● Characteristics and applications of KESMON, a new aldehyde deodorant

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1. Introduction

Formaldehyde, acetaldehyde, etc. are considered to be causative agents of sick building syndrome. Reduction of aldehyde gas in living spaces is being pursued through approaches such as switching to aldehyde-free materials and using aldehyde deodorants. In addition, aldehyde deodorants have been attracting more attention recently as the reduction of aldehyde gases in automobile cabins has come under consideration.

We have developed the KESMON series of deodorants for various odors in living spaces, which are already used in a wide range of fields. We have recently developed a deodorant with much higher aldehyde deodorization performance than conventional KESMON. This article introduces the characteristics and applications of KESMON, the newly developed aldehyde deodorant.

2. Efforts to reduce aldehyde

In recent years, due to increased airtightness in homes and the use of building and interior materials that emit chemical substances, "sick building syndrome," in which people experience irritation of the nose and throat, headaches, dizziness, and other physical symptoms upon entering newly built or recently renovated homes and buildings, has become a recognized problem. The "Investigation Committee on Sick House Syndrome" of the Ministry of Health, Labour and Welfare has set guideline values for indoor concentrations of 13 substances (**Table 1**). In response, the Building Standards Act was revised, and the housing industry has implemented measures such as banning the use of certain substances and restricting the permitted usage area based on formaldehyde emission levels from building materials. In addition, the automobile industry is implementing efforts to keep the concentration of aldehydes and other gases in the cabin below the guideline values set by the Ministry of Health, Labour and Welfare[1].

Table 1: Indoor concentration guideline values for 13 substances specified by the Ministry of Health, Labour and Welfare

	Indoor concentration guideline value		Remarks
Formaldehyde	100 μg/m³	0.08 ppm	
Acetaldehyde	48 μg/m³	0.03 ppm	
Toluene	260 μg/m³	0.07 ppm	
Xylene	870 μg/m³	0.20 ppm	
Ethylbenzene	3800 μg/m³	0.88 ppm	
Styrene	220 μg/m³	0.05 ppm	
Di-n-butyl phthalate	220 μg/m³	0.02 ppm	
Tetradecane	330 μg/m³	0.04 ppm	
Di-2-ethylhexyl phthalate	120 μg/m³	7.6 ppb	Ant repellent and insecticide components
Paradichlorobenzene	240 μg/m³	0.04 ppm	
Chlorpyrifos	1 μg/m³	0.07 ppb	
Diazinon	0.29 μg/m³	0.02 ppb	
Fenobucarb	33 μg/m³	3.8 ppb	

3. Characteristics of aldehyde deodorant KESMON

3.1 Physical properties

Table 2 shows the physical properties of aldehyde deodorant KESMON. Major grades include NS-231 in powder form, KP-240 in water-dispersion form, and KS-210 in ultrafine particle form.

NS-231 in powder form has heat resistance up to 160°C, and exhibits deodorization effects against basic gases such as ammonia in addition to its aldehyde deodorizing performance.

KP-240 in water-dispersion form is specially designed for aldehyde-based gases, giving it heat resistance up to 210°C. In addition, the water-dispersion form provides excellent handling characteristics for spray application, dipping processes, and other applications.

KS-210 in ultrafine particle form is a transparent liquid with particle sizes adjusted to the nanoscale. NS-231 and KP-240 above are particles with an average particle diameter of 5 μm, and require a binder resin when deposited on the surface of substrates such as felt. In contrast, KS-210 can in some cases be deposited on the substrate without a binder resin. Furthermore, substrates treated with KS-210 exhibit very little white haze, allowing deodorization treatment without compromising product appearance.

Table 2: Physical properties of aldehyde deodorant KESMON

	NS-231	KP-240	KS-210
Form	Powder	Aqueous dispersion Solid content: 40%	Transparent liquid Solid content: 10%
Average particle diameter	5 μm	5 μm	10 to 30 nm
Heat resistance	160°C	210°C	210°C
pH	4.7 (5 wt% aqueous dispersion)	4.3	3.3

3.2 Deodorization mechanism

Aldehyde deodorant KESMON is a chemical adsorption-type deodorant composed of an amine compound bearing multiple primary amino groups at its terminals and a porous inorganic compound. The deodorization effect arises when the amino groups at the terminals of the amine compound, which are the active ingredient, react with aldehyde compounds (Schiff reaction) to form Schiff bases (**Fig. 1**).

Compared to using the amine compound alone, combining it with an inorganic compound that has a large specific surface area significantly improves both deodorization speed and deodorization effectiveness against low-concentration aldehyde gases.

