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In vitro Adsorption Removal of Paraquat by Activated Carbon and Cation Exchange Resin

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With the modernization of agriculture, environmental pollution and accidental poisoning by agricultural chemicals have become a great social problem. With the remarkable increase in the amount of paraquat used, the number of deaths by swallowing of paraquat has also increased in recent years.

Presently, an effective antidote and treatment for paraquat poisoning is not available. For primary treatment, administration of an adsorbent is done at the same time as gastrointestinal lavage. As an adsorbent for paraquat poisoning, the efficacy of activated carbon (Okonek et al 1982-83), Fuller's Earth (Clark 1971, Vale et al 1977), bentonite (Smith et al 1974), and a cation exchange resin (Staiff et al 1973, Nokata et al 1984, Yamashita et al 1987) have been reported.

In this work, we discuss the adsorption characteristics of paraquat in artificial gastric juice and normal saline solution.

MATERIALS AND METHODS

Paraquat was obtained as a commercial preparation (Gramoxone S, Nihon Nohyaku Co., Ltd.) and its concentration was indicated as 24%. Activated carbon and cation exchange resin were obtained from commercial sources, that is, Hokutan Kogyo Ltd., G-AC (AC-1), Nakarai Chemical Ltd., M2A2733 (AC-2), Kanto Chemical Co., 908R3092 (AC-3), Takeda Chemical Ind. Ltd., Shirasagi S2x (AC-4), Kureha Chemical Ltd., BAC-MU (AC-5), Wako Pure Chemical Ind. Ltd., CDK1269 (AC-6), Torii Co. Ltd., Kayexalate (Resin-1), Organo Ltd., IR-120B (Resin-2), IR-122 (Resin-3), IR-124T (Resin-4), 200C (Resin-5), CG-120 (Resin-6).

The adsorption capacity of an adsorbent was determined in vitro. Five hundreds milligrams of adsorbent was

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shaken with 50mL of paraquat solution which was diluted with artificial gastric juice or normal saline solution (ca.800mg/L) at a constant temperature of 37°C for 24 hrs. After extraction using a Sep-Pak C18 cartridge (Waters Associates) for the filtrate (Tsunoda 1983), the paraquat concentration was measured photochemically according to the method of Calderbank and Yuen (1965).

The adsorption rate of the paraquat-artificial gastric juice or normal saline solution / adsorbent system was measured at 37°C. Five grams of adsorbent was placed in a stirred solution of one liter of paraquat solution (ca.800mg/L). Five milliliters of the suspension was taken up at regular intervals, and the paraquat concentration was measured.

RESULTS AND DISCUSSION

The removal ratios in artificial gastric juice and normal saline solution are shown in Table 1. Removal ratio was calculated according to the formula,

$$\text{Removal Ratio (\%)} = (C0 - C_{24}) / C0 \times 100$$

where C0 was initial concentration and C_{24} is the concentration at after 24 hrs of elapsed time. When using activated carbon, the removal ratio of paraquat in artificial gastric juice was 22.91-40.99%; however, that in normal saline solution was 31.29-91.83%. The ratio of increase was 1.37-2.30 times. When using a cation exchange resin, a significant difference between

Table 1. Removal Ratio of Paraquat by Activated Carbon and Cation Exchange Resin.

	Removal Ratio (%)	
Adsorbent No.	HCl*	NaCl**
AC-1	22.91	31.29
AC-2	37.03	71.05
AC-3	32.80	79.16
AC-4	40.90	77.68
AC-5	39.92	91.83
AC-6	40.99	76.76
Resin-1	98.55	95.68
Resin-2	88.44	93.59
Resin-3	98.57	95.69
Resin-4	82.45	94.09
Resin-5	91.43	88.80
Resin-6	88.46	84.96

*artificial gastric juice,
**normal saline solution.

the removal ratio in artificial gastric juice and that in normal saline solution was not found. The removal ratio of activated carbon of No.5 in normal saline solution was comparable to that by cation exchange resin.

