detected in further specimens of urine passed about 12 hours later. It is concluded that, in this observer, chlorophyll in doses at least 25 times greater than those usually recommended was valueless in preventing the characteristic smell of the urine following ingestion of asparagus. It was also noted that the smell of the faeces was unaffected by this large dose of chlorophyll.

I have confirmed these findings in similar manner, and have also found that the oral administration of 800 mg. of chlorophyll daily for a week did not remove the odour of urine, faeces, or axillary perspiration.

So much has been made of the alleged deodorant effect of chlorophyll on the urine of persons who have eaten asparagus that it would be helpful if a large number of doctors would themselves repeat this simple experiment. The experience would be in the best tradition of the advice offered to Jenner by John Hunter.

Conclusions

Exposure of methylmercaptan gas in a closed system to water-soluble chlorophyll did not reduce the amount of gas passing over to an indicator, compared with a control.

Exposure of small quantities of methylmercaptan gas to water-soluble chlorophyll in a closed system for up to three days did not remove the smell of mercaptan.

Mixtures of water-soluble chlorophyll and various strong-smelling solutions did not remove the smell of these solutions even after exposure for one or more months.

Clinical trials are reported in which the smell of urine, faeces, sweat, and of urine after ingestion of asparagus was not removed after taking large numbers of chlorophyll tablets.

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The Faculty of Ophthalmologists has for some time been considering the desirability of standardizing reading types used for testing vision. Suggestions from many sources have been studied and the final recommendations of the Council of the Faculty have been embodied in a memorandum by Mr. F. W. Law (*Brit. J. Ophthalm.*, 1952, **36**, 689). The Council's recommendations for a standard test of near vision are that: (1) "Times Roman" type shall be used, with "standard" spacing; (2) suitable passages of literature shall be selected, and a different passage used for each type; (3) specimens of printing in 5, 6, 8, 10, 12, 14, 18, 24, 36, and 48 point type shall be used, starting with the smallest [1 point=1/72 in.]; (4) a few isolated words in lower-case letters shall be printed in each size; (5) near acuity shall be recorded by the letter N, followed by a number indicating type-face size—for example, N.5, N.8, etc.; (6) the test shall include a facsimile of a Snellen distance chart reduced to 1/17 normal size and used at 35 cm. distance, the result being recorded as a "Snellen equivalent"—for example, N=6/9; (7) the test may also include reproductions or actual portions of familiar types in everyday use; (8) near test types shall be reproduced on sheets about 9×6 in. (23×15 cm.); (9) the print shall be on dead-white matt-surface cartridge paper or board, and the latter may be varnished to increase durability.

CAPACITY OF A CATIONIC EXCHANGE RESIN ("ZEO-KARB 225") IN VIVO

BY

PAUL FOURMAN, M.D., M.R.C.P.

With the technical assistance of ALISON SHEPHERD and BARBARA SEIBERT

(From the Nuffield Department of Clinical Medicine, Oxford)

Cationic exchange resins are insoluble powders which will exchange cations on the same principle as the familiar water softeners. The exchange obeys the law of mass action, and mixtures of cations combine with the resin *in vitro* in proportions determined by equilibrium constants (MacIntyre and Jordan, 1951). *In vitro* the affinity for monovalent ions follows the order $K > Na > NH_4 > H$. The affinity for divalent ions is greater than for monovalent ions. The resins have been given in the H or NH_4 form to prevent absorption of Na from the bowel in patients with oedema or ascites and in patients with hypertension (McChesney, Dock, and Tainter, 1951; Greenman and others, 1951). The resins give off H or NH_4 in exchange for Na; H or NH_4 is absorbed combined with acid, and Na is excreted in the faeces combined with resin. The resin takes up K and other cations as well, and the depletion of cations may result in acidosis. To minimize these complications the resin has been given partly combined with K.

Most of the information available is on the effects of carboxylic exchange resins. In the course of work on experimental depletion of potassium we have obtained data on the effects of a sulphonated polystyrene resin, "zeo-karb 225," on the absorption of K, Na, Mg, Ca, and P with a normal diet in man. Though these data are incidental to another investigation and give information of limited scope, we think it may be useful to report them now that a pharmaceutical preparation of zeo-karb 225 has become available ("kationium"). Additional information was derived from studies of three patients who were receiving only small amounts of sodium in their diet.