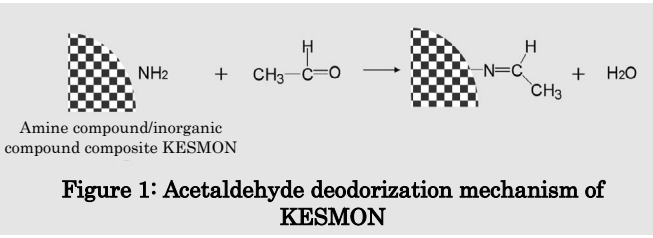

Figure 1: Acetaldehyde deodorization mechanism of KESMON

3.3 Deodorization performance

1) Deodorization capacity

Fig. 2 shows the results of evaluating the aldehyde deodorization capacity of KESMON NS-231. We measured the residual concentration 2 hours after loading a 0.1 g sample with acetaldehyde at 600 ppm·1 L, and calculated the deodorization rate from the initial concentration. Next, the test gas was purged and 600 ppm·1 L of acetaldehyde was loaded again. When this cycle was repeated, the deodorization rate dropped sharply from the ninth cycle onward. In other words, this point marked the breakthrough of deodorization performance, with a deodorization capacity of approximately 50 mL/g. This substantially exceeds the deodorization capacity of the impregnated activated carbon for aldehyde deodorization, which we tested in parallel. For formaldehyde, repeated tests in which 0.02 g of KESMON NS-231 was loaded with 200 ppm·1 L of formaldehyde gave a deodorization capacity of approximately 80 mL/g (**Fig. 3**).

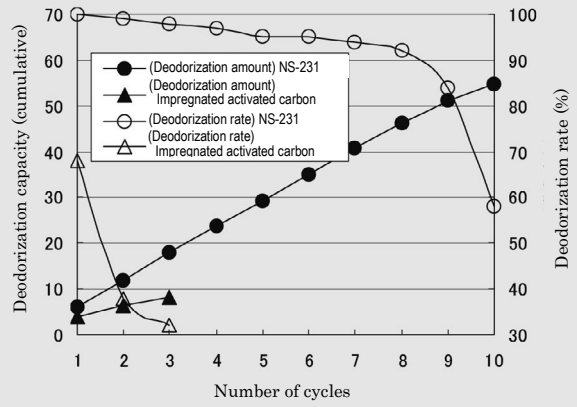

Figure 2: Repeated loading test with acetaldehyde

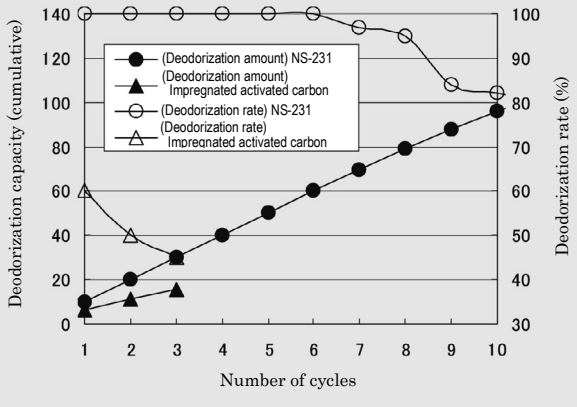

Figure 3: Repeated loading test with formaldehyde

2) Deodorization performance in low concentration range

Aldehyde deodorant KESMON also shows excellent effects on aldehyde gas in the low concentration range. **Fig. 4** shows the changes in concentration of acetaldehyde over time when 0.1 g of NS-231 and KP-240 dry solid contents were loaded with 100 ppm·1 L of acetaldehyde. KESMON eliminates the odor within a few minutes. The human olfactory threshold for acetaldehyde is reported to be 0.01 ppm[2], and after KESMON has deodorized the acetaldehyde, no odor can be detected by smell.

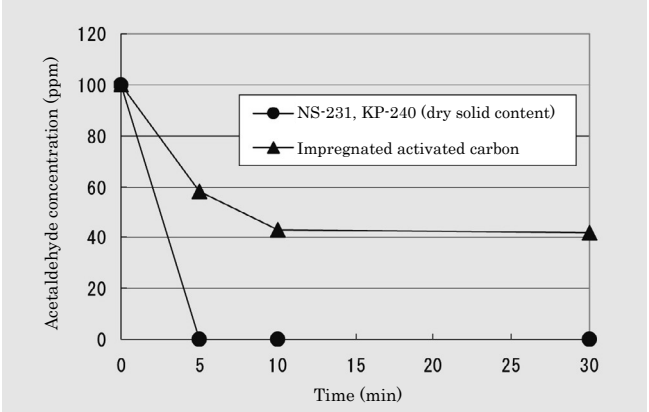

Figure 4: Deodorization performance in the low concentration range

3) Deodorization performance and re-release behavior at high temperatures

Although the cabin of an automobile parked under the blazing sun can reach high temperatures, the aldehyde deodorant KESMON exhibits sufficient deodorization performance even at high temperatures. In addition, almost no aldehyde gas that has been deodorized at room temperature is re-released even at high temperatures. This is characteristic of a chemical adsorption-type deodorant, in which aldehydes react with the amine compound. In contrast, activated carbon deodorizes by physical adsorption. The adsorption performance of activated carbon at high temperatures is greatly reduced compared to that at room temperature, and most of the aldehyde gas adsorbed at room temperature is re-released at high temperatures.

3.4 Safety

The safety of KESMON NS-231, KP-240, and KS-210 has been confirmed as shown in **Table 3**.

