatalyst was coated on the surface of the emitter of the light pipe. The experiment shows obvious effect on decomposing formaldehyde under sunny conditions. The intensity of sunlight nearly has little effect on the photocatalytic decomposition under sunny conditions.

Keywords: Light Pipe, Photocatalytic decomposition, Titanium dioxide

1. INTRODUCTION

Light pipe is one of the effective ways to guide sunlight into the room which is short of daylight. It has three components basically, sunlight collector, transport and emitter. Light pipes used in the buildings have two types, one is "active style", and the other is "passive style". The active style light pipe has a sun track system. It can move with the sun. The passive style light pipe has a top dome which is can not remove. The active style light pipe is very expensive than the passive one, so the passive light pipes are widely used in buildings. Light pipe for day lighting is also called sunpipe (Monodraught). The products of light pipes mostly have one function of lighting. Light pipe combined with natural ventilation has been developed. The University of Nottingham and University of Porto are the main participations. The project entitled as "TRIPLESAVE" (JOR3-CT97-0172). The work aimed to develop and assess the performance of a unit combining light pipe by utilizing the light pipe as an exhaust stack. This system had been also integrated with an energy transmission system for heating.

Light pipe combined with photocatalysis makes light pipe technology more attractive. Photocatalytic oxidation is an emerging technology for destruction of dilute air contaminants that is currently under commercial development, which using TiO_2 as photocatalyst. UV illumination of the TiO_2 film placed in a gaseous formaldehyde (HCHO) / air container resulted in the total degradation of formaldehyde to CO_2 and H_2O . TiO_2 is a semiconductor with a band gap energy $E_g = 3.2$ eV. If this material is irradiated with photons of the energy >3.2 eV (wavelength <388 nm), the band gap is exceeded and an electron is promoted from the valence to the conduction band.

Light pipe technology integrated with photocatalysis brings not only good luminous environment but also better indoor air quality for the room.

2. EXPERIMENTAL

The experimental set up was shown in Fig 1.A light pipe was mounted to the top of a sealed metal box. The light pipe was a straight light pipe, which was 550mm long; with diameter of 280mm. A highly reflective film was laminated to the internal surface which reflectivity was 88.8%. The emitter was made up of polystyrene with the thickness 2mm. The obverse of the emitter was smooth plate, the reverse side was accidented. The accidented surface was at the bottom of the light pipe. This kind of installation can make light output more uniform. Degussa P25 titanium dioxide ("Degussa", Germany) as photocatalyst was coated on the reverse surface of the emitter of the light pipe. The coating was uniform and adhering well. It was 5% TiO_2 water solution which was sprayed on the surface of the emitter. The mass of the coating is 0.8 gram. The measurement box was made up of stainless steel and had a removable side panels for easy access to the interior to release Formaldehyde. The volume of the box is 0.1m^3 . There was a quartz glass during the light pipe body and its emitter to keep airproof of the measuring box.

Light pipe combined with photocatalysis to decompose formaldehyde under sunny conditions in summer was tested in Beijing. Before the experiment, it had been proved that the measuring box was airproof enough. The measurements were made on June 1, 2005 at the first time. It was a cloudy day. So the data was not including in this paper. The second measurements were made on June 2, 2005 which

had been proved that light pipe combined with photocatalysis would nearly have on effect to decompose formaldehyde if there was no light into the light pipe. June 3 was a sunny day; there was no cloud in the sky all the day.



Figure 1: Experimental apparatus of light pipe combined with photocatalysis.

3. RESULTS AND DISCUSSION

3.1 No light into the light pipe

Photocatalytic oxidation has two conditions, one is light, the other is photocatalyst. Experimental research had been carried out on June 2, 2005 when the capture of the light pipe sheltered from gobo and natural attenuation of formaldehyde. There were no light into the light pipe under these two conditions. The experimental results were showed in Figure 2 and Figure 3. During one hour, the concentration of formaldehyde when the capture of the light pipe sheltered from gobo reduced from 1ppm to 0.78ppm. In the evening, natural attenuation of formaldehyde was from 1ppm to 0.73ppm. There had not any photocatalytic effect if no light into the light pipe.

