

Simultaneous removal of acetaldehyde, ammonia and hydrogen sulphide from air by active carbon impregnated with *p*-aminobenzoic acid, phosphoric acid and metal compounds

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Simultaneous removal of acetaldehyde, ammonia, and hydrogen sulphide from air by the impregnated active carbon was studied at 25 °C. *p*-Aminobenzoic acid (PABA), phosphoric acid (H_3PO_4), and metal compound such as copper (II) chloride dihydrate ($\text{CuCl}_2 \cdot 2\text{H}_2\text{O}$), copper (II) nitrate trihydrate ($\text{Cu}(\text{NO}_3)_2 \cdot 3\text{H}_2\text{O}$), and potassium iodide (KI) were investigated as impregnation ingredients. Acetaldehyde and ammonia were simultaneously removed from air by the active carbon impregnated with PABA and H_3PO_4 . The removal was found to be made mainly through chemical reaction. Acetaldehyde, ammonia, and hydrogen sulphide were simultaneously removed from air by the active carbon impregnated with PABA, H_3PO_4 , and metal compound such as $\text{CuCl}_2 \cdot 2\text{H}_2\text{O}$, $\text{Cu}(\text{NO}_3)_2 \cdot 3\text{H}_2\text{O}$, and KI.

1. Introduction

The temperature and humidity of air are important factors for a comfortable atmosphere in small spaces such as closed rooms and cars, and also the absence of offensive odours is important. Some examples of odour are tobacco smoke, rotten vegetables' odour, and foul body odour. These odours contain various amounts of acetaldehyde, ammonia, and hydrogen sulphide, which are stipulated offensive odorants in the Offensive Odour Control Law of the Environment Agency of Japan [1, 2]. So far, the most widely used method for deodorization is filtration on active carbon, which can adsorb odorous substances efficiently in mixtures with air [3]. The adsorption capacity of active carbon for acetaldehyde and ammonia is not as large in ambient air [4, 5]. Another method of dealing with odours is to mask them with strongly smelling perfumes. However, they do not remove the substance itself, and sometimes themselves produce unpleasant odours, and staining of clothes and interior materials, such as fabric cloths and carpets.

The impregnation of active carbon to enhance the adsorption capacity of active carbon is known as "active carbon" for gas masks, which have been used as respirators [3].

Active carbon impregnated with an alkaline substance for the removal of hydrogen sulphide, and with an acidic substance for removal of trimethylamine, were investigated by Ikeda *et al.* [6], who found that it was much more effective to pass air containing hydrogen sulphide and trimethylamine into the former active carbon forward, and into the latter active carbon backwards in series, than to pass it into a mixture, in

order to achieve simultaneous removal of them from the air.

It is necessary to use active carbon impregnated with several kinds of impregnation ingredients, which are individually very reactive with multiple odorous substances in a small space, as an adsorptive filter in air conditioners and air purifiers to reduce foul body odours and tobacco smoke in closed rooms, rest rooms or cars.

Previously, we reported that gaseous acetaldehyde was not so reactive with, nor adsorbed by *p*-aminobenzoic acid (PABA) but that it was very reactive with *p*-aminobenzoic acid hydrochloride ($\text{PABA} \cdot \text{HCl}$) [7].

There have been few investigations into the simultaneous removal of multiple odorous substances, such as acetaldehyde, ammonia, and hydrogen sulphide, in the air. The purpose of this study was to discover a method of removal of acetaldehyde and ammonia from the air using active carbon impregnated with PABA and H_3PO_4 , and for the removal of acetaldehyde, ammonia, and hydrogen sulphide from air by active carbon impregnated with PABA, H_3PO_4 , and metal compounds such as $\text{CuCl}_2 \cdot 2\text{H}_2\text{O}$, $\text{Cu}(\text{NO}_3)_2 \cdot 3\text{H}_2\text{O}$, and KI.

