Nanometer catalyst cleans up bad cigarette smoke in smoking room

July 8 2015

A prototype of the air cleaning equipment for cigarette smoke installed in an actual smoking room. Credit: ©KIST

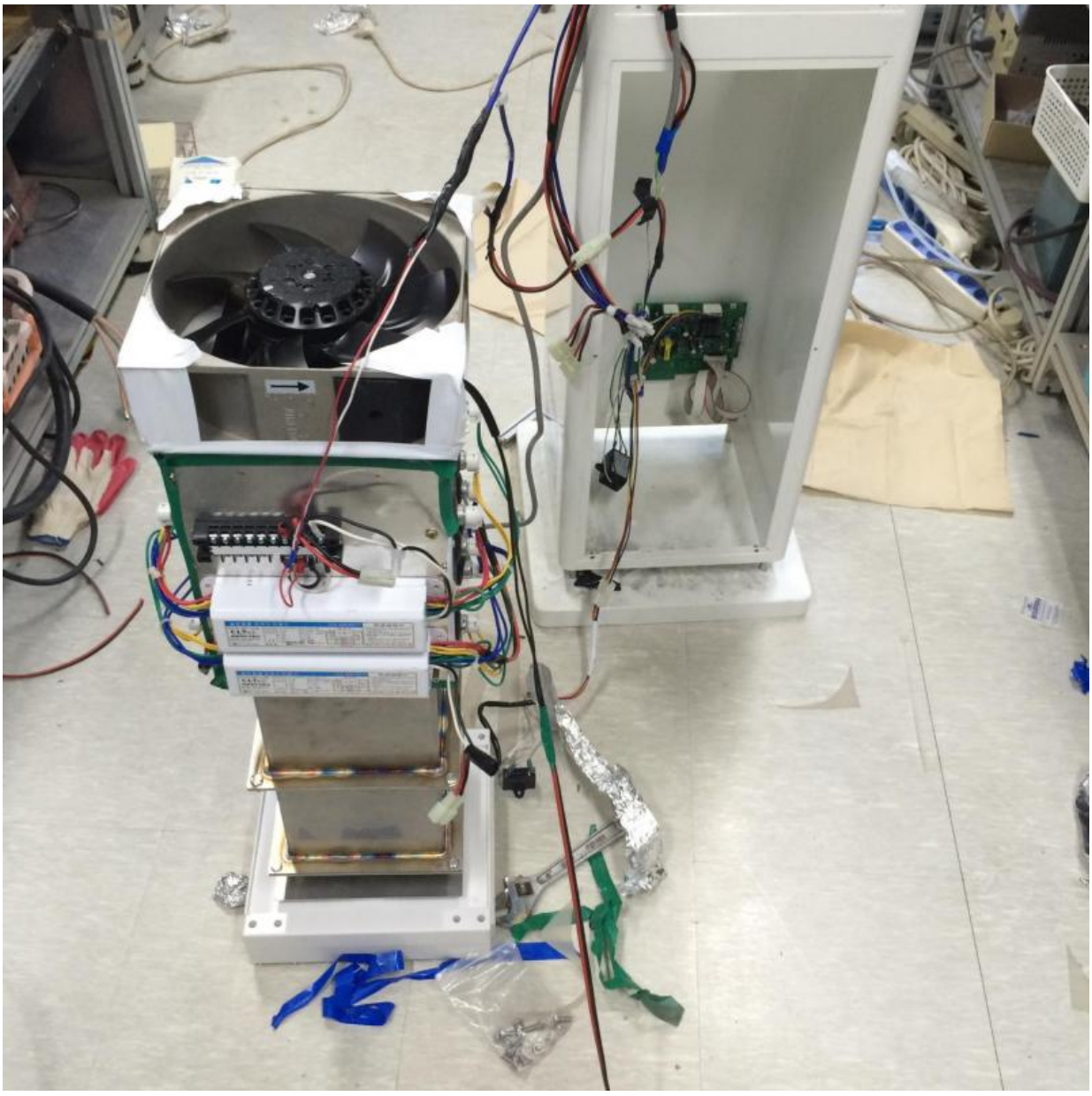
KIST research team has developed a nano-catalyst for air cleaning in a smoking room that removes 100 percent of acetaldehyde which accounts for the largest portion of the gaseous substances present in cigarette smoke.