Figure 4 shows the photodegradation of formaldehyde at dust on June 2, 2005. There was sunlight at the beginning of the experiment, obscuration of the sky occurred in the end. Although the exterior illuminance reduced rapidly, the photocatalytic effect on concentration of formaldehyde was obvious. Photodegradation of formaldehyde was from 1ppm to 0.1ppm during 1 hour. Figure 5 shows exterior illuminance and Figure 6 shows the intensity of UV radiation under the sun. The intensity of UV radiation was measured by UV light meter (290nm-390nm, UVA, UVB).

3.2 Photodegradation of formaldehyde at noon

Photocatalytic decomposition of formaldehyde at noon had been carried out on June 3, 2005 as shown in Figure 7. The concentration of formaldehyde decomposed 0.8ppm from 12:38 to 13:33. Figure 8 shows the exterior illuminance and Figure 9 shows the relative intensity of UV radiation. Air temperature in measuring box, exterior air temperature under sunny conditions and exterior air temperature shelter from the sun changed at any moment as shown in Figure 10. The relative humidity was shown in Figure 11. The temperature and relative humidity were measured by outo thermoscope.

The effect of photodegradation of formaldehyde at noon was also obvious. Compared with the values of Figure 4, not the intensity of UV radiation more bigger, the effect better. It was not a direct proportion. There must have a high-point of the intensity of UV radiation.

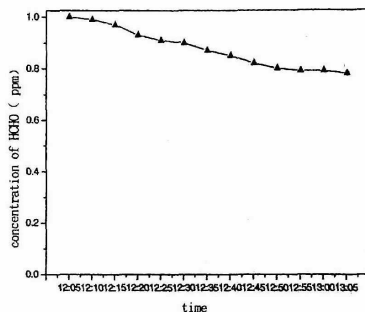


Figure 2: The attenuation of formaldehyde when the capture of the light pipe sheltered from gobo.

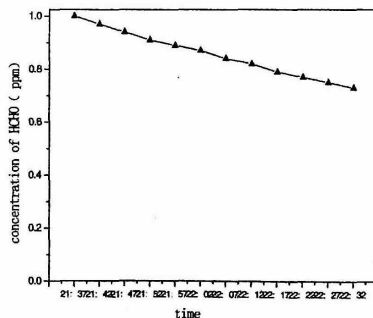


Figure 3: Natural attenuation of formaldehyde.

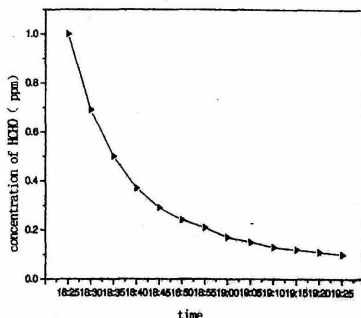


Figure 4: Photodegradation of formaldehyde.

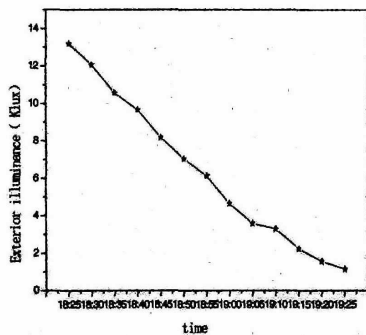


Figure 5: Exterior illuminance.

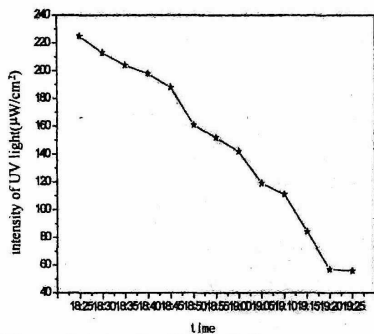


Figure 6: Intensity of UV radiation.