2. Experimental procedure

2.1. Materials

Coconut-shell active carbon 2.4–3.3 mm in size (Kintal[®] PG 4–6; Cataler Industrial Co. Ltd, Japan) was used as a carrier and an adsorbent. PABA (Aldrich Chemical Company, Inc., USA), 85% and 96% H_3PO_4 , $\text{CuCl}_2 \cdot 2\text{H}_2\text{O}$, $\text{Cu}(\text{NO}_3)_2 \cdot 3\text{H}_2\text{O}$, and KI

(Nakarai Chemicals Ltd, Japan) were used as impregnation ingredients on the active carbon. Acetaldehyde (> 99% purity; Aldrich Chemical Company, Inc., USA), 28% ammonia aqueous solution (Wako Pure Chemical Industries, Ltd, Japan), ammonia (100 p.p.m. in air and 1800 p.p.m. in nitrogen), and hydrogen sulphide (200 and 20 000 p.p.m. in nitrogen; Takachiho Chemical Industries Co. Ltd, Japan) were used as adsorbates.

2.2. Preparation of impregnated active carbon

The adsorbent, such as active carbon impregnated with PABA, 96% H₃PO₄, and CuCl₂·2H₂O, was made by the following procedure: 12 g PABA, 18 g 96% H₃PO₄, 12 g CuCl₂·2H₂O (or others), and 200 g hot water (80 °C) were mixed in a beaker and the mixture was stirred for 10 min to obtain the mixed aqueous solution. Then, 300 g active carbon was impregnated with the mixed aqueous solution in the beaker, followed by drying for 10 h at 100 °C, and then immediately transferred to a desiccator at 25 °C except for 10 g which were retained. These 10 g were pulverized using an agate mortar and pestle, then sieved into particles 0.18–1.0 mm size. These were immediately transferred to a desiccator at 25 °C. Other active carbons impregnated with other ingredients were prepared in the same way, using fixed amounts of compounds as shown in Table I.

2.3. Removal rate: measurement of adsorbate concentration

The apparatus for measurement of the adsorbate concentration in a bag consists of five parts, as shown in Fig. 1: a bag, an acetaldehyde-vaporizing system, a flow meter, and two gas containers containing ammonia (1800 p.p.m. in nitrogen) and hydrogen sulphide (20 000 p.p.m. in nitrogen). These parts are connected with teflon tubes. The bag, with a capacity of 5 l, is made of aluminium foil laminated with polyethylene terephthalate.

The adsorbent (1 g) was put into the bag. Acetaldehyde (12 µl) was introduced into the bag through the vaporizing system with the stream of ammonia (1800 p.p.m., 2.5 l) and hydrogen sulphide (20 000 p.p.m., 2.5 l), or the mixed gases (5 l). The bag

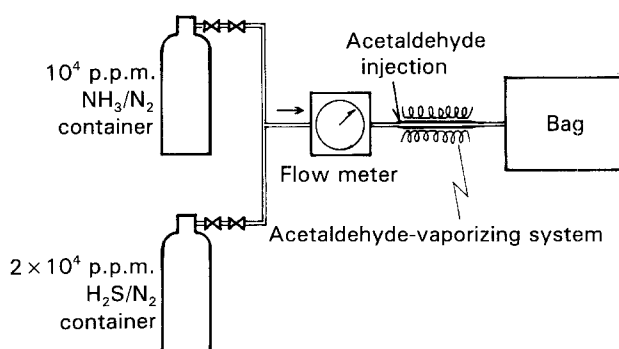


Figure 1 Apparatus for the measurement of adsorbate concentration. →, Direction of gas flow.