Figure 1 shows the time course of paraquat concentration by activated carbon and the cation exchange resin. Paraquat removal by activated carbon was faster in normal saline solution than in artificial gastric juice. However, paraquat removal by the cation exchange resin was faster in artificial gastric juice. From these facts, it is assumed that the paraquat removal by the cation exchange resin is affected by the sodium cation, that is, the paraquat cation and sodium cation are both competing for the cation exchange resin. Kinetic constants (k) were calculated to elucidate

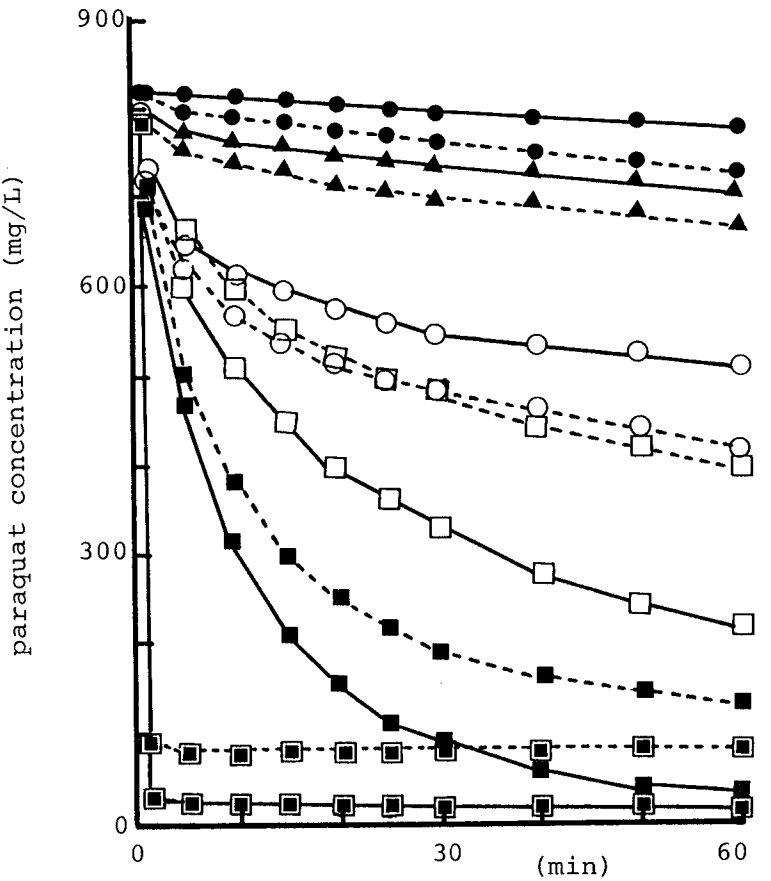

Figure 1. Time Course of Paraquat Concentration.
——:HCl, - - - - -:NaCl, ●:AC-1, ○:AC-5, ▲:AC-6,
▣:Resin-1, ■:Resin-4, □:Resin-5.

adsorption rates according to the formula,

$$Ct = C0 - kt$$

where C0 is the initial concentration and Ct is the concentration at elapsed time, t. Table 2 shows the kinetic constants. The revel of significance of regression line was indicated in parentheses of Table 2. From these values, it was found that the removal rate of the removal rate of paraquat is affected by the presence of sodium cations.

Table 2. Kinetic Constant of Paraquat by Activated Carbon and Cation Exchange Resin.

	Kinetic Constant($mg/L \cdot min^{-1}$)	
Adsorbent No.	HCl*	NaCl**
AC-1	0.673($p<0.001$)	1.135($p<0.001$)
AC-2	1.167($p<0.001$)	1.575($p<0.001$)
AC-3	1.177($p<0.001$)	1.882($p<0.001$)
AC-4	1.803($p<0.001$)	2.316($p<0.001$)
AC-5	3.819($p<0.01$)	5.323($p<0.001$)
AC-6	1.381($p<0.001$)	1.947($p<0.001$)
Resin-1	4.619(N.S.)	4.150(N.S.)
Resin-2	10.170($p<0.01$)	9.240($p<0.01$)
Resin-3	10.381($p<0.01$)	9.393($p<0.01$)
Resin-4	11.093($p<0.01$)	10.146($p<0.01$)
Resin-5	8.992($p<0.001$)	5.907($p<0.001$)
Resin-6	5.027(N.S.)	4.582(N.S.)

*artificial gastric juice,
**normal saline solution.

Nokata et al (1984) and Yamashita et al (1987) reported the efficacy of the cation exchange resin, kayexalate and kalimate as adsorbents for paraquat. Administration of an adsorbent has been performed at the same time as gastrointestinal lavage. When the gastrointestinal lavage is performed, normal saline solution is used. Therefore, one has to pay attention to the effect of the presence of sodium cations on the paraquat removal by the cation exchange resin. Although the cation exchange resin has a significant removal capacity for paraquat, it causes an imbalance of body fluids. Activated carbon as antidote has been applied to the treatment of various poisonings (Okonek et al 1982-83, Winchester et al 1977). It has received much attention as a reliable, safe and cheap antidote. In this investigation, we found a preferable activated carbon for paraquat removal from normal saline solution.

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