Procedure

There were three experiments—F.1, W., and F.2—on two normal subjects, F. and W. The H form of the resin was given in F.1 and the NH_4 form in W. and F.2. The dose of resin was 60 g. daily for eight days, followed by 90 g. daily for eight days in F.1 and F.2 and 90 g. daily for four days in W. (These doses are two or three times what is likely to be given therapeutically.) The diets contained, per day, Na, 180–220 mEq; K, 31–38 mEq; Mg, 12–22 mEq. The composition of the diet in each experiment was constant. Resin was given with meals; added sodium was given between meals. The faecal excretion of N, P, Ca, K, Na, and Mg and the urinary acidity and ammonia were measured. Other details are available in a previous publication (Fourman, 1952).

In addition three patients were studied: a woman (A.) with intractable cardiac oedema; a man (M.) with cirrhosis of the liver, ascites, and oedema; and a woman (P.) with hypertension but without oedema or other evidence of heart failure. The patients received resin in a dose of 20, 30, or 45 g. daily while taking a diet which contained less than 20 mEq of Na a day. The faecal excretion of Na was measured in periods of seven or twelve days while the resin was given in the NH_4 form and also while it was

TABLE I.—Effect of Resin on Daily Faecal Loss of Cations (mEq) in Consecutive Periods of Four Days

Form of Resin:	H				NH ₄							
Experiment:	F.1				W.				F.2			
Cation:	Na	K	Mg	Sum	Na	K	Mg	Sum	Na	K	Mg	Sum
Period:												
Control .. {	8.2 8.8	9.9 8.6	2.4 6.9	20 24	5.4	7.2	5.7	18*	3.2 7.4 6.0	5.5 8.9 6.5	6.4 12.1 7.6	15.1 28.4 20.1
Resin, 60 g. {	103 121	40.9 51.2	5.7 15.9	150 188					126 132	61.1 56.3	11.3 12.0	198 200
„ 90 „ {	139 156	47.6 63.3	12.3 15.9	199 235	169	78.6	10.3	258	149 192	64.3 88.5	9.0 17.8	222 298
Recovery .. {	21.2 8.3	17.6 9.7	24.7 12.8	64 31					26.9 13.8 3.1	21.2 9.1 7.9	9.6 12.1 18.5	58 35 30
Diet ..	223	38	22		212	36	12		181	31	13	

* Eight-day period.

given in the NH₄ form with K salts added to the treatment or in the K form as prepared in the laboratory. Potassium salts were given between doses of resin and not with resin.

Effect of Resin on Different Ions

In the experiments the resin took up Na, K, and Mg (Table I), but not Ca (Table II). Absorption of phosphate was possibly enhanced (Table II).

The proportions of Na, K, and Mg in the faeces were remarkably similar for the different doses of resin and in

the different experiments (Table III). The mean ratio of Na:K:Mg was approximately 11:5:1. It seems likely that these proportions represented an equilibrium mixture of Na, K, and Mg for the diet provided, where the intake of Na was liberal. The amount of Na taken up by the NH₄ resin was about 2 mEq/g. and slightly more than twice that of K. The uptake of K exceeded the dietary intake. The amount of Mg taken up was small compared with the two other ions, but constituted a large proportion of the dietary intake.

In the patients who were receiving a low intake of Na, the amount of Na taken up by the resin was small and equivalent to only 0.7 mEq/g. When K was given in addition, either as K salts or as the K form of resin, the amount of Na taken up was even smaller (Table IV). The amounts of Na taken up per g. of resin were again similar for the different doses of resin given.

The number of data is small and the agreement may be fortuitous; but the results suggest that the equilibrium between resin and Na depends on the cation content of the diet and not on the dose of resin, for the range of doses given.

Capacity of Resin in Vivo

The capacity of the H and NH₄ forms of resin *in vitro* differs because the NH₄ form has a lower moisture content (10% as opposed to 30%). Thus, while the same weights of both forms of resin were given, the effective dose of the NH₄ form was about 130% of that of the H form. The following estimates of capacity are based on the weight of resin given.

