

most probable errors of  $\pm 5$  per cent, which is likely to produce an error of  $\pm 15$  per cent in the value of  $\epsilon$  at high temperatures and of about  $\pm 5$  per cent at very low temperatures. Nevertheless, the decrease in the value of  $\epsilon$  is definite and unmistakable, though the magnitudes may be much in error. These investigations thus show that the 12:6 potential function can represent the interaction even over a long range of temperatures, provided  $\epsilon$  and  $r_0$  (as will be seen later) are varied very slowly with temperature. Exact calculations by us from viscosity data also show an unmistakable tendency for  $\epsilon$  to increase with increase of temperature. Using these values of  $\epsilon$  in the expressions for viscosity and self-diffusion,  $r_0$  at different temperatures has also been found, the values being given in the table.

This variation of  $\epsilon$  and  $r_0$  can be accounted for theoretically. Writing equation (1) in the form:

$$E(r) = \lambda r^{-12} - \mu r^{-6}, \quad (3)$$

it can be shown that

$$\epsilon = \frac{1}{2} \mu^2 / \lambda, \quad r_0 = (\lambda / \mu)^{1/6}, \quad (4)$$

where  $\mu$  and  $\lambda$  are supposed to remain constant. From London's quantum-mechanical formula for the dispersion energy leading to the van der Waals' attraction<sup>5</sup>:

$$E(r) = -\mu r^{-6} - \mu' r^{-8} - \mu'' r^{-10} - \dots \quad (5)$$

it is evident that if, for large distances, we limit the formula to the first term only,  $\mu$  must be made to increase when the intermolecular distance  $r$  is decreased, in order that the single term may still give the attraction correctly. Since at higher temperatures the most effective contribution of the molecular field to the transport properties will be for smaller intermolecular distances, it follows that  $\mu$  must increase with increase of temperature. Similarly, it can be shown that the repulsion term  $\lambda$  must decrease with rise of temperature. In consequence,  $\epsilon$  will increase and  $r_0$  will decrease with rise of temperature. In fact, from equations (4) the effective  $\mu$  and effective  $\lambda$  can be calculated at different temperatures and are found to be fully consistent with the virial coefficient data. A similar procedure has been used for other gases also. Detailed investigations are being published in a series of papers.

B. N. SRIVASTAVA  
M. P. MADAN

Physics Laboratory,  
University, Lucknow. July 7.

<sup>1</sup> Chapman, S., and Cowling, T. G., "The Mathematical Theory of Non-uniform Gases" (Camb. Univ. Press, 1939).

<sup>2</sup> Hirschfelder, J. O., Bird, R., and Spotz, E. L., *Chem. Rev.*, **44**, 205 (1949).

<sup>3</sup> Winter, E. R. S., *Trans. Farad. Soc.*, **46**, 81 (1950).

<sup>4</sup> Jones, R. C., and Furry, W. H., *Rev. Mod. Phys.*, **18**, 153 (1946)

<sup>5</sup> London, F., *Z. Phys.*, **63**, 245 (1930).

### Ion-exchanging Surfaces in Radiological Decontamination

THE adsorption of radioelements by the walls of glass vessels is recognized as a source of inaccuracy in radiochemical assessments, and the great affinity shown by many radioactive substances for working surfaces in the laboratory is shown by the vigorous chemical and mechanical treatments which are needed for their removal from these surfaces. Chemically resistant metals such as stainless steel and lead have been shown<sup>1</sup> to adsorb phosphorus-32, barium-140 and iodine-131, and complete removal was possible only by removing a thin layer of the

surface. Organic materials such as polythene<sup>2</sup> and vinyl chloride-acetate copolymer have been found to be particularly resistant to contamination by aqueous solutions of radioisotopes, and they are extensively employed as constructional materials or protective coatings. We have found that films of unplasticized polystyrene, prepared by brushing a surface with a 30 per cent solution of 'Distrene' in toluene, possess very low adsorption for fission elements (which were in aqueous solution as nitrates). Results of experiments are given in the accompanying table.

RETENTION OF FISSION PRODUCT ISOTOPES BY POLYSTYRENE AND SULPHONATED POLYSTYRENE

Surface	Beta/gamma count after 1 min. immersion in fission products solution (10,000 counts min. <sup>-1</sup> , c.c. <sup>-1</sup> )	Beta/gamma count after washing with 5 per cent ammonium citrate for 3 min.
Polystyrene	108 counts/min. 58 65 85	5 counts/min. 3 2 19
Sulphonated polystyrene (prepared by exposing to SO <sub>2</sub> for 2 min.)	769 1,091 1,470 1,140	7 114 235 44

It was considered that decontamination might be more readily effected if a surface could be rendered ion-exchanging by some means, since it has been established<sup>3</sup> that isotopes of rare-earth elements can be adsorbed on ion-exchanging phenol formaldehyde resins and can afterwards be completely removed by treating the resin surface with an elutriating solution of citric acid. We have recently carried out a comprehensive series of experiments to determine the degree of attachment and relative ease of removal of fission elements from sulphonated polystyrene, which we prepared in the laboratory, and have come to the conclusion that the use of a cation-exchanging material of this kind does not facilitate complete decontamination to the extent that might have been expected. Full details will be reported in due course, but the table shows typical results.

It will be seen that the adsorption of fission elements is higher for the ion-exchanging surface and that elutriation does not bring the final level of activity down to that of untreated polystyrene.

We are indebted to the Admiralty for permission to publish this note.

E. W. JACKSON  
L. GARRARD

Admiralty Research Laboratory,  
Teddington, Middlesex.

Dec. 11.

<sup>1</sup> Tompkins and Bizzell, *Indust. and Eng. Chem.*, **42**, 1469 (1950).

<sup>2</sup> *Fay Atomic*, **3**, 93 (1952).

<sup>3</sup> Tompkins, Khym and Cohn, *J. Amer. Chem. Soc.*, **69**, 2773 (1947).

### Column Procedures for the Salt Fractionation of Enzyme Preparations

TWO procedures for fractionating enzyme preparations on a column, somewhat different from the previously described chromatopile<sup>1</sup>, have been found useful in preliminary tests.

In the first procedure, a column of the precipitated enzyme in the presence of an inert carrier and in a medium of high salt concentration is eluted with a dilute salt solution. The resulting fractions of effluent are then analysed for enzyme activity and for protein.