A study on eco friendly furniture for mitigation of the indoor air pollution

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Abstract

Furniture can raise indoor air contaminants with toxic emissions of VOC and formaldehyde.. While furniture is classified as a subject of safety and has quality labeling, there is a lack of domestic regulations related to contaminant emissions with the exception of sinks. When looking at the analysis on environment-related patients related to the smell or odors from furniture every year, patients suffering from asthma, allergic rhinitis, and atopic dermatitis are on the rise. Likewise, because there was an urgent need to prepare control standards, there was a prior notice of legislation for the introduction of a contaminant emission labeling system from 2010 onwards. This study conducted an analysis on the emission characteristics of VOCs and formaldehyde, an indoor air contaminant emitted from furniture. After an analysis was conducted on contaminant emission characteristics on conventional furniture versus eco-friendly furniture that can reduce harmful elements with closets, which are special-offer products, and office desks which are general market products, improvements were shown which indicate materials were working continuously to reduce indoor air

contamination factors. Because of the comparative analysis on characteristics of the furniture of which has eco-friendly engineering against conventional furniture engineering, contaminants had been reduced in furniture using the eco-friendly engineering methods.

Keywords: Furniture, Formaldehyde, VOC, emission, chamber, harmful elements, eco-friendly, indoor air, contaminants

Introduction

According to the materials announced by the Ministry of Environment in February 2008, it appeared that furniture had the possibility of working as an indoor air contamination factor unlike existing construction materials by gradually reducing its formaldehyde emissions, a major indoor air contaminant. However, it is a reality that there is a lack of awareness that furniture is a source of indoor air contamination.[2]

According to the survey conducted by the Korea Consumer Agency, the number of consumer complaints received in relation to smells or odors from furniture for about 4 years from 2002 to 2005, was 264 and is on the rise every year.[2] Furthermore, in the analysis on major environmental disease patients from the National Health Insurance Corporation, environmental diseases such as asthma, allergic rhinitis, and atopic dermatitis are also on the rise every year.[2] Thus, there was an urgent need to prepare related control standards. Therefore, the Ministry of Environment has introduced the “Prior Certification System” on wood-based panels used

extensively in home appliances such as furniture made since 2010 and there was a prior notice of legislation on the introduction of the “Contaminant Emission Labeling System” on various construction materials.[3] The Korea Environment Institute announced that the cause of atopic dermatitis, an environmental disease, exists not only indoors but also outdoors, and contaminated indoor air can be fatal to infants and children under the of age 4.[2] In order to solve the root cause of these problems stemming from contaminants of indoor space, the characteristics of indoor air contaminants like formaldehyde and VOC emissions from furniture must be analyzed, and securing sufficient data about it must be a priority. Likewise, the analyses on the characteristics of contaminant emission on furniture and eco-friendly furniture that can reduce harmful substances desperately require the commercialization of eco-friendly products due to the technological development of materials.

Therefore, this study aimed to analyze the characteristics on eco-friendly furniture that can reduce formaldehyde and VOC emissions.

Methods

A large chamber (24㎥) was used in this study. A test product was purchased personally for the emission test, and the storage period was minimized by receiving earliest possible delivery of products that corresponded with the test schedule. The chamber was washed prior to installing the test product and the background concentration was maintained below standard levels. Measurement of the background concentrations was done by the collection of air inside the chamber using Tenax-TA and a DNPH cartridge after sufficiently ventilating the

washed chamber for over 24 hours. The test was conducted after checking if the analyzed background concentration was below the standard levels of TVOC 20㎍/㎥ and HCHO 5㎍/㎥.

It is a general rule to use Tenax-TA and a DNPH cartridge for the collection of VOCs and formaldehyde. The emission test on contaminants emitted from the furniture was first conducted by installing test products that had a verified background concentration on the center of the chamber while all the drawers were opened. The sampling was done after 24 hours, after 72 hours, after 120 hours, and after 168 hours from the point of installing the test product. The test aimed to check the characteristic of contaminant emissions of the product by measuring the emission concentration according to the previously mentioned intervals. The number of times that ventilation was conducted was maintained to 0.5 times/h.

The sampling conditions for VOCs and formaldehyde is shown on Table 1, and the analysis of VOCs after sampling used GC/MS as the conditions for Table 2. In addition, the analysis on formaldehyde used HPLC as conditions shown in Table 3.

Table 1 Sample Collection Conditions

	formaldehyde	TVOC
Absorption Pipe	DNPH-silica cartridge (Ozone scrubber)	Tenax-TA(60/80mesh) 200 ㎎충전(ATD/TCT Tube)
Flow	500 ㎖/min × 30min	100 ㎖/min × 30min
Collected Amount	15ℓ	3ℓ

Table 2 Analysis condition of TD-GC/MS

TD	Turbo matrix 400(Perkinelmer)
Valve temperature	195℃
Desorption temperature	290℃
Desorption time and flow	10min, 30 ㎖/min
Cold trap low temperature	-30℃
Cold trap high temperature	300℃
Transfer line temperature	240℃
Split ratio	10:1
GC/MS	GCMS-QP2010(Shimadzu)
Column	DB-1(0.25 ㎜×1.0 ㎛×60.0m)
Carrier gas	He, 1.0 ㎖/min
Oven temperature	35℃(5min) - 5℃/min - 200℃(17min) - 10℃/min - 250℃(20min)
Electron energy	EI(70eV)
Mass range	m/z 35 - 300

Table 3 Analysis of condition for HPLC

HPLC	Waters 1525 / 717 plus
Column	Ace5 C-18(150 ㎜×4.6 ㎜)
Eluent	Acetonitrile/Water
Flow rate	1.0 ㎖/min
Gradient elution	ACN/Water(40/60→70/30(28min)→40/60(30min))
Injection volume	20 ㎕
Detector	UV@360 ㎚, Waters 2487

Test conditions were in accordance with KS I 2007, and the objective of the test results were ensured by setting the temperature/humidity conditions and ventilation conditions of the general indoor space in a similar fashion.

- Temperature : (25 ± 1) ℃

- Humidity : (50 ± 5) %
- Number of Ventilations : (0.5 ± 0.05) times/h
- Air Velocity : 0.1 ~ 0.3 m/s
- Test Period : 7 days

Results

The test was conducted using a large chamber (24㎥) for the evaluation of furniture material through contaminant emission analysis. It targeted the measurement of contaminants of the emitting component applied with sufficient ventilation within the large chamber. Measurement and analysis was conducted on special products such as closets, which are special-offer products, and office desks, which are general market products.

Table 4 Harmful elements emission of VOCs and Formaldehyde on the closets

Compound Name	CAS No.	mg/(unit . h)				
		general product	eco-friendly product	functional product	general product	all edge-bonding product
Formaldehyde	50-00-0	5.686	0.278	0.515	0.146	0.080
TVOC	-	2.435	1.419	4.010	18.057	17.813
Chloroform	67-66-3	0.005	0.005	0.005	0.043	0.052
Ethane, 1,1,1-trichloro-	71-55-6	0.002	0.001	0.002	0.015	0.017
Benzene	71-43-2	0.010	0.009	0.006	0.052	0.056
Toluene	108-88-3	**0.509**	**0.080**	**1.542**	**1.531**	**1.002**
Ethylbenzene	100-41-4	0.024	0.005	0.061	0.018	0.038
m,p-Xylene	106-42-3	0.025	0.005	0.100	0.061	0.089
Styrene	100-42-5	0.007	0.003	0.006	N.D	0.004
o-Xylene	95-47-6	N.D	N.D	N.D	0.020	0.025
1,4-cyclohexadiene	**99-85-4**	**N.D**	**N.D**	**N.D**	**8.607**	**5.718**
Benzene, 1,2,4-trimethyl-	95-63-6	0.009	0.002	0.003	N.D	N.D
Benzene, 1,3,5-trimethyl-	108-67-8	0.002	N.D	0.002	N.D	N.D

