the fluidity, the resulting values for these three vapors vary less than two-fold.

5—Inasmuch as thermal conductivity plays such an important part in determining the coefficient for any given vapor, H. F. Weber's equation for predicting the thermal conductivity is quoted and its application is illustrated by a table of values.

6—These experiments are being continued for the purpose of determining the effect of other variables which may affect the coefficient of heat transfer between condensing vapor and pipe.

7—From the results of these preliminary experiments the numerical value of the coefficient of heat transfer between (0.49 in. inside diameter) pipe and cooling water is found to vary from 200 to 1500 B. t. u. per hr. per sq. ft. per °F., while the water velocity varies from 0.5 to 7.5 ft. per sec. It is shown that these results check within 10 per cent of the values figured from an equation to be published in the next article of this series.

ACKNOWLEDGMENT

The writers wish to express their appreciation of suggestions offered by various friends, and of the work of Mr. A. Wishnew, who performed the greater part of the experimental work herein described.

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- 1—Walker, Lewis and McAdams, "Chemical Engineering Notes."
- 2—(a) Carl Hering, *Chem. Met. Eng.*, **9** (1911), 652; (b) J. W. Richards, "Metallurgical Calculations," McGraw-Hill Book Co., Inc., 1918; (c) See Note 1; (d) Marks' "Mechanical Engineering Handbook," McGraw-Hill Book Co., Inc., 1916.
- 3—The existence of a stationary liquid or gas film at the point of contact with solid surfaces and its low heat conductivity has long been appreciated. The first mention of a water film was made by Peclet in 1844 ("Traite de la Chaleur-Liege," Chapter 8, p. 131) and since that date many investigators have checked this idea and demonstrated the existence of the film. The most tangible conception of the gas film is represented by Langmuir (*Phys. Rev.*, **34** (1912), 421) although the film concept was not his originally. The explanation in terms of the film concept of the effect of velocity upon heat transfer is definitely stated and the part played by velocity in tearing down this film noted.
- 4—Clement and Garland, Univ. of Ill., Engineering Experiment Station, *Bulletin* **40** (1909).
- 5—Nusselt (*Z. Ver. deut. Ing.*, 1908, 1750) introduced the thermal conductivity of air in his formula for the film coefficient between a gas and a tube.
- 6—Bell (*Proc. Eng. Soc. W. Pa.*, **32** (1916-17), 797) points out that the over-all coefficient of heat transfer in a condenser would be a function of the fluidity of the condensate.
- 7—Orrok (*Trans. Am. Soc. Mech. Eng.*, **32**) introduces a cleanliness coefficient in connection with the over-all coefficient in a condenser, and a correction for the percentage of noncondensable gas in the steam.
- 8—The greater part of these data was taken from the undergraduate thesis of Wishnew (Mass. Inst. Tech., Chemical Engineering Thesis, 1921).
- 9—H. F. Weber, *Berl. akad. Ber.*, 1885, 809, and Exners Reppert, **22** (1886), 116.
- 10—H. F. Weber, *Wied. Ann.*, **48** (1893), 173.

The Decolorizing Action of Bone-Black¹

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This investigation was suggested by Bancroft² in his list of problems in colloid chemistry. There are only three important references bearing on the phase of the subject under discussion: Bancroft³ gives a synoptical account of charcoal before the war, chiefly from an industrial point of view; Knecht⁴ agrees with Patterson, but introduces no new evidence; and Patterson,⁵ who describes at considerable length the extraction from bone-black, and the examination of a nitrogenous material to which is due the decolorizing action of the bone-black. The object of this investigation was to repeat the work of Patterson, which has never been confirmed, and to carry his researches a step further.

EXPERIMENTAL

The procedure finally adopted as most satisfactory is to digest about 15 g. of bone-black with 90 cc. of 15 per cent hydrochloric acid for 20 min., filter through an alundum crucible, and dry residue at about 120° C. The loss is approximately 30 per cent, chiefly mineral matter. Suