the published values[7] do not cover the range of wave lengths covered by this multiplet.

In agreement with a general rule that the most sensitive lines of a spectrum always involve a quantum jump with $\Delta K=1$, the *raies ultimes,* 3436.74 and 3498.95A, occur also in a ^5D–^5F combination.

More details of this investigation will appear in the Journal of the Washington Academy of Sciences.

W. F. Meggers
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Bureau of Standards
May 29, 1925

MANGANESE AS A CURE FOR A CHLOROSIS OF SPINACH*

Yellow chlorotic foliage and poor growth have been noted in spinach grown for several years on heavily limed soil at the Rhode Island Experiment Station. During the season of 1925, spinach planted on April 3 and grown under low temperature and high moisture conditions began to show chlorosis very soon after the unfolding of the first pair of leaves. Accompanying a very slow growth rate, the first indications of chlorosis were observed in the yellowing of the older leaves which gradually led to a disintegration of the chloroplasts and finally to the appearance of dead transparent areas. Determinations of the soil pH range gave figures from 6.2 to 6.9 and when the lime requirement was determined, the range was from 683 pounds to 233 pounds per acre (modified Jones method).

In an attempt to correct this situation without appreciably changing the soil reaction, solutions of 0.02 per cent. ferrous sulfate, 0.004 per cent. manganous sulfate, 0.08 per cent. ammonium nitrate, 0.1 per cent. potassium sulfate, 0.2 per cent. potassium phosphate, 0.02 per cent. ferric ammonium citrate, 0.02 per cent. citric acid, and manure leachings were sprayed on the rows of chlorotic spinach, 9 liters of solution being added to 30 feet of row. These additions were made on soil which had been treated with a complete chemical fertilizer ration and also moderately manured before the spinach was planted. Of these treatments, the only one which gave any positive or marked result was the manganous sulfate. After a period of four days from treatment, a definite improvement in the color of the leaves could be seen and at the end of a week the change was very marked. The previously afflicted plants developed a bright green color and resumed normal growth. Following this initial result, other spinach plants which were growing under the same range of pH and lime requirement and which had begun to show definite indications of chlorosis were treated with a solution of 8 parts per million. Similar results were obtained as with the weaker treatment, thus confirming the original observations. When harvested a 40 per cent. increase in yield was obtained from the treated plat.

In order to localize more definitely the reacting element, plants were treated with a solution of 5 parts per million of sulfuric acid. This treatment caused no noticeable improvement in the chlorotic plants. From these results there are indications that the active element concerned in the cure of chlorotic plants is manganese.

Other investigators have shown, recently, relationships concerning manganese. Loew and Sawa,[2] McCool[3] and Brenchley[1] used solutions containing 15 and more parts per million of manganese salts and obtained chlorosis (in solution culture), which condition was followed by a definite toxic effect. Other investigators, working with concentrations below 10 parts per million, have obtained definite growth stimulation. McHargue,[4] Brenchley[1] and Skinner and Sullivan[6] observed in this connection a correlation between the soil reaction and this stimulatory effect; the less the acidity, the more marked was the growth response to manganese applications. Finally McHargue[5] obtained chlorosis of spinach in sand cultures from which manganese had been very carefully excluded. To the best of our knowledge, however, no one has reported the correction under practical conditions of a chlorotic disturbance of spinach by the use of manganese salts.

The results obtained wtih manganous sulfate as a cure for chlorotic spinach serve to corroborate the observations of other workers and at the same time seem to point to the use of manganese salts in field

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[7] Kayser, Handbuch der Spektroscopie VI, 371.

* Contribution 320 of the Rhode Island Agricultural Experiment Station, Kingston, R. I.

[1] Brenchley, Miss W. E., ''Effect of manganese compounds.'' In ''Inorganic Plant Poisons and Stimulants,'' p. 78–92, 1914.

[2] Loew, O., and Sawa, S., ''On the action of manganese compounds on plants,'' Tokyo Imp. Univ., Coll. Agr. Bul. 5: 161–172, 1902–03.

[3] McCool, M. M., ''The action of certain nutrient and non-nutrient bases on plant growth,'' Cornell Univ., Agr. Exp. Sta. Memoir 2: 113–116, 1913.

[4] McHargue, J. S., ''Effect of different concentrations of manganese sulfate on the growth of plants in acid and neutral soils and the necessity of manganese as a plant nutrient,'' Jour. Agr. Research, XXIV: 781–793, 1923.

[5] McHargue, J. S., ''Rôle of manganese in plants,'' Jour. Amer. Chem. Soc., 44: 1592–1598, 1922.

[6] Skinner, J. J., and Sullivan, M. X., ''The action of manganese in soils,'' U. S. Dept. Agr. Bul. 42: 1–32, 1914.

work. Studies of soil conditions and plant reactions are being carried on in the endeavor to interpret more fully this phenomenon.