Benzene, 1,3-dichloro-	541-73-1	0.002	N.D	N.D	N.D	N.D

The TVOC emission of closets appeared in the order of functional products, general products, and eco-friendly products. The amounts of toluene emissions were same as the order of TVOC emissions and the major emission substance was toluene. The formaldehyde emission of closets appeared in the order of general products, functional products, and eco-friendly products. This test was able to confirm that the amount of TVOC and formaldehyde emissions were reduced in the eco-friendly products compared to conventional products. Eco-friendly products are products made with air purification technology, all edge bonding treatment of 4 sides, air circulation engineering, and eco-friendly materials.

Regarding closets, comparative analysis was conducted on conventional products and all edge-bonding products with interval of 1 month. This was to have comparative analysis of all edge-bonding treated and conventional products applied with just one engineering method among three types of engineering methods of eco-friendly products. Even in the engineering method applied with just one method out of three,, it was able to confirm that lower amounts of contaminants were emitted in all edge bonding products than the conventional products. The TVOC emission of a general closet was 18.057mg/unit・h, and the TVOC emission of all edg-bonding treated closets appeared to be 17.813mg/unit・h. It was reasoned that contaminants are emitted from the part where there is no edge-bonding treatment. Furthermore, the emissions of 1,4-cyclohexadiene was detected more. This is thought to have occurred through the finishing materials from the sub materials. However, contaminant emissions of toluene are thought to appear with major emission substances in most furniture products.

