[PRELIMINARY TRANSLATION]

Report No. H03-13731
Date of Report: January 26, 2004

Report of Experimental Test Results
Test Name: Efficacy of Photocatalyst Product in Removing Solvent Gases

Environmental Control Center K.K.

Environmental Consulting Operations Hino 475-1, Hino City, Tokyo 191-0012
Telephone 042-586-6820 (Main) Fax 042-582-0017
Analysis Center Hino 304-9, Hino City, Tokyo 191-0012
Telelphone 042-582-1496 (Main) Fax 042-582-1484

1. Purpose

The purpose of project is to test your company's photocatalytic product by a stationary method and to develop basic data on the product's efficacy in reducing or eliminating certain gases.

2. Description of the Test

(1) Testing materials
   a. For testing efficacy in removing: a glass plate (20cmx20cm) sprayed with 0.4 grams of a photocatalytic product known as Clean Air Guard
   b. For control group: a glass plate of the same quality used above (but not treated with the photocatalytic product)

(2) Testing the Efficacy of the Photocatalyst Product to Remove or Eliminate

Measure the efficacy of the photocatalyst in removing solvent gases by filling a container with solvent gases, inserting a treated glass plate and measuring at specified defined intervals the concentration of the solvent gases within the container. The same operations were performed with the untreated glass plate.

Table 1 shows the solvent gases that were measured, the initial concentrations and the resulting concentrations.

Table – 1. Identification of Target Gases and Initial Concentrations

Test Gas	Initial Concentrations	Method of Analysis	Detection Limits
Formaldehyde	10 ppm	Detection Tube Method	0.05 ppm

Acetaldehyde	18 ppm	“	0.2 ppm
Toluene	17 ppm	“	0.5 ppm
Xylene	30 ppm	“	1 ppm
Ethylbenzene	30 ppm	“	2 ppm
Styrene	60 ppm	“	0.5 ppm

3. Test Procedures

(1) Insert 1 treated glass plate into a 10 liter polyester container (hard plastic) and fill with the specified gases to be measured (See Table – 1).
(2) Place the bag in a fixed location in a room set at 20°C, irradiate with a single fluorescent black light lamp (20W, FL20SBL-B: made by NEC) and measure the concentrations of the solvent gases at specified times. Place the black light and the glass plate a distance of 30cm from each other.
(3) Conduct the same operations as set out in (1) and (2) above for the control experiment and in addition to finding out the capacity of ultraviolet radiation to remove (or eliminate) the solvent gases on their own, one can also determine the efficacy of black light on its own to remove (or eliminate) solvent gases.
(4) Conduct the experiment separately for each target gas and perform 9 measurements for each gas at the times set out in Table – 2 (measure the initial concentration of the gas and then make four measurements each with the treated glass plate and with the untreated glass plate).

Test Type	Initial Gas Measurement	After 1 hour	After 1 day	After 2 days	After 1 week
Treated Glass	O	O	O	O	O
Untreated Glass		O	O	O	O

The mark “O” indicates when a measurement is taken.

(5) In order to calculate the amount of gases reduced or eliminated per given weight of the photocatalyst product Clean Air Guard, measure the amount of gas remaining in the container after the test.
(6) The steps of the test are set out in graphic form in Diagram – 1.

Diagram – 1 [not included]

4. Test Results

The results of the measurements for the concentration of each of the gases for the materials testing the efficacy of Clean Air Guard (a photocatalyst product) and a control sample as well as the reduction percentages are set out in Table – 3. A graph showing the amount and rate of reduction or elimination is set out in Diagram – 2. [not included]

The reduction or elimination rates after irradiating with ultraviolet light for seven days the container with the glass treated with 0.4 grams of Clean Air Guard (a photocatalyst product) were found to be relatively strong, at 87% for formaldehyde and 86% for acetaldehyde.

The reduction or elimination rates for toluene, xylene and styrene were lower, at 61%, 42% and 44% respectively.

Moreover, given that ethylbenzene's reduction or elimination rate was only 15%, the product seemed to have little impact upon ethylbenzene.

Finally, we note the delayed effect of Clean Air Guard. Little immediate effect upon the target solvent gases was detected.

Table – 3 Chart of Results of Efficacy Test of Clean Air Guard (a photocatalyst) in Reducing or Eliminating Specified Solvent Gases.