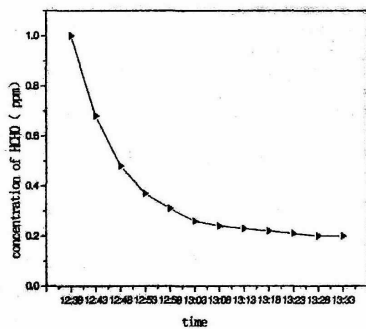


Figure 7: Photodegradation of formaldehyde.

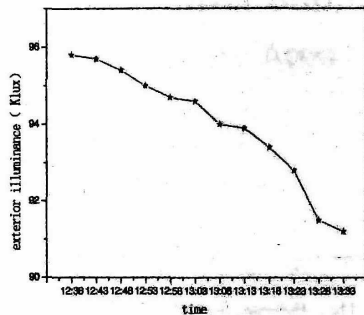


Figure 8: Exterior illuminance.

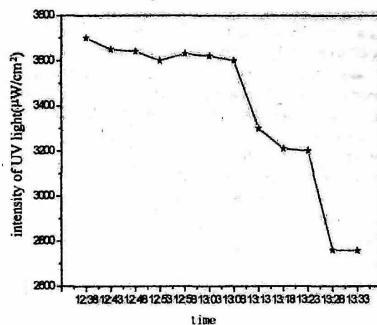


Figure 9: Intensity of UV radiation.

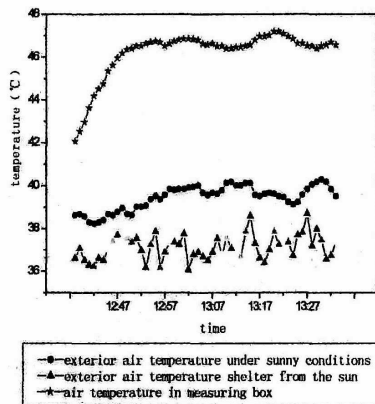


Figure 10: Temperature curve.

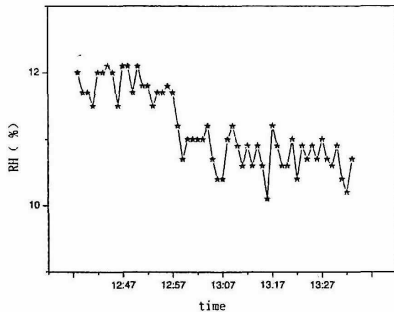


Figure 11: Relative humidity of the air in the measuring box.

3.3 The relationship of Exterior illuminance and illuminance in the middle of the emitter

Figure 12 shows the relationship of exterior illuminance and illuminance in the middle of the emitter. It was very difficult to measure illuminance and intensity of UV radiation under the light pipe when the experiment was in operation. It would be harmful to the sensor of the instruments if they had been arranged in the measuring box. The performance of light pipe was easy to be examined. So it was enough to know exterior illuminance. Illuminance was measured by illuminometer (0.1-100,000lx).

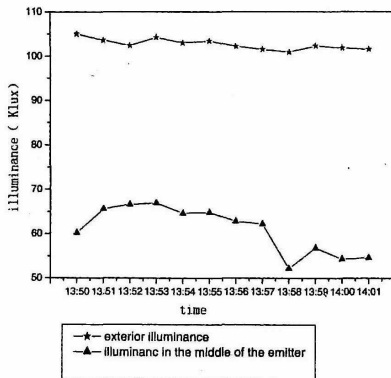


Figure 12: Exterior illuminance and illuminance in the middle of the emitter.

4. CONCLUSIONS

Light pipe is one of sustainable energy technologies. Light pipes can reduce the electricity consumption during the day. Light pipe combined with photocatalysis is a innovative idea to the light pipe research and development. Experiment research showed that light pipe combined with photocatalysis can decompose formaldehyde rapidly in a short time under sunny conditions at dusk and at noon. The success of the experiment made the light pipe technology more interesting and valuable. An extended research of light pipe combined with photocatalysis is underway at the Beijing University of Technology. Results of new investigations will be reported in the future publications by the authors. Light pipe combined with photocatalysis will not only provide good luminance environment but also better indoor air quality to the room.

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