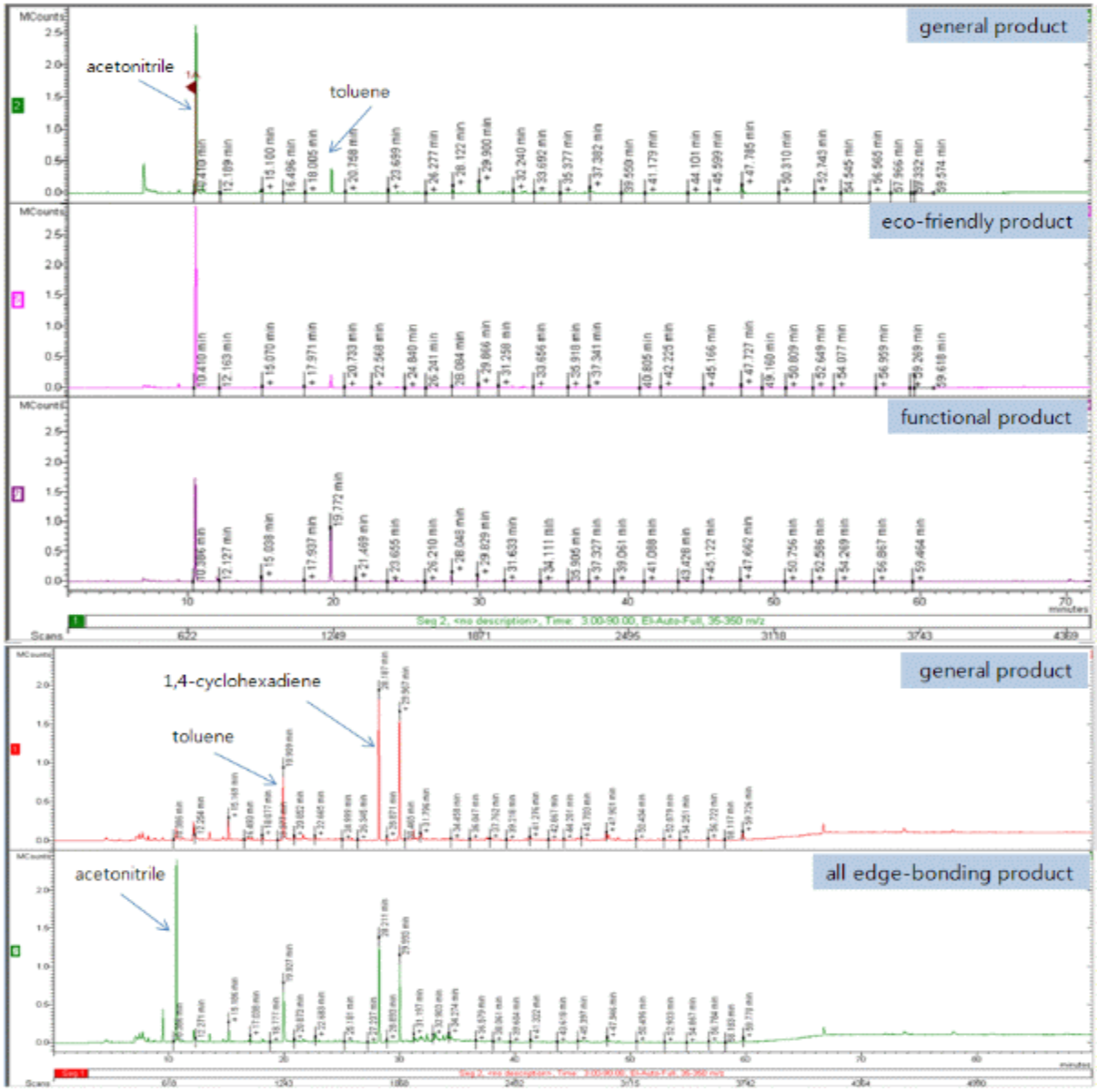

Fig.1 Gas Chromatogram of the closets

For TVOC emissions of office desks, conventional products appeared to be 2 times higher than silver nano sheet products. The toluene emissions was same as the order of TVOC emissions, and cyclohexene and 1-methyl-4-(1-methylidene) which does not come from silver nano sheet products were detected from conventional products. The reason such harmful substances were identified from the general products is because it has been determined that harmful substances are included in the ingredients of bonding agents and finishing

materials which are sub materials.

Table 5 Harmful elements emission of VOCs and Formaldehyde on the office desks

Compound Name	CAS No.	mg/(unit . h)	
		silver nano sheet product	general product
Formaldehyde	50-00-0	0.063	0.071
TVOC	-	0.251	0.506
Chloroform	67-66-3	0.005	0.004
Benzene	**71-43-2**	**0.006**	**0.008**
Toluene	108-88-3	**0.100**	**0.069**
Ethylbenzene	100-41-4	N.D	0.001
m,p-Xylene	106-42-3	N.D	N.D
Styrene	100-42-5	N.D	N.D
Cyclohexene, 1-methyl-4-(1- methylidene)	586-62-9	**N.D**	**0.092**