The research team led by Dr. Jongsoo Jurng and Dr. Gwi-Nam at KIST stated that, "In cooperation with KT&G, KIST has developed a nano-catalyst filter coated with a manganese oxide-based nano-catalyst, which can be used in a smoking room to reduce and purify major harmful substances of cigarette smoke. the KIST-developed catalyst removes 100% of the particle substances of cigarette smoke, such as nicotine and tar, converting those into water vapor and carbon dioxide. According to the research team, the air cleaning equipment based on the newly-developed catalyst can purify over 80% of the cigarette smoke within 30 minutes and 100% of it within 1 hour in a 30 square meter smoking room, where 10 people are simultaneously smoking

Activated charcoal-based filters have been mostly used in a smoking room to remove gaseous materials in cigarette smoke. However, those filters are not effective in removing gaseous materials such as acetaldehyde, their absorbtion performance decreases fast in a closed facility such as a smoking room, and they need to be replaced at least every other week, which is rather inconvenient.

The research team has developed a nano-catalyst filter by evenly coating a manganese oxide-based (Mn/TiO_2)) nano-catalyst powder onto a ceramic-based filter media. The nano-catalyst filter uses a technology that decomposes elements of cigarette smoke using oxygen radical, which is generated by decomposing ozone in the air on the surface of the manganese-oxide-based nano-catalyst filter. An evaluation test with total volatile organic compounds (TVOC), such as acetaldehyde, nicotine and tar, which account for the largest volume of gaseous materials in cigarette smoke, is conducted to evaluate the performance of the newly-

developed catalyst. The results show that the new catalyst decomposes over 98% of the aforementioned harmful substances (refer to Fig. 3).



Circulation fan is installed on top of the air cleaning equipment for air circulation inside the equipment. Underneath the fan is a UV lamp that supplies ozone and the nanometer catalyst filter to process pollutants. The circulation fan operates with the capacity of 4 CMM(m3/min) based on the room size of 16.52

square meters. Credit: ©KIST

For the performance evaluation test, the research team made an air cleaning equipment prototype using the nano-catalyst filter. The equipment was installed in an actual smoking room in the size of 30 square meters (with processing capacity of 4 CMM). About 80% of cigarette smoke elements were processed and decomposed to water vapor and carbon dioxide, within 30 minutes, and 100% of them within 1 hour. The test condition was designed based on the processing capacity which could circulate the air inside the entire 30 square meter smoking room once every 15 minutes.

The research team expected that it would take a year or so to commercialize this technology as the nano-catalyst and the filter coating technologies had been developed already.

The lead researcher Dr. Jurng mentioned that "this research holds a significance since the new air cleaning equipment based on a simple catalyst successfully processes and removes gaseous materials in cigarette smoke, which are not easily removed with the existing air cleaning technologies. If the new equipment can be simplified and is economically feasible, it will be an important tool for keeping smoking room pleasant and clean. Also, from the convergence perspective, the new nanometer catalyst filter can be integrated with other air cleaning products such as air purifiers and air conditioners."

Compounds	Concentration (μg/m^3)		
	Before treatment	After treatment	Removal efficiency (%)
Acetaldehyde	75.3	23.0	69%
Acetonitrile	123.9	105.1	15%
Propanenitrile	25.4	22.4	12%
Diacetyl	223.9	41.9	81%
Benzene	176.9	113.7	36%
Toluene	242.3	102.2	58%
Ethylbenzene	35.2	9.1	74%
m-Xylene	64.0	10.3	84%
Styrene	36.9	0.0	100%
o-Xylene	23.3	3.8	84%
Phenol	8.7	6.4	27%
Limonene	92.7	1.6	98%
Decanal	4.8	2.0	58%
Triacetin	20.5	12.5	39%
Nicotine	106.2	0.0	100%
Phenylacetyle	57.8	30.2	48%
TVOC	2229.4	492.7	78%

Decomposition performance per TVOC element in the cigarette smoke. Credit: ©KIST

Research overview

Ozone (O_3) decomposition method using a catalyst can be utilized as a permanent decomposition technology. When O_3 interacts with a metal oxide (Mn/TiO_2), O_3 is decomposed by the following reactivity formula on the surface of manganese (See Figure 1), generating reactive oxygen species, i.e., oxygen radical. The right side of Figure 1 shows the oxidation process of acetaldehyde (CH_3CHO), a substance that accounts for the biggest portion of gaseous materials in cigarette smoke. Acetaldehyde is oxidized and turns into innocuous CO_2 and H_2O by reactive oxygen species generated in the O_3 decomposition process.

Other VOCs go through similar oxidation reaction.

The performance of the newly developed catalyst (Mn/TiO_2) was evaluated using testing devices at the research lab. The decomposition performance was 98% at maximum in the range from low concentration (10ppm) to high concentration (200ppm). Ozone, which was used for processing reaction, was not discharged or detected after the decomposition reaction as it was completely decomposed by the catalyst.

The air cleaning equipment based on the present technology can be used to clean up cigarette smoke in smoking rooms, etc., and can be utilized in various products such as air conditioners and air purifiers. Also, the technology has great potential and values as it can be converged with other technologies.

Provided by Korea Institute of Science and Technology