Gas Measured	Elapsed Time	Start Time	After 1 hour	After 1 day	After 2 days	After 7 days	Reduction or Elimination Ratio*
Formaldehyde	Treated	10	8.8	4.8	2.4	0.8	87
	Untreated	10	9.6	8.5	7.5	6.0	
Acetaldehyde	Treated	18	18	12	5	2	86
	Untreated	18	18	18	17	14	
Toluene	Treated	17	17	11	10	5.5	61
	Untreated	17	17	17	16	14	
Xylene	Treated	30	30	30	28	14	42
	Untreated	30	30	30	30	24	
Ethylbenzene	Treated	30	30	30	28	22	15
	Untreated	30	30	30	30	26	
Styrene	Treated	60	55	50	40	28	44
	Untreated	60	60	60	55	50	

*The Reduction or Elimination Ratio (%) = Control concentration (ppm) – treated material concentration (ppm)/control concentration x 100

5. Observations

(1) Calculation of Amount of Solvent Gases Removed per unit of Weight of Clean Air Guard

The amount of gases eliminated per unit of Clean Air Guard is calculated and set out in Table – 4 based upon the concentrations of the solvent gases after seven days in both the treated and untreated tests, the volume of the container, and the volume of Clean Air Guard used.

The amount of the gases that were eliminated per unit of Clean Air Guard are as follows: formaldehyde – 0.2 mg/g; acetaldehyde - 0.5 mg/g; toluene – 0.8 mg/g; xylene – 1.1 mg/g; ethylbenzene – 0.4 mg/g; and styrene – 2.3 mg/g.

Table – 4 Solvent Gases Removed per unit of Clean Air Guard applied

Material	Molecular Weight	Concentration of Gas after 7 days w/o CAG	Amount of Gas in bag w/o CAG (liters)	Concentration of Gas after 7 days w/ CAG	Amount of Gas in bag with w/ CAG (liters)	Weight in bag after 7 days (mg) w/o CAG	Weight in bag after 7 days (mg) w/ CAG*	Amount of Clean Air Guard per unit of VOC removed**
F	30	6.0	8.8	0.8	8.6	0.071	0.009	0.2
A	44.1	14	8.5	2	9.0	0.233	0.035	0.5
T	92.1	14	9.3	5.5	9.3	0.534	0.210	0.8
X	106.2	24	9.1	14	9.1	1.035	0.604	1.1
E	106.2	26	8.7	22	8.7	1.077	0.911	0.4
S	104.2	50	8.8	28	8.8	2.052	1.149	2.3

*Absolute weight (mg) = (concentration of gas (ppm) x molecular weight/22.4) x amount of gas (liters)/1000
**VOC eliminated per unit of Clean Air Guard (mg/g) = absolute weight of materials in untreated bag (mg) – absolute weight of materials in treated bag (mg)/volume of Clean Air Guard applied (g)

(2) Trial Calculation of Amount of Clean Air Guard Used

Table – 5 sets out the amount of Clean Air Guard (by weight) that is required to eliminate the amount of the gases set out in the guidelines for Sick House Syndrome established by the Ministry of Health and Welfare if those gases were placed in a room of about 24 square meters.

Note that ethylbenzene has been omitted from the table because Clean Air Guard had little effect on ethylbenzene.

Table – 5 Test Results of Amounts of Clean Air Guard (a photocatalyst product)

Material	Sick House Guidelines Established by the Ministry of Health and Welfare (μg/m^3)*	Amount by weight in 24m^3 Room (mg)	Amount of VOC Eliminated per unit of Clean Air Guard (mg/g)	Amount of Clean Air Guard to be used (g)**
Formaldehyde	100	2.4	0.2	12.0

Acetaldehyde	48	1.152	0.5	2.3
Toluene	260	6.24	0.8	7.8
Xylene	870	20.88	1.1	1.9
Styrene	220	5.28	2.3	2.3

*Extract from the Interim Report on Sick House Syndrome (Internal Air Pollution) Issues by the Ministry of Health and Welfare; Part 4 (H14.2.8).
**Amount of Clean Air Guard to be used (g) = weight of target substance (mg)/elimination weight per weight of Clean Air Guard (mg/g)

As a result of having calculated the amount of Clean Air Guard used based on the data from this test and the limits set out in the Sick House guidelines of the Ministry of Health and Welfare for the maximum concentrations permitted for a hypothetical 24 cubic meter room, we have calculated that it is possible to remove each of the gases by coating the following amounts of Clean Air Guard on wall surfaces: formaldehyde – 12 grams; acetaldehyde – 2.3 grams; toluene – 7.8 grams; xylene – 1.9 grams; and styrene – 2.3 grams.

Please note, however, that these amounts were derived from tests involving a single gas at a time and that the numbers will be different if more than one gas is present.

Moreover, in actual use, results may vary due to the condition of the room (for example, size, shape, and air flow), the strength of the ultraviolet radiation, the length of the irradiation period, the area on which the photocatalyst material is applied, and the degree of VOCs present. In response to these variables, the amount of Clean Air Guard used may have to be adjusted.