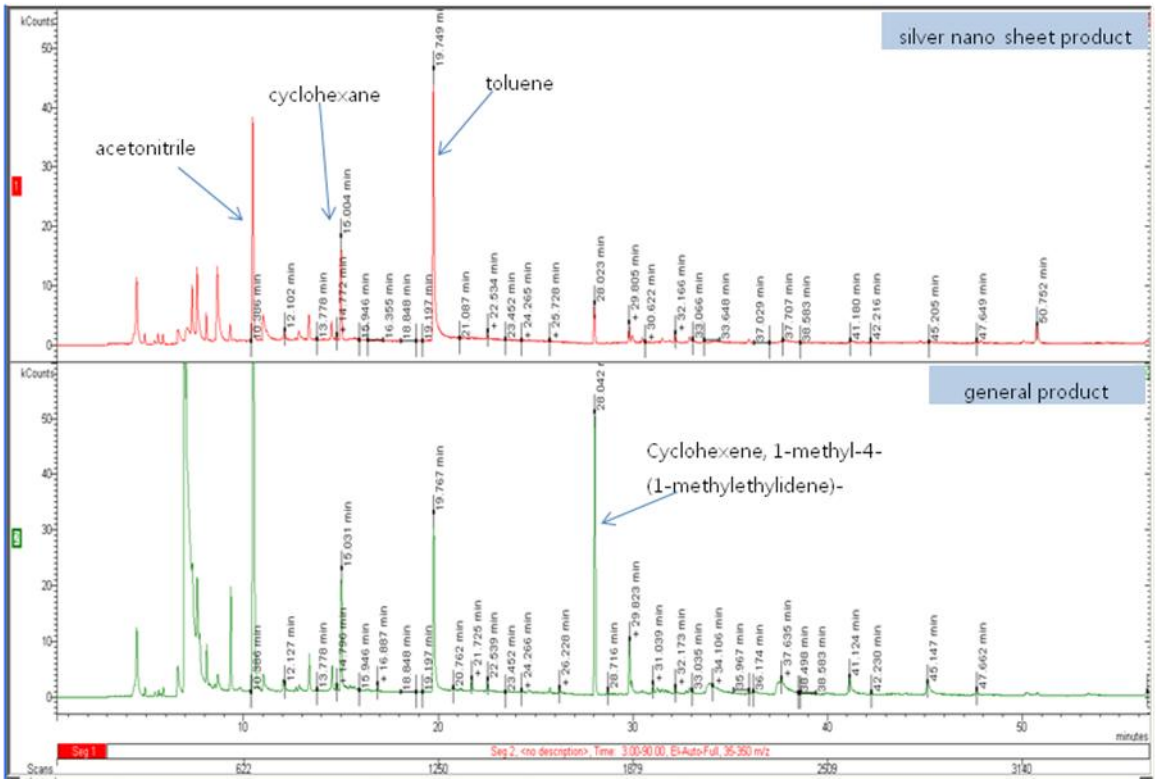

Fig.2 Gas Chromatogram of the office desks

Results and Discussion

This study measured and analyzed closets, which are special-offer products and office desks, which are general market products for the development of eco-friendly furniture in order to reduce indoor harmful substances, and the results are as follows.