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THE AMERICAN CHEMICAL SOCIETY[1]

PHYSICAL AND INORGANIC CHEMISTRY

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The application of the Lewis-Langmuir structure of the atom to the theory of coordination: C. J. BROCKMAN. In building up his theory of complex compounds Werner postulated the existence of a "coordination number" for certain elements, the theory being more or less at variance with the accepted ideas concerning valence, etc. Now it is suggested that the formation of complex compounds be due to an inherent desire on the part of certain elements to complete its outer shell of electrons to that configuration which is characteristic of the next higher inert gas, by taking on single or pairs of electrons from ions in solution or from molecules, etc., as they are available for such absorption. When electrons in such ions are absorbed by the central element the union between coordinated atoms or radicals becomes noniogenic. In support of this theory complexes containing Pt, Cr, Co and Fe as the central atoms have been studied.

The electric moments of the molecules of monocarboxylic acids and their esters: CHARLES P. SMYTH. The electric moments of the molecules of a number of monocarboxylic acids and esters are calculated from their structures, which are assumed to be formed by the linking of atoms by electron pairs symmetrically located at the apices of regular tetrahedra. The ratio of the moments thus obtained to those previously calculated in a similar manner for the molecules of the ketones, aldehydes and alcohols is in good agreement with that of the moments obtained from experimental data on these substances. The principal moments of the molecules induce secondary moments on the carbon chains of the esters, but, in conformity with the structures indicated by the X-ray measurements of Müller and Shearer, these induced moments oppose and nearly cancel one another in the carbon chain of the acyl radical of the ester, but reenforce one another in the chain of the alcohol radical, so that the moment of the molecule as a whole increases with increasing length of this chain, but changes little with increasing length of the acyl chain. The fact that the variations among the electric moments of different molecules may be explained by the assumption of electrons pairs shared between atoms which tend strongly to maintain their effective positions in definite symmetrical locations in the molecules seems to support the idea that valence forces are highly localized and directive in character, as indicated by the X-ray study of solids and the recent conclusions of Vorländer upon liquid crystals.

Adsorption and Schulze's law: HARRY B. WEISER. Schulze's law, that the precipitating power of an electrolyte is greater the higher the valence of the precipitating ion, is but little more than a qualitative rule. In so far as the rule holds, the adsorbability of an ion is greater the higher the valence. The conclusion of Dhar and his collaborators that ions with the lowest precipitating power are adsorbed the most and *vice versa* is both theoretically and experimentally unsound. An indirect method has been devised for determining the relative adsorbability of weakly adsorbed univalent ions. With strong electrolytes containing weakly adsorbed precipitating ions and the same stabilizing ion there is a direct relation between the relative adsorbability of the precipitating ions and the coagulating power of the electrolytes in the sense that the electrolyte containing the most readily adsorbed precipitating ion coagulates a sol in lowest concentration.

Mechanism of the photochemical reaction between hydrogen and chlorine: A. L. MARSHALL. An investigation has been made of the reaction between atomic hydrogen and a mixture of hydrogen and chlorine at low pressures. It has been found that below 0.001 cm pressure there is a yield of one molecule of hydrogen chloride per atom of hydrogen, while at 0.60 cm pressure the yield is ten molecules per atom of hydrogen. An explanation of these results can be found assuming the reactive form of chlorine to be an energy-rich chlorine molecule. It can be shown from kinetic theory considerations that at pressures below 0.01 cm the mean free time between impacts is longer than the average life of excited chlorine molecules which is taken as of the order of (10) -6 secs. Hence a yield of one molecule of hydrogen chloride per atom of hydrogen is to be expected. At higher pressures where the kinetic mean free time is shorter than this the yield per atom should increase. The mechanism postulated for the reaction is

$$H + Cl_2 = HCl\ (\text{active}) + Cl$$
$$HCl\ (\text{active}) + Cl_2 = Cl_2\ (\text{active}) + HCl$$
$$Cl_2\ (\text{active}) + H_2 = 2\ HCl\ (\text{active})$$

On the basis of this mechanism an explanation is given for the effect of water vapor in the photochemical reaction between hydrogen and chlorine. The primary action of light in this reaction is assumed to be the production of energy-rich chlorine molecules and not atomic chlorine.

Primary and secondary valence. An attempt to improve the classification of valence: ARTHUR A. BLANCHARD. Valence is classified in terms of the nuclear atom with the aid of certain general postulates concerning the extra nuclear electrons. Polar valence is the algebraic charge. Non-polar valence in the number of pairs of electrons held in common in the sheath of the atom

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[1] Baltimore meeting, April, 1925.