The capacity of the H resin *in vitro* is 2.5 mEq/g. (Lancet, 1950). The capacity of the NH₄ resin *in vitro* was estimated as 3.3 mEq/g. (calculated from the N content, on the assumption that all the N was present as NH₄). An estimate of the capacity of the resin *in vivo* was obtained from the increase in faecal excretions of cations when resin was given. The capacity calculated in this way from data in Table I was 2.4 mEq/g. for the H form and 2.8 mEq/g. for the NH₄ form in both experiments in which this form was given. These are minimum estimates of the capacity of the two forms of resin, because some resin was excreted with cation after the marker for the end of the resin period had appeared in the faeces (cf. Table I), and because not only of the increase in faecal cation but also the cations normally present in faeces may have combined with the resin.

Another estimate of the capacity of the NH₄ resin *in vivo* was given by the change in faecal N when the NH₄ resin was given. In W. there was an increase of faecal N while the resin was given, equivalent to 0.4 mEq of NH₄ per g. of resin; this suggests that 2.9 mEq of NH₄ per g. of resin was exchanged. This estimate corresponds well with the one above of 2.8 mEq/g. In F.2 the faecal N did not increase, so that in this experiment all the NH₄, or 3.3 mEq/g. of

TABLE II.—Effect of Resin on Daily Faecal Loss of Ca and P (mg.) in Consecutive Periods of Four Days

Form of Resin:	H		NH ₄			
Experiment:	F.1		W.		F.2	
Cation:	Ca	P	Ca	P	Ca	P
Period:						
Control .. {	720 574	540 420	1,012	544*	402 845 500	344 712 443
Resin, 60 g. {	495 673	360 378	515	362*	472 296	362 372
Resin, 90 g. {	580 454	289 268	976	240	416 588	220 356
Recovery .. {	797 881	566 676			550 776 1,146	380 731 792

* Eight-day period.

TABLE III.—Percentage of Na, K, and Mg in Faeces During Administration of Resin

Form of Resin:	H		NH ₄				
Experiment:	F.1		W.		F.2		Mean
Dose of Resin (g.):	60	90	60	90	60	90	
Na	66.3	68.0	56.1	65.5	64.8	65.3	64.3
K	27.2	25.6	38.2	30.5	29.5	29.3	30.0
Mg	6.4	6.5	5.7	4.0	5.8	5.1	5.6

TABLE IV.—Faecal Na per g. of Resin in Patients on Low-sodium Diets

Case	Duration of Faecal Collection	Dose of Resin	Faecal Na (mEq/g. of Resin)		Amount of Added K (mEq)
			Without K Added to Treatment	With K Added to Treatment	
M.	12 days	20 g.	—	0.25	84 (as mist. pot. cit.)
A.	7 „	30 „	0.87 0.67	0.28	90 (resin given in K form)
P.	7 „	45 „	0.73 0.59	0.16 0.18	120 (as KCl)
Mean uptake of Na (mEq) per g. of resin			0.7	0.2	

resin, was apparently exchanged. This estimate is higher than the one above, but it may be noted that a small error in measuring faecal N would mean a large error in the estimate of capacity. Faecal N was measured in only one of the patients (P.) receiving a diet low in Na. In her the faecal N did not increase with resin, and, moreover, the changes in faecal K were consistent with the suggestion that the total capacity was not appreciably diminished when the uptake of Na was small.

These estimates show that the capacity of the resin *in vivo* may approach the capacity *in vitro*. For the NH_4 form the capacity *in vivo* was more than 2.8 and less than 3.3 mEq/g. A figure of 3 mEq/g. provides a working approximation.

Compensatory Effects

The resin prevents absorption of fixed base, but absorption of acid radicals is not diminished, and if the resin is given in the NH_4 form the acid radicals are absorbed as NH_4 salts. NH_4 is metabolized to urea, and the excess of acid radicals is excreted by the kidney. This is achieved by an increase in the renal excretion of titratable acid and NH_4 .

