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EVALUATION OF MACROEETICULAR ANION EXCHANGE RESIN - RTA-893-R

Introduction

Macroreticular anion exchange resin, which is characterized by a rigid pore structure, was evaluated for use in the reactor purification deionizers in response to RTA-893-R. Macroreticular resins are reported to possess greater physical stability and resistance to oxidation than normal gel-type anion exchange resins, but they are also slightly more costly and have a slightly lower volume exchange capacity. Because the service life of 100-Area deionizers is limited by radiolytic degradation of the resins[1], the primary incentive for using the macroreticular resin would have to come from an improvement in radiation resistance over the resins currently in use.

In this work the stability of macroreticular resin Amberlite® IRA-900 to gamma radiation was determined and compared with that of Amberlite® IRA-400[2]. An experimental resin volunteered by Ionac Chemical Company as possibly radiation resistant was also examined.

1. Technical Progress Report, Atomic Energy Division, September 1963. DP-63-1-9, pp. I-20 ff. (Secret)
2. E. W. Baumann. "Effects of Gamma Radiation on Individual and Mixed Ion Exchange Resins". DPST-64-564. December 31, 1964.
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Summary

The macroreticular anion exchange resin, Amberlite® IRA-900-OH, and an experimental resin from Ionac Chemical Company were irradiated by a ^{60}Co source to doses of 5×10^7 rad and 10^8 rad. These doses approximate or exceed the dose encountered by the deionizer resins in 100-Area service.

The loss in exchange capacity and the volume changes of Amberlite® IRA-900 on irradiation were similar to those found previously for Amberlite® IRA-400. The Ionac experimental resin, which had a considerably lower initial exchange capacity, likewise was not stable to radiation.

It is concluded that Amberlite® IRA-900 offers no advantage over Amberlite® IRA-400 for 100-Area purification service. Since there is little justification for further evaluation of macroreticular resin for 100-Area use, the present work completes RTA-893-R.

Discussion

Background

The reactor deionizer resins accumulate a radiation dose during service that is sufficient to cause a loss of exchange capacity which reduces the service life of the deionizer bed. The anion resin component of the mixed bed limits deionizer lifetime not only because it is preferentially depleted by the acidic moderator but also because it has a lower resistance to radiolytic degradation than the cation resin. Therefore an anion exchange resin with better radiation stability would be of value for use in the 100-Area deionizers.

The recently marketed macroreticular ion exchange resins seemed to offer possible increased resin stability as well as other advantages. In contrast to the conventional gel resins, which shrink and swell, macroreticular resins have an open structure with well-defined pores. According to the manufacturer they also are less susceptible to attrition and oxidation than gel resins and are more resistant to organic fouling. The pore structure should provide greater absorption of particulate matter and improve the capability of the purification system to remove long-lived activities.

Resins Tested

e resins tested for radiation stability were Amberlite® IRA-900 (OH^- orm), Ionac XAX-1071 (OH^- form) and a mixture of Amberlite® 200 (H^+ form) d the Amberlite® IRA-900.

berlite® IRA-900 is the macroreticular counterpart of the gel resin berlite® IRA-400, the anion exchange resin currently used in 100-Area rification systems. Both resins have quaternary ammonium exchange groups the trimethylamine type.

o experimental resins were supplied by Ionac Chemical Company, as ssibly radiation resistant. One of these, Ionac XAX-1072, apparently st exchange sites as it was converted to the hydroxyl form and it was considered further. The other resin, Ionac XAX-1071, was carried ough the irradiation testing procedure. The nature of this experital resin was not established; the infrared absorption spectrum was irely different from the macroreticular and gel resins. The exchange oups are probably of the amine type.

Also tested was a 1:1 equivalent mixture of Amberlite® IRA-900 and Amberlite® 200. Amberlite® 200 is the macroreticular counterpart of Amberlite® IR-120, the cation exchange resin currently used. Amberlite® 200 was tested previously and found to have stability similar to the gel resin; neither resin undergoes appreciable damage in the dose range of interest.

Experimental Procedure

The anion exchange resins were converted to the hydroxyl form with 10% NaOH solution and rinsed free of excess caustic. Exchange capacities were determined by placing the resin in a 20% NaCl solution and titrating the alkalinity released with 0.1 N HCl. The resins, now in the Cl^- form, were dried and weighed.

Amberlite® IRA-900, Ionac XAX-1071, and a 1:1 equivalent mixture of Amberlite® 200 and IRA-900 were irradiated in the water-saturated state with a ^{60}Co source.

After a dose of approximately 5×10^7 rad, the resins were rinsed free of water-soluble products and a portion of each anion resin was taken for exchange capacity determination. The remainder of the resin was irradiated a second time, for a total dose of approximately 10^8 rad. Again water-soluble products were rinsed out and the exchange capacity of the anion resins determined.

The wet packed volume of each resin was determined before and after irradiation.

Results

The initial exchange capacities of the resins investigated are presented in Table I for comparison with that of Amberlite® IRA-400. The exchange capacity per unit weight is greater for the macroreticular resin than for the gel resin, but the capacity per unit volume is slightly less. The capacity of the Ionac resins was relatively low.

In Figure 1 the loss of initial exchange capacity with gamma dose is seen to be similar for Amberlite® IRA-900 and Amberlite® IRA-400[2]. The Ionac resin loses a greater fraction of its capacity than do the Amberlite resins.

Also in Figure 1 are shown changes in volume of the resin on irradiation. Volume changes for macroreticular resins and their mixtures are similar to those of the gel resins.

Table II gives information about the water-soluble material from the irradiated resins. Some of the exchange capacity loss of the anion resins was accounted for as water-soluble alkalinity, which could be titrated. As with gel resins, little soluble material was released from the mixed resin.