was kept at 25 °C for 24 h after sealing. The final concentration (*C*, p.p.m.) of the gases remaining in the bag was measured using the following methods. The concentrations of acetaldehyde and hydrogen sulphide were measured using a gas chromatograph with hydrogen flame ionization (FID) and a flame photometric detector (FPD). The concentration of ammonia was measured by using the gas detector tube (Kitagawa Precision Gas Detector, Komeirika Co., Ltd, Japan). These adsorbates were introduced into a bag containing no adsorbents under the same conditions, and the original concentration (*C*₀, p.p.m.) of the adsorbate in the bag was measured, which gives the initial value for the concentration of the system. The initial concentrations of acetaldehyde, ammonia, and hydrogen sulphide were 400, 820, and 7200 p.p.m., respectively. The removal rate (RR, %) of the adsorbate in the bag is given by

$$RR = \frac{C_0 - C}{C_0} \times 100 (\%) \quad (1)$$

2.4. Gas flow test

2.4.1. Acetaldehyde flow test

The apparatus for the acetaldehyde flow test consists of seven parts, as shown in Fig. 2a: a bag, two sampling ports, a column, a flow meter, and a bottle. These parts are connected with teflon tubes. The bag has a capacity of 50 l, and is made of aluminium foil laminated with polyethylene terephthalate. The bag is used to supply to the system 50 l of the air containing acetaldehyde. The sampling port is made of three-way glass

TABLE I Composition of adsorbents

Run	Active carbon (g)	Impregnation ingredients						
		PABA (g)	H ₃ PO ₄		Metal compounds			
			96% (g)	85% (g)	CuCl ₂ ·2H ₂ O (g)	Cu(NO ₃) ₂ ·3H ₂ O (g)	KI (g)	
1	300	12	18			12		
2	300	12		18		12		
3	300	12		18			12	
4	300	12		18				12
5	300	12		18				
6	300	12						
7	300					12		
8	300							

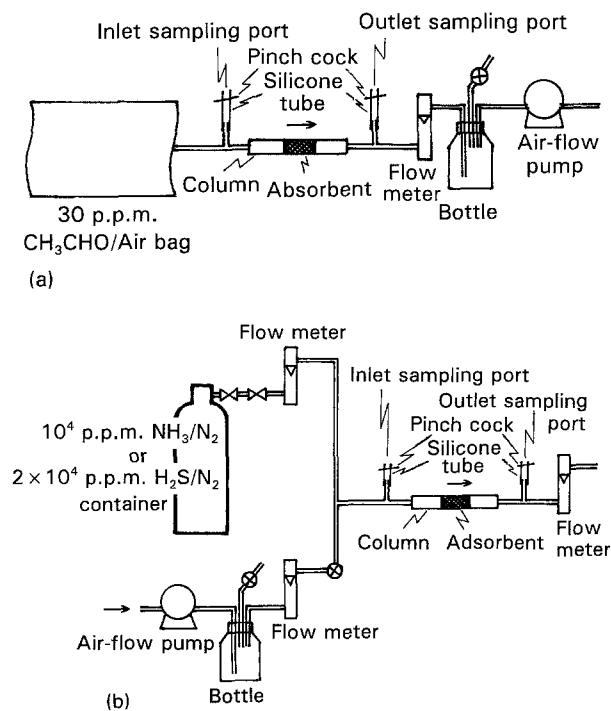


Figure 2 Apparatus for the gas flow tests. (a) Acetaldehyde flow tests. (b) Ammonia and hydrogen sulphide flow tests. \rightarrow , Direction of gas flow.

tube, which has a silicone tube with a pinchcock on one end and a teflon tube on the other two ends. The needle point of a gas-tight syringe is inserted into the tube through the silicon tube, and the sample gas was collected in the syringe. The column is made of a glass tube (6 mm diameter \times 150 mm) and an adsorbent is packed into the tube. The bottle is used to regulate the pressure by partly opening the cock. The air-flow meter, the bottle, and the air-flow pump are used to regulate the gas flow rate.