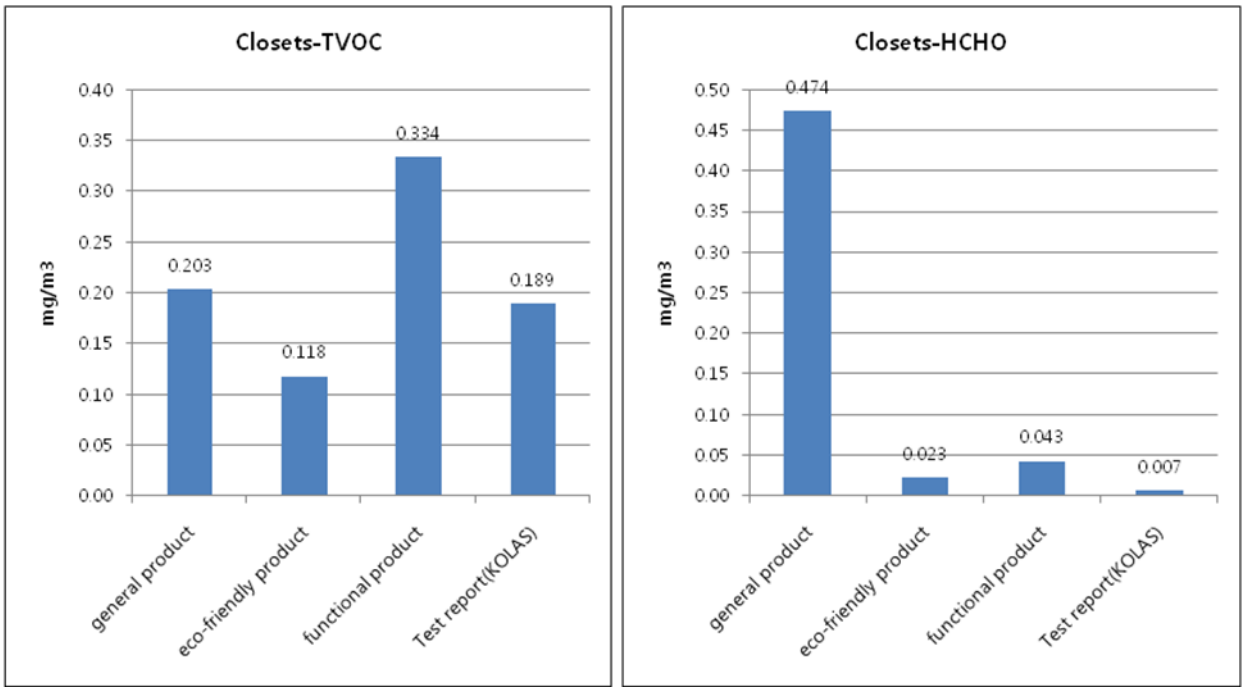

Fig. 3 Harmful elements emission of VOCs and Formaldehyde on the Closets

For closets, a total of 6 specifications were analyzed, and out of those, this is a chart comparing 4 products excluding any overlapping products. The four products include conventional products, eco-friendly product #1, functional products, and eco-friendly product #2. General products use E1 grade wood-based panels, and the finishing materials for the furniture body use PVC-vinyl materials and a one side edge-bonding method is used

for edge bonding as its engineering method. Moreover, there is no many line boring due to the application of fixed shelves, and it is applied to the rear side of the body and an original PVC ventilation grill device. Eco-friendly products use Eo grade wood-based panels, and use a LPM material as the finishing material for the body. For their engineering method, the edge bonding side is bonded with 4 side edges, and the moveable shelf many line boring is done in many line boring. Ventilation holes was fabricated using the mop tray on the bottom of the body, charcoal green deodorant was applied to the side of the body interior and a square PVC ventilation grill was applied to the rear plate. Last of all, functional products are products were covered with yellow earth charcoal during its production process.

While it is deemed that harmful substances, including TVOC, occur during the production process with the use of bonding agents to cover the yellow earth charcoal, it appears that contaminants are not emitted from formaldehyde. It could be determined that less contaminant were emitted in closets with improvements using eco-friendly materials and engineering methods.

