

crown. Bode<sup>5</sup> has also shown that similar changes follow altered cohesion tensions in small plants. Singular reversals of these alterations have been recorded in the Monterey pine, by which increase in diameter takes place during the daylight period—the usual program of tree cactuses. It is notable that large roots near the base of the trunk of a pine show reversible variations of opposite phase to those in the trunk.<sup>6</sup>

A pine tree dying as a result of complete defoliation in midsummer still carries on transpiration at a lessened rate, but which is sufficient to maintain a cohesive column of upwardly moving water in which daily variations in tension are measurable. Any disturbance of the system would destroy the experiment, but it is highly probable that ascent of sap and reversible variations continue for a time in trees in which every cell is dead. The colloidal masses of dead cells at the terminals are the seat of a minimized transpiration of an amount sufficient to maintain tension on the water-column in wood-cells which are dead when they become conductors. The absorption of water by dead roots is a well-established fact. The conditions described may be taken to illustrate the ascent of sap in trees without the participation of living cells.

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#### THE PURIFICATION OF ZIRCONIUM

SALTS of zirconium are used in X-ray crystal analysis as filters for the rays from a Coolidge tube having molybdenum target. This is because of the property, peculiar to zirconium atoms,<sup>1</sup> of transmitting the "Mo alpha" wave lengths very readily, but of being especially opaque to Mo beta and gamma rays. In all zirconium compounds commercially obtainable this property is not as pronounced as it should be, probably because of the presence of some impurity. It therefore seemed worth while to attempt to find a method for separating zirconium from the other elements with which it is naturally associated. The raw material used was zirconium nitrate, because it is water soluble. It was known that the citrate was also water soluble and gave a clear solution with ammonia. It seemed at first that this might serve as a starting point for working out a method of eliminating at

least some of the impurities. Contrary to expectations, a precipitate was formed upon adding a limited amount of citric acid to the solution of zirconium nitrate. This precipitate is soluble in an excess of citric acid or in ammonium hydroxide.

It was thought advisable to investigate both the precipitate and the filtrate obtained when a limited amount of citric acid was used. A test was, therefore, made of the absorption of each for the molybdenum alpha and beta X-rays.<sup>2</sup> This test showed at once that the precipitate was a zirconium compound, because it strongly absorbed molybdenum beta wave-lengths while it transmitted the molybdenum alpha wave-lengths easily. This is a property of zirconium atoms and is not shown by the atoms of any other element, so that the identification of the precipitate as a zirconium compound was complete. A rough test with the dried filtrate did not show this characteristic X-ray absorption and transmission. It was, therefore, concluded that the filtrate contained either little or no zirconium or a mixture of zirconium and some other elements of such atomic weights as to mask the effect of the zirconium. If the second conclusion is correct, it would be expected from an X-ray standpoint that the impurities which had been concentrated in the filtrate were of higher atomic weight than zirconium.

It was decided to make further experiments with the oxides obtained, first by ignition of zirconium citrate and second by ignition of the part soluble in citric acid. A rough atomic weight determination was made by the writer, by converting the first oxide to chloride and precipitating the chloride with silver nitrate. This gave a value for zirconium equal to 91.09 or .7 lower than that obtained by Venable and Bell.<sup>3</sup> The second oxide treated similarly gave values varying from 92.39 to 92.46. While the latter evidently is mostly zirconia it still contains some impurity of a higher atomic weight.

The observations indicate that a partial separation of zirconium from hafnium might have been effected. It is certain that a single precipitation with citric acid gives a zirconium compound which is much purer than any zirconium salt ever worked with in this laboratory. Further work is being done and a full account of all the experiments will be published in the near future.

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<sup>5</sup> Bode, H. R., "Beiträge zur Dynamik der Wasserbewegung in den Gefässpflanzen," *Jahrb. f. Wiss. Bot.* 62, 92-127, 1923.

<sup>6</sup> MacDougal, D. T., "Reversible variations in volume, pressure and movement of sap in trees," Publ. 365, Carnegie Institution of Washington, 1925.

<sup>1</sup> A. W. Hull, *Phy. Rev.*, 18, 88, 1921.

<sup>2</sup> These tests were made by Dr. Wheeler P. Davey, of this laboratory.

<sup>3</sup> F. P. Venable and J. M. Bell, *J. A. C. S.*, 39, 1598 (1917).