Gaseous acetaldehyde with a given concentration was prepared in the following way: acetaldehyde (7 μ l) was introduced into the bag (50 l) using the apparatus for the measurement of adsorbate concentration, and the bag was kept at 25 $^{\circ}$ C for 24 h. Then, the initial concentration was measured; the value was 30 p.p.m. The adsorbent (200 mg), 0.18–1.0 mm in size, was packed into the column. On both sides of the adsorbent in the column, silica wool was packed tightly to keep the contents in position. The aldehyde-containing bag and the adsorbent-packed column were connected to the other parts by teflon tubes. Air containing acetaldehyde (30 p.p.m.) was passed at a flow rate of 0.8 l min^{-1} into the column packed with the adsorbent. The outlet gas was collected at 5, 10, or 20 min intervals in a gas-tight syringe through the outlet sampling port and the concentration of acetaldehyde was measured by the method mentioned above.

2.4.2. Ammonia and hydrogen sulphide flow tests

The apparatus for the ammonia and hydrogen sulphide flow tests consists of seven parts (Fig. 2b): a gas

container, an air-flow pump, a bottle, a three-way flow meter, two sampling ports and a column. The gas container contains ammonia (100 p.p.m. in air at 5–10 atm) or hydrogen sulphide (200 p.p.m. in nitrogen at 5–10 atm). The column is made of a glass tube (22 mm diameter \times 220 mm) into which the adsorbent is packed. The adsorbent (10 g), 2.4–3.3 mm in size, was packed into the column in the same way as mentioned above. The adsorbent-packed column was connected to other parts by teflon tubes.

For the ammonia flow test, the air containing ammonia (100 p.p.m.) was passed at a flow rate of 5 l min^{-1} into the adsorbent (10 g)-packed column using the ammonia container. The concentration of ammonia in the outlet gas was measured as described above.

For the hydrogen sulphide flow test, the hydrogen sulphide container (200 p.p.m. in nitrogen at 5–10 atm) and the air-flow pump were used to mix air with nitrogen containing hydrogen sulphide. The air (2.5 l min^{-1}) and nitrogen containing hydrogen sulphide (200 p.p.m.) (2.5 l min^{-1}) were mixed by using the apparatus (Fig. 2b) and the mixed gas (100 p.p.m. hydrogen sulphide) was passed at a flow rate of 5 l min^{-1} into the adsorbent (10 g)-packed column. The concentration of hydrogen sulphide in the outlet gas was measured at the same intervals and by the same method as described above.

3. Results and discussion

3.1. Simultaneous removal of acetaldehyde, ammonia, and hydrogen sulphide from air

Table II shows the removal rate of acetaldehyde, ammonia, and hydrogen sulphide by the adsorbent shown in Table I. The removal rates of acetaldehyde, ammonia, and hydrogen sulphide by the active carbon impregnated with various species were found to be remarkably dependent on the composition of the impregnation ingredient, as shown in Table II. The removal rate of acetaldehyde is the largest in the carbon with PABA and H_3PO_4 and in the carbon with PABA, H_3PO_4 and metal compounds such as $\text{CuCl}_2 \cdot 2\text{H}_2\text{O}$, $\text{Cu}(\text{NO}_3)_2 \cdot 3\text{H}_2\text{O}$ and KI ($\geq 99.5\%$). The value is second largest in the carbon with PABA ($\approx 84\%$), and very small in the carbon without PABA ($\approx 20\%$).

PABA is thought to be very reactive with acetaldehyde in the presence of H_3PO_4 (RR $\geq 99.5\%$) on the active carbon. The reactivity of PABA on the active carbon without H_3PO_4 (RR = 84.1%) is lower than that with H_3PO_4 (RR $\geq 99.5\%$). The reactivity of active carbon alone is much lower than that of the carbon with PABA. This suggests that PABA is activated by both the active carbon and H_3PO_4 . In our previous paper [7], *p*-aminobenzoic acid hydrochloride (PABA \cdot HCl) was shown to be most reactive with gaseous acetaldehyde. The high reactivity of PABA with acetaldehyde in the presence of H_3PO_4 can also be explained on the same basis for PABA \cdot HCl. Therefore, it is very important to use PABA in contact with H_3PO_4 on the active carbon for removal of acetaldehyde from the air.