In our experiments the titratable acidity of the urine increased rapidly to about 40 mEq/day while the resin was given. The urinary ammonia increased more gradually up to 200 mEq/day. The change in the sum of the two was about equal to the increase in faecal loss of cations (Table V). In spite of the renal compensation, the subjects were

TABLE V.—Urinary Acidity $+\text{NH}_4$ (mEq/day). Increase Over Control Values During Four-day Periods of Giving Resin

Form of Resin:	H	NH_4	
Experiment:	F.1	W.	F.2
Dose of resin:			
60 g. . . .	117	142*	144
60 " . . .	123		182
90 " . . .	160	218	229
90 " . . .	186	—	270

* Eight-day period.

acidotic while taking resin: the plasma bicarbonate fell to 17, 12, and 15 mEq per litre in F.1, W, and F.2. This may have been partly because it takes some days for the renal production of NH_4 to become fully established (Sartorius, Roemmelt, and Pitts, 1949). An additional reason may have been that K was lost from the body without equivalent amounts of the corresponding anion, phosphate (Fourman and Ainley-Walker, 1952). These changes were accompanied by loss of water from the cells, manifested clinically by thirst.

Discussion

With a normal intake of Na, the capacity of zeo-karb 225 *in vivo* approached its capacity *in vitro* (cf. McChesney, 1952). Na, K, and Mg were taken up in approximately constant proportions of 11:5:1, and 1 g. of NH_4 resin took up about 2 mEq of Na. But in three patients who were receiving little Na a lesser amount of Na was taken up—about 0.7 mEq/g. without added K and only 0.2 mEq/g. when K was added to the diet. The amount of Na taken up per gramme of resin did not apparently depend on the dose of resin given.

It is possible that when only small amounts of Na are available, either because the intake is low or because the intestinal secretions contain less Na (Berger and Steele, 1952), the resin may be free to take up K and other ions in greater amounts. Though this does not apparently happen with carboxylic resins, our results suggest that with the sulphonated resin the uptake of other ions may be inversely related to the uptake of Na.

The resin can take up more K than is provided in the diet and can cause depletion of K. Unfortunately such depletion is not always revealed in good time by a fall in the serum level of K: with acidosis, in particular, the serum level may not fall and renal loss may persist in the face of

a deficit. Depletion of K is undesirable: on a conservative view it produces apathy and anorexia; it can predispose to oedema; it may potentiate the effects of digitalis and produce myocardial lesions. An attempt is made to overcome the risk of depletion when the resin is given partly combined with K, as in kationium. Nevertheless if given with a diet low in Na this type of resin might combine with more K than it provides and it might remove significant amounts of Mg. It may prove necessary with some diets to add K and even Mg to the treatment, though an excess of cations given with the resin would render it less effective for combining with Na. Laboratory control will be necessary if the resin is to be used effectively and without danger of K depletion and acidosis.

Summary

In three balance experiments a cationic exchange resin (zeo-karb 225) was given in H or NH_4 form to two normal persons in a daily dose of 60 and 90 g. The diets contained about 200 mEq of Na, 31–38 mEq of K, and 12–22 mEq of Mg. With either form of resin and with both doses the resin took up Na, K, and Mg in a fairly constant ratio of about 11:5:1. Ca was not taken up. The amount of Na taken up by the NH_4 form was about 2 mEq/g.

In three patients with a low intake of Na the amount of Na taken up was only 0.7 mEq/g., and was further diminished when K was added to the treatment.

The capacity of the resin *in vivo* was estimated from the change in faecal excretion of cations and also, for the NH_4 form, from the change in faecal N. The capacity of the two forms of resin *in vivo* approached their capacity *in vitro*; that of the NH_4 form was about 3 mEq/g. *in vivo*.

With resin, the change in daily excretion of acid and ammonia in the urine was approximately the same as the change in excretion of cations in the faeces.

The results suggest methods of assessing the capacity of the resin *in vivo*. The capacity of the resin *in vivo* and the proportions of Na, K, Mg, and Ca that combine with the resin may well vary with the amounts of Na, K, Mg, and Ca in the intestine.

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A new British Standard for Fireguards and Heating Appliances (B.S. 1945:1953) has now been prepared. Its object is to assist the implementation of regulations which are to be issued by the Home Office under the Heating Appliances (Fireguards) Act. The new specification applies to all types of gas fires, electric fires, and oil-burning heaters used for domestic purposes. Guards must pass a test designed to control size of opening; a scorching test, in which a piece of flannelette is placed in contact with the guard and must not smoulder or ignite within a specified time; and a test for mechanical strength. Heating appliances provided with guards in accordance with this new specification are required to be marked with the words "Guarded in accordance with B.S. 1945." Copies of the standard may be obtained from the British Standards Institution, Sales Branch, 24, Victoria Street, London, S.W.1, price 2s.