The nature of the leach water from the macroreticular anion resin was different from that for gel resins, where the water was brown and murky as if it contained suspended polymer. The turbidity in the macroreticular leach was mostly filterable and was due to resin fines.

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TABLE I

Initial Exchange Capacity of Resins

	Exchange Capacity meq/g anhydrous resin	Exchange Capacity meq/ml	Type of Resin
mberlite IRA-400-Cl	(3.3)*	(1.2)	gel
mberlite IRA-900-Cl	3.8 (4.4)	0.9 (1.0)	macroreticular
onac XAX-1071-Cl	1.8	---	experimental; not known
onac XAX-1072-Cl	0.5	---	experimental; not known

*Values in parentheses are from trade literature; others are experimental.

TABLE II

Characteristics of Water-Soluble Material from Resins

	Properties of Supernate	Fraction of Exchange Capacity Loss Found as Water-Soluble Alkalinity
ter 5×10^7 rad:		
Mixed Amberlite 200 and IRA-900	pH 6; Faintly tan, turbid, foamy; no odor	---
Amberlite IRA-900	pH 11; colorless, turbid, foamy; strong NH_3 odor	0.7
Ionac XAX-1071	pH 11; colorless, very clear; faint NH_3 odor	0.6
er 5×10^7 rad more (10^8 rad total):		
Mixed Amberlite 200 and IRA-900	pH 6.5; slightly yellow, turbid, foamy, faint NH_3 odor	---
Amberlite IRA-900	pH 11; colorless, turbid, foamy; strong NH_3 odor	0.3
Ionac XAX-1071	pH 9; colorless, very clear; no odor	0.7 0.7

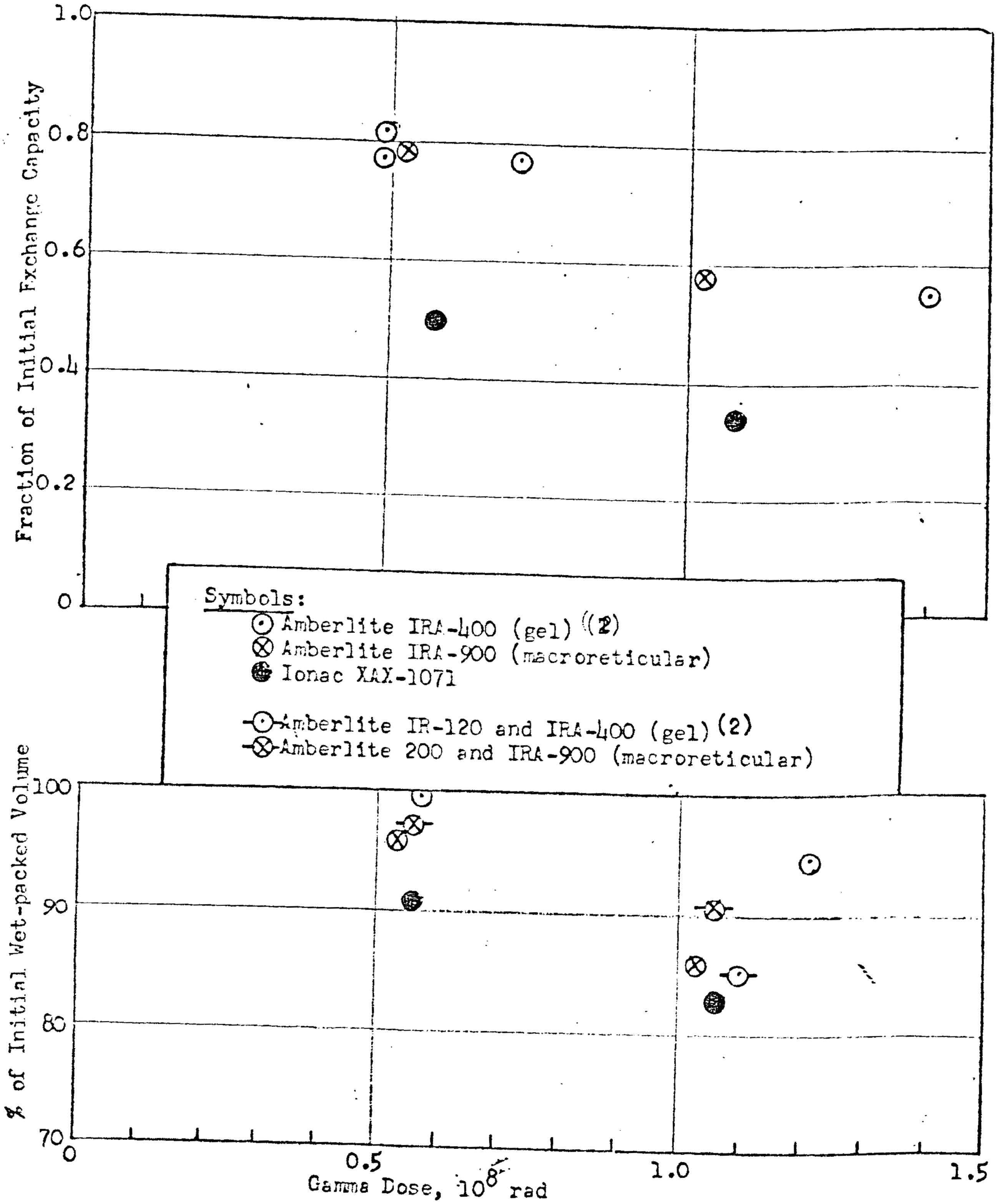

FIGURE 1

CAPACITY AND VOLUME CHANGES ON IRRADIATION