TABLE II Removal rate of acetaldehyde, ammonia, and hydrogen sulphide in the presence of adsorbent

Removal rate, RR (%) of			Impregnation ingredients
Acetaldehyde	Ammonia	Hydrogen sulphide	
99.5	100	100	PABA, 96% H ₃ PO ₄ , CuCl ₂ ·2H ₂ O
100	99.1	85.6	PABA, 85% H ₃ PO ₄ , CuCl ₂ ·2H ₂ O
99.6	99.1	86.0	PABA, 85% H ₃ PO ₄ , Cu(NO ₃) ₂ ·3H ₂ O
99.6	99.0	100	PABA, 85% H ₃ PO ₄ , KI
100	99.0	27.0	PABA, 85% H ₃ PO ₄
84.1	18.2	96.0	PABA
20.1	89.5	100	CuCl ₂ ·2H ₂ O
20.0	18.0	96.4	- ^a

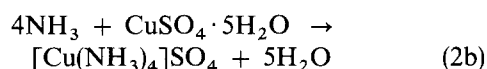
^a Active carbon.

The removal rate of ammonia is the largest (100%) in the carbon with PABA, 96% H₃PO₄, and CuCl₂·2H₂O. The value is second largest in the carbon with PABA, 85% H₃PO₄, and metal compounds such as CuCl₂·2H₂O, Cu(NO₃)₂·3H₂O, and KI, and in the carbon with CuCl₂·2H₂O (≈ 99%). The value is very small (≈ 18%) in the carbon with PABA and carbon, alone.

Ammonia is thought to be very reactive with H₃PO₄ (RR = 99%–100%) on the active carbon, because ammonia is alkaline and H₃PO₄ is acidic. Furthermore, it is also very reactive with CuCl₂·2H₂O (RR = 89.5%), forming the following product



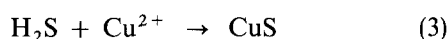
which is very analogous to Reaction (2b) [3, 8].



These reactions are responsible for the high removal rate of ammonia in contact with carbon with H₃PO₄ and copper (II) compounds (Table II). The active carbon, as well as the carbon impregnated with PABA, is not as adsorptive for, nor as reactive with, ammonia (both of RR ≈ 20%), because of the hydrophilic property of ammonia, the hydrophobic one of active carbon [5], and the non-reactivity of PABA with ammonia.

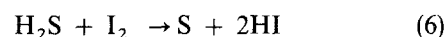
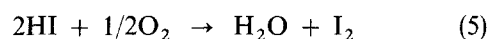
The removal rate of hydrogen sulphide is the largest in the carbon with PABA, 96% H₃PO₄, and CuCl₂·2H₂O, and with PABA, 85% H₃PO₄, and KI, and in the carbon alone (≥ 96%), second largest in the carbon with PABA, 85% H₃PO₄, and CuCl₂·2H₂O, and Cu(NO₃)₂·3H₂O (≈ 86%), and very small in the carbon with PABA and 85% H₃PO₄ (≈ 27%).

Hydrogen sulphide is very reactive with the active carbon impregnated with CuCl₂·2H₂O or Cu(NO₃)₂·3H₂O in the presence of PABA and H₃PO₄ (RR = 86%–100%). The high reactivity of the impregnated active carbon can be explained on the same basis as the reaction of H₂S with Cu²⁺ in acidic solution, described by the following reaction [9]



The effect of KI on the removal of hydrogen sulphide was highest (RR = 100%) in the presence of H₃PO₄, suggesting that the mechanism for the

removal of the sulphide by KI is different from that by Cu²⁺. It can be explained as a kind of catalytic action for the reaction of I₂ with H₂S in the presence of the concentrated H₃PO₄, described by the following reactions [10]