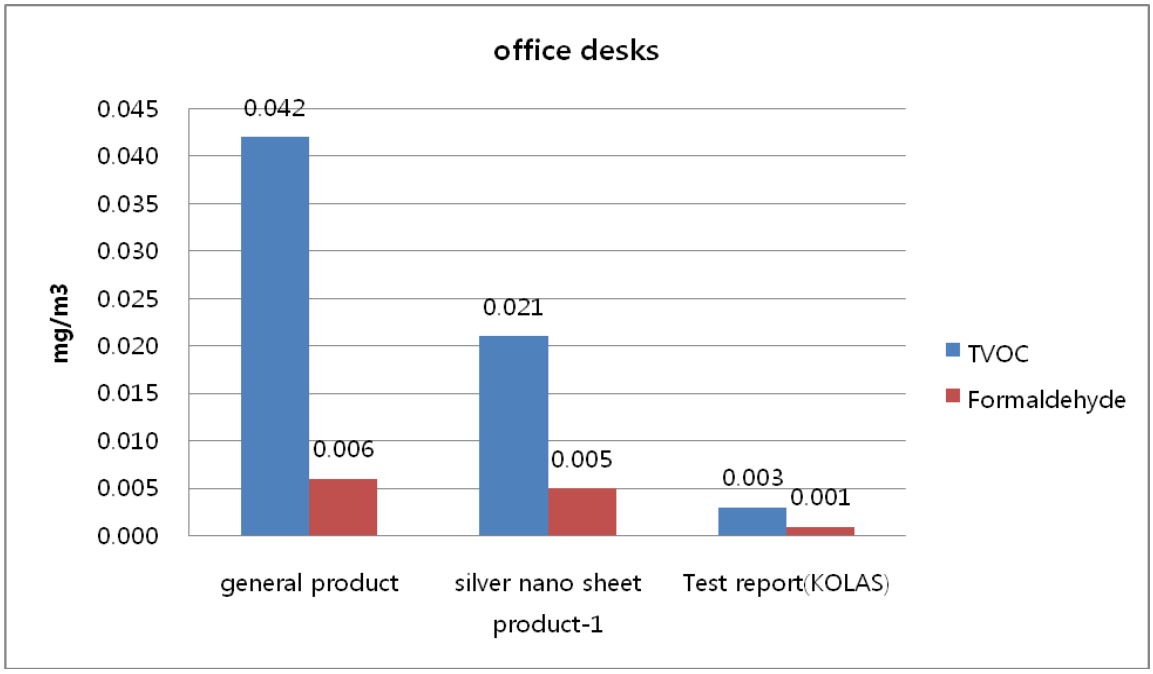

Fig. 4 Harmful elements emission of VOCs and Formaldehyde on the office desks

Measurement and analysis was conducted on the office desk, the market product of Wooami regarding conventional products and functional products. Functional products used the engineering method of a silver nano sheet coating during the production process. As shown in picture 4, it was confirmed that there was less emission of contaminants of VOC and formaldehyde from functional products using the engineering method for coating it with a silver nano sheet. This enabled confirmation that harmful substances were reduced in furniture due to the use of the silver nano sheet engineering method.

Conclusions

As a result of conducting a research on the actual conditions of furniture materials and products sold in Korea, wood based panels are classified into E2, E1, E0, and SE0 grade according to the amount of HCHO emissions,

and its use is identified as maintaining its level at the E1 level. However, in recent times, major developed nations like Japan, the U.S., and Taiwan are strengthening the control of formaldehyde emitted from wood based panel products to the level of SE0, and along with this, they are expanding their control to even major VOCs such as benzene and toluene. Therefore, it is deemed that only when the performance of wood based panel products used as major furniture materials is improved to the E0 or SE0 level, it can then make a contribution to the eco-friendliness of domestic furniture products.

In this study, the amount of contaminant emissions on major home appliances produced and sold in Korea was measured and analyzed using a $24m^3$ large chamber.

In order to do this, samples of closets among furniture that can potentially emit indoor air contaminants in excessive amounts were produced using materials of E1 grade and E0 grade respectively, and the level of contaminant emissions were then analyzed. In addition, in order to identify the extent of any performance changes according to differences in production methods, an experiment was conducted on the S Construction specification with eco-friendly engineering methods partially applied and furniture with general specifications equivalent to this. To identify performance for the reduction of harmful substances according to the application of materials related technology such as functional materials, samples using yellow earth charcoal and silver nano sheet was produced, and its performance was then measured.

Through this study, the analysis on the characteristics of contaminant emissions of eco-friendly furniture products ultimately developed was conducted using a $24m^3$ large chamber. In order to measure contaminants of indoor furniture products, closets, a special-offer product among furniture products was selected. For the

measurement and analysis of TVOC and HCHO, office desks which are general market products were chosen.

The emission of closets with improved manufacturing methods has shown TVOC emissions were 2 times lower than in conventional products, and formaldehyde emissions also appeared to have a significantly lower value. However, closets with yellow earth charcoal emissions appeared to have a somewhat large amount of TVOC emissions. It concludes that harmful chemical substances were emitted from bonding agents used during the process of coating the yellow earth charcoal.

For office desks, which are products on the market, a comparative analysis was carried out on conventional products and silver nano sheet products. From functional products produced by covering silver nano sheets during the production process, TVOC, individual VOCs and formaldehyde (HCHO) appeared to have a low amount of contaminant emissions.

It could be identified that VOCs and formaldehyde emissions emitted from furniture were reduced by applying eco-friendly engineering methods for the reduction of indoor harmful substances. As a result of this study, eco-friendly engineering methods can be utilized in the engineering method for the reduction of contaminant emissions from furniture.

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