Table 3: Safety test data for KESMON

	NS-231	KP-240	KS-210
Acute oral toxicity (rat LD_{50})	> 2,000 mg/kg	> 2,000 mg/kg	> 2,000 mg/kg
Primary skin irritation (rabbit)	P.I.I = 0	P.I.I = 0	P.I.I = 0
Mutagenicity (AMES)	Negative	Negative	Negative

4. Application examples

By coating it onto the surface of, or incorporating it inside, various automotive interior products (ceiling materials, flooring, door trim, seats, etc.) and home building materials (wallpaper, flooring, paint, etc.), the deodorant can both suppress aldehyde emission from products and deodorize aldehydes in indoor spaces.

It can also be loaded into the filters of air conditioners, air purifiers, etc.

4.1 Examples of volatile aldehyde suppression

1) Felt sheet

We applied a dispersion of KESMON NS-231 and a urethane binder in water to one side of a felt sheet at 30 g/m^2, then dried it at 120°C to produce a sheet containing 2 g/m^2 of KESMON and 0.6 g/m^2 of binder as solids. We placed a 10 cm × 8 cm piece of this sheet in a Tedlar bag, filled it with 4 L of nitrogen, and let it stand at 65°C for 2 hours. After standing, the gas in the Tedlar bag was collected onto a DNPH cartridge, extracted with acetonitrile, and analyzed for aldehydes by HPLC. As shown in **Fig. 5**, the KESMON-treated sample exhibited excellent reduction of volatile aldehydes for both formaldehyde and acetaldehyde.

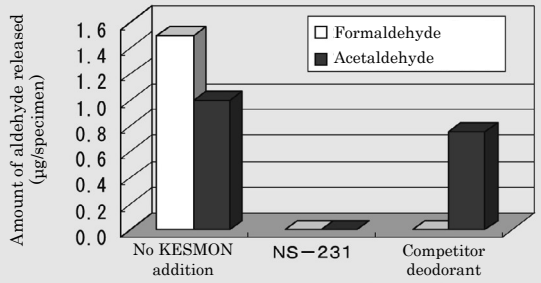

Figure 5: Amount of aldehyde released from felt sheet

2) Woody materials

KESMON KS-210 was applied to both sides of a particle board and air-dried to give a solid add-on of 1, 3, or 6 g/m^2. We measured volatile aldehydes from the particle board using the same method as the felt sheet. As shown in **Fig. 6**, the KESMON-treated sample exhibited excellent reduction of volatile aldehydes for both formaldehyde and acetaldehyde.

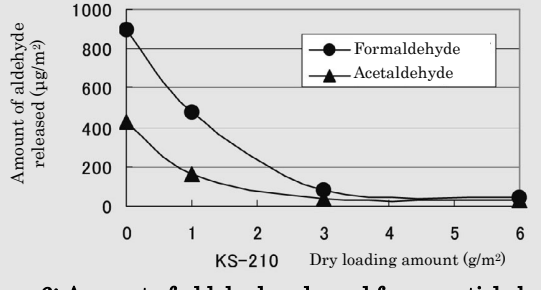

Figure 6: Amount of aldehyde released from particle board

4.2 Examples of aldehyde deodorization

1) Car mats

We applied a dispersion of KESMON NS-231, NS-80E (a deodorant for acidic gases), and an acrylic acid-based binder in water to the surface of a car mat at 50 g/m^2, then dried it at 120°C to produce a car mat containing 5 g/m^2 of KESMON and 1.5 g/m^2 of binder as solids. We placed 0.4 m^2 of the car mat inside a 1 m^3 acrylic box, burned five cigarettes inside the box, and measured the concentrations of acetaldehyde, ammonia, and acetic acid in the box with a detector tube. As shown in **Fig. 7**, we confirmed that the KESMON-treated mat effectively deodorized the acetaldehyde, ammonia, and acetic acid generated by cigarette combustion.

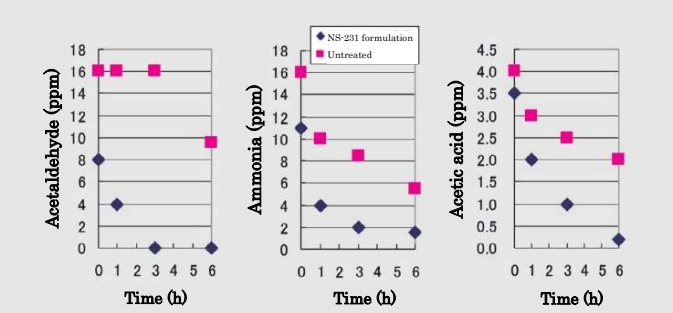

Figure 7: Deodorization performance against cigarette smoke

5. Conclusion

The aldehyde deodorant KESMON introduced in this article has already attracted inquiries from many customers in industries such as automobile interior materials, home building materials, and interior design, and has earned high praise.

In the future, we hope that as many of these projects as possible will be put to practical use, and that products treated with KESMON will contribute to improving the health of end-users.

Reference

1) Japan Automobile Manufacturers Association, Inc., *JAMA Report,* 98 (2005).
2) K. Nishida (supervisor), "Progress and Practice of Deodorization Technology," 2nd edition, General Technology Center (1993), p.105.