Of the other activators, hydrogen sulphide is not so reactive with the active carbon impregnated with PABA and H₃PO₄ (RR = 27%), while it is very reactive with active carbon alone (RR = 96.4%) and the carbon impregnated with just PABA (RR = 96%), as mentioned above. According to Smisek and Cerny [3], who used active carbon for desulphurization of industrial gases, it catalyses the oxidation of hydrogen sulphide as follows



The effective removal of the sulphide by the carbon is based on Reaction 6, and judging by this, the presence of H₃PO₄ is concluded to suppress the reaction of H₂S with O₂ or the adsorption of H₂S on the carbon impregnated with PABA and 85% H₃PO₄. However, the detailed process of the suppression still remains unknown. The reactivity of carbon with H₂S in the presence of H₃PO₄ can be restimulated by the addition of metal compounds such as CuCl₂·2H₂O, Cu(NO₃)₂·3H₂O, and KI, as shown in Table II.

3.2. Removal of acetaldehyde, ammonia, and hydrogen sulphide from air in the gas-flow test

Fig. 3 shows the concentration of acetaldehyde in the air which passed through the adsorbent column, plotted as a function of time. The relative humidity of the air was 30% at 25 °C. The concentration increases drastically after 6 min for active carbon alone, reaching about 30 p.p.m. after 30 min, which is the initial value (Fig. 3). This indicates that most of the carbon comes into contact with acetaldehyde in about 30 min, that the adsorption of the aldehyde by the carbon reaches saturation and that about 30% acetaldehyde contained in the air which passed through the column during 30 min is removed.

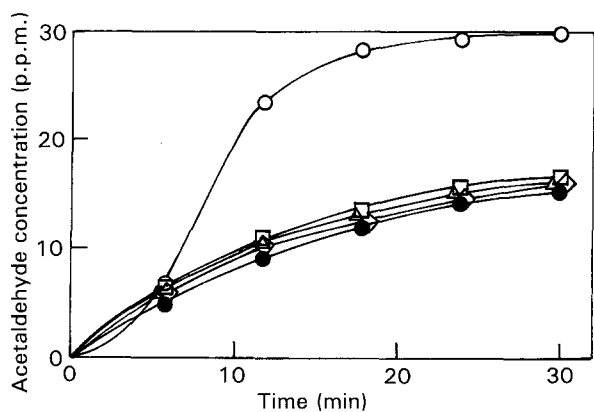


Figure 3 Acetaldehyde concentrations in the outlet air plotted as a function of time in the gas flow test. $C_0 = 30$ p.p.m. (●) Active carbon impregnated with PABA and 85% H_3PO_4 . (□) Active carbon impregnated with PABA, 85% H_3PO_4 , and $CuCl_2 \cdot 2H_2O$. (◇) Active carbon impregnated with PABA, 85% H_3PO_4 , and $Cu(NO_3)_2 \cdot 3H_2O$. (△) Active carbon impregnated with PABA, 85% H_3PO_4 , and KI. (○) Active carbon.

The concentration increases gradually for the active carbon impregnated with PABA and H_3PO_4 , the values being 6.3 p.p.m. at 6 min, 14 p.p.m. at 18 min and 17 p.p.m. at 30 min. Saturation appears to be reached at 30 min. Thus about 68% acetaldehyde contained in the air which passed through the column in 30 min is removed, and therefore the reaction rate is very low for carbon. This suggests that the air should be circulated through the carbon column to remove acetaldehyde. This will result in complete removal because the aldehyde can react with the remaining PABA, whose total amount is about 20 times the molar amount of aldehyde.

The concentration also increases gradually for the carbon with PABA, H_3PO_4 , and metal compounds such as $CuCl_2 \cdot 2H_2O$, $Cu(NO_3)_2 \cdot 3H_2O$, and KI. The value for the carbon is slightly lower than that for carbon with PABA and H_3PO_4 at any time. This suggests that $CuCl_2 \cdot 2H_2O$, $Cu(NO_3)_2 \cdot 3H_2O$ and KI do not greatly influence the reactivity of acetaldehyde with PABA in the presence of H_3PO_4 .

