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SHORT COMMUNICATION

Radiochemical separations by amalgam exchange

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A RAPID and selective radiochemical separation procedure has been developed using the techniques of amalgam exchange. Separation of the radio-isotope takes place by virtue of the rapid exchange occurring between an element present in a dilute amalgam and its ions in solution. If there are many more inactive atoms of the element in the amalgam than there are of its radio-isotope in solution, amalgam exchange will result in almost all of the activity being incorporated in the amalgam. (In this it is somewhat similar to the isotopic exchange separation of silver.[1]) Selectivity is obtained since ions of other elements in solution will not exchange with the desired element in the amalgam. In the case of cadmium, thallium, lead and bismuth, amalgam exchange has been reported to be exceedingly rapid,[2,3] thus the method can be useful for the separation of short-lived isotopes. In this preliminary survey of the method it appears that amalgam exchange can give satisfactory yields in short periods of time for a number of radio-elements.

EXPERIMENTAL

Apparatus and reagents

A 50-ml round-bottom centrifuge tube was used for all extractions. The aqueous and mercury layers were vigorously agitated by a glass stirring rod rotated at 1500 to 2000 r.p.m. by an electric stirrer. All aqueous solutions were made with distilled water from salts of analytical reagent purity. Mercury and other solid metals used to make the amalgams were of analytical reagent purity, and in some cases of spectroscopic standard purity.

Preparation of amalgams

Amalgams of bismuth, cadmium, gallium, indium, lead, tin, thallium, and zinc were prepared by direct combination (with heating) of metal with the mercury. The strontium amalgam was prepared by reducing a solution of strontium nitrate with sodium amalgam. All amalgams were made to contain 2% by weight of the element to be exchanged.

Procedure

To test the method 2 ml of a solution containing a particular electrolyte and tracers of the element to be exchanged were added to the centrifuge tube. One half gram of the amalgam was added to the solution with a calibrated micro pipette and the solution stirred for five minutes. An aliquot of the solution was then measured for activity.

In all of the experiments a volume ratio of 40 : 1 was maintained between the aqueous solution and the amalgam.

RESULTS AND CONCLUSIONS

A short summary of typical yield results for several different electrolytes is shown in Table I. Individual amalgams containing milligram amounts of cadmium, thallium, bismuth, strontium, zinc, indium, or lead have been found to remove trace amounts (μgm or smaller) of their respective radio-active isotopes from dilute acid or salt solution with a yield of at least 50% in five minutes of stirring. Tin and gallium did not exchange.

One problem arises in that these amalgams have a reducing power comparable to the reducing power of the pure metal of which the amalgam is made.[4] These contaminants as well as other oxidizing agents (MnO_4^-, $Cr_2O_7^{2-}$, etc.) can cause a considerable reduction in the yield of the desired

TABLE I. EXCHANGE OF AN ELEMENT WITH ITS AMALGAM
(Five minute stirring time)

Isotope and amount	Solution	Exchange %
^{212}Bi (*)	5*M* HCl	49
^{115m}Cd (24 μg)	0.5*M* $NaClO_4$	94
	0.5*M* $Na_2C_2O_4$	94
	0.5*M* $NaNO_3$	94
	5*M* $HClO_4$	94
^{72}Ga (1 mg)	0.5*M* $NaNO_3$	none
	sat'd NaCl	none
	2*M* $HClO_4$	none
	2*M* HNO_3	none
^{114}In (1 mg)	5*M* HCl	50
^{212}Pb (*)	0.5*M* $NaNO_3$	90
^{113}Sn (1 mg)	0.5*M* $NaNO_3$	none
	sat'd NaCl	none
^{90}Sr (*)	0.5*M* $NaNO_3$	50–60
^{204}Tl (21 μg)	0.5*M* $NaNO_3$†	85
^{65}Zn (40 μg)	0.5*M* $NaNO_3$	90

* Carrier free.
† This value is taken at two minutes stirring.

metal. This potential source of contamination in the separation might be avoided, however, by bringing the solution into contact with an amalgam made of an element (scavenger) which is just below the desired element in the electromotive series. This separation would then be followed by contact with a larger amount of amalgam of the desired element.

The potentialities of this method can be shown in the separation of cadmium from zinc. This usually difficult separation was accomplished in three minutes with a decontamination factor for zinc of 10^4 by agitation of the cadmium amalgam with a solution of the cadmium and zinc.

At the end of the separation the desired activity is in the amalgam. Direct gamma-ray counting of the amalgam may be possible without too large an error caused by absorption losses, although β counting might prove more troublesome. In any case it may be possible to strip the element selectively from the mercury, either by a wash with an oxidant or by electrolytic stripping.

A detailed evaluation of this method for elements which demonstrate the exchange is being made by measuring the purity of activity separated from solutions containing many representative tracers. Problems of the accurate assay of the activity separated by this amalgam method are also being studied.

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