THE ISOTOPIC FRACTIONATION OF WATER DUE TO EVAPORATION AND DISTILLATION.

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It has been shown by several investigators[1] that the isotopic fractionation of water occurs either by a slow evaporation or by a distillation especially under a reduced pressure. From this point of view we have examined two samples of water. The first sample was prepared from the mother liquor of the salt which was separated from sea-water by its slow evaporation being exposed to wind and sun. The mother liquor of the salt thus prepared is a brown syrup liquid and contains above all a considerable amount of magnesium chloride in solution which contributes to its bitter taste. Hence it is called "Nigari" (nigai = bitter) in Japanese. The sample water was prepared by distilling the "Nigari" to dryness. The second sample of water was obtained, according to the suggestion of Professor Ikeda, from the molasses of the cane sugar which was prepared by a vacuum distillation of the sap-juice of sugar canes. The molasses was burned in a flow of air and the water formed was twice passed over heated copper oxide for the purification.

The density of the both samples of water, after being carefully purified in the same way as before,[2] was compared with that of the ordinary water by the use of a quartz bouyancy balance. The water from "Nigari" was found, as a result of two determinations, to be heavier than the normal water by 5.4 parts per million. And the increase in density of the water from the cane sugar molasses was found, as a mean of three independent determinations, to be 2.8 parts per million. The increase in the density should be mainly due to the evaporation in the former case and to the distillation in the latter. However, it seems possible that very hygroscopic substances such as magnesium chloride dissolved in

(1) E. W. Washburn, E. R. Smith, and M. Frandsen, *J. Chem. Phys.*, **1** (1933), 288; *Bur. Standards J. Research*, **11** (1933), 453; E. W. Washburn and E. R. Smith, *J. Chem. Phys.*, **1** (1933), 426; *Bur. Standards J. Research*, **12** (1934), 305; *Science*, **79** (1934), 188; G. N. Lewis and R. E. Cornish, *J. Am. Chem. Soc.*, **55** (1933), 2616; G. N. Lewis and R. T. Macdonald, *J. Am. Chem. Soc.*, **55** (1933), 3502; E. S. Gilfillan, Jr., *J. Am. Chem. Soc.*, **56** (1934), 406; R. J. Clark and F. L. Warren, *Nature*, **134** (1934), 29; T. Tucholski, *Nature*, **134** (1934), 29, Cf. also the preceding article.

(2) M. Harada and T. Titani, this Bulletin, **9** (1934), 457.

"Nigari" plays a certain rôle in the former case. Moreover, the sap-juice of certain plants were found to be slightly heavier than the ordinary water.[3] Such a possibility can not be overlooked in the case of the sugar cane. These points will be interesting for further investigations.[4]

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(3) E. W. Washburn and E. R. Smith, *loc. cit.*

(4) At the end of our experiment a comprehensive research by Messrs. Emeléus, James, King, Pearson, Purcell, and Briscoe (*J. Chem. Soc.*, **1934**, 1207) has been published. These authors have found that the water from the combustion of sucrose was heavier than the normal water by 8.61 p.p.m. This result is very interesting in connection with our present observation.