Fig. 4 shows the concentration of ammonia in air passed through the adsorbent, plotted as a function of time. The concentration of ammonia increases drastically after 5 min on the active carbon alone, reaching about 100 p.p.m. after 60 min, which is the initial value (Fig. 2). Thus about 22% ammonia contained in the air which passed through the column in 60 min was removed.

The concentration of ammonia in the outlet air for the carbon impregnated with PABA and H_3PO_4 , or with PABA, H_3PO_4 and metal compounds such as $CuCl_2 \cdot 2H_2O$, $Cu(NO_3)_2 \cdot 3H_2O$, and KI, increases gradually with time up to 60 min, at which point it seems to reach saturation (45–48 p.p.m.), as shown in Fig. 4. Thus 71%–74% ammonia contained in the air which passed through the column in 60 min was removed by the reaction with both H_3PO_4 and these metal compounds, and the reaction is very slow. This suggests that the circulation of the air is needed to remove completely the ammonia remaining in the air,

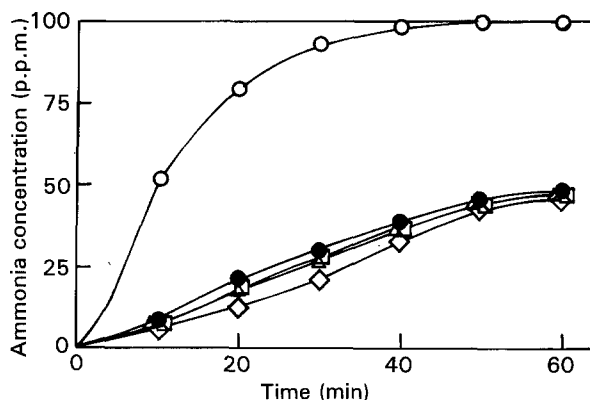


Figure 4 Ammonia concentrations in the outlet air plotted as a function of time in the gas flow test. $C_0 = 100$ p.p.m. For key, see Fig. 3.

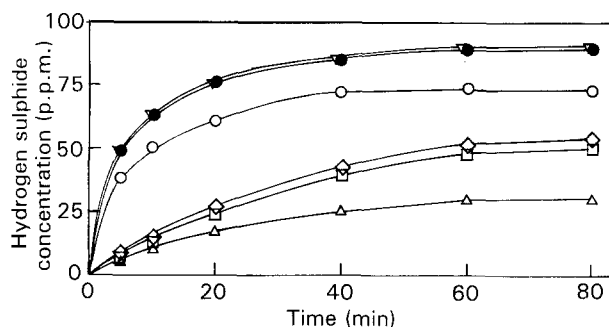


Figure 5 Hydrogen sulphide concentrations in the outlet gas plotted as a function of time in gas flow test. $C_0 = 100$ p.p.m. For key, see Fig. 3. (▽) active carbon (in nitrogen).

because it can still react with H_3PO_4 and these metal compounds.

Fig. 3 shows the concentration of hydrogen sulphide in the air which passed through the adsorbent, plotted as a function of time. The concentration of hydrogen sulphide for the active carbon alone increases with time and it seems to approach saturation: it is 73 p.p.m. in air at 80 min, as shown in Fig. 5, but is about 90 p.p.m. in nitrogen at 80 min. The difference between the value of the concentration in air and that in nitrogen must be due to the oxidation in air (Reaction 7) and adsorption on the carbon.

The removal of hydrogen sulphide from the air which passed through the carbon impregnated with PABA and H_3PO_4 was less than that for the carbon alone, the concentration being 90 p.p.m. for the former and 73 p.p.m. for the latter, after 80 min. Thus about 20% hydrogen sulphide contained in the air which passed through the column in 80 min for the former and about 35% for the latter were removed, suggesting that PABA and H_3PO_4 affect the oxidization of hydrogen sulphide, as mentioned before.

The value of the concentration for the active carbon impregnated with KI, or $Cu(NO_3)_2 \cdot 3H_2O$ in the presence of PABA and H_3PO_4 in air, increases with time and it seems to approach saturation at 80 min. The value with KI is smaller (30 p.p.m.) than those with $CuCl_2 \cdot 2H_2O$ (50 p.p.m.) and $Cu(NO_3)_2 \cdot 3H_2O$ (54 p.p.m.). The amounts of hydrogen sulphide

removed from the air which passed through the column in 80 min were about 78%, 65%, and 62% of the sulphide contained in the air, respectively, for the carbon with KI, $\text{CuCl}_2 \cdot 2\text{H}_2\text{O}$, and $\text{Cu}(\text{NO}_3)_2 \cdot 3\text{H}_2\text{O}$. As shown in Equations 2–5, KI is a catalyst and Cu^{2+} in $\text{CuCl}_2 \cdot 2\text{H}_2\text{O}$ and $\text{Cu}(\text{NO}_3)_2 \cdot 3\text{H}_2\text{O}$ is a reactant. Therefore, this difference between the values with KI and with $\text{CuCl}_2 \cdot 2\text{H}_2\text{O}$ or $\text{Cu}(\text{NO}_3)_2 \cdot 3\text{H}_2\text{O}$ is thought to be due to the difference between the reactions. This suggests that the hydrogen sulphide remaining in the air can be removed completely from it by circulation of the air, because it can react with the remaining abundant $\text{CuCl}_2 \cdot 2\text{H}_2\text{O}$, or $\text{Cu}(\text{NO}_3)_2 \cdot 3\text{H}_2\text{O}$, or with oxygen by the catalytic action of KI in the impregnated system.

In any case, the adsorptive or reacting capacity of the active carbon impregnated with PABA and H_3PO_4 , is very large for acetaldehyde and ammonia, and that with PABA, H_3PO_4 , and metal compounds is also very large for acetaldehyde, ammonia, and hydrogen sulphide. The system of active carbon, PABA, and H_3PO_4 has been partly applied to the deodorizing filter of an air purifier and air conditioner for the removal of foul body odours and tobacco smoke in a closed room or in a car, giving adequate results.

4. Conclusions

1. Simultaneous removal of acetaldehyde and ammonia from air was found to be achieved by active carbon impregnated with PABA and H_3PO_4 .

2. Acetaldehyde was very reactive with PABA in the presence of H_3PO_4 on the active carbon.

3. Ammonia was very reactive with H_3PO_4 in the presence of PABA on the active carbon. The high reactivity of H_3PO_4 with ammonia can be understood as the result of neutralization.

4. Hydrogen sulphide was not so easy to remove from air in the presence of active carbon impregnated with PABA and H_3PO_4 . It was fairly easily removed in active carbon alone. The low removal rate of hydrogen sulphide by active carbon impregnated with PABA and H_3PO_4 was found to result from the presence of H_3PO_4 .

5. Simultaneous removal of acetaldehyde, ammonia, and hydrogen sulphide from air was achieved by active carbon impregnated with PABA, H_3PO_4 , and metal compounds such as $\text{CuCl}_2 \cdot 2\text{H}_2\text{O}$, $\text{Cu}(\text{NO}_3)_2 \cdot 3\text{H}_2\text{O}$, and KI.

6. The reactivity for H_2S in the presence of H_3PO_4 on the carbon was found to be enhanced by the addition of metal compounds such as $\text{CuCl}_2 \cdot 2\text{H}_2\text{O}$, $\text{Cu}(\text{NO}_3)_2 \cdot 3\text{H}_2\text{O}$, and KI.

7. In any case, a system composed of active carbon, PABA, and H_3PO_4 can be applied as a deodorizing filter in an air purifier and air conditioner for the removal of foul odours and tobacco smoke containing acetaldehyde, ammonia, and hydrogen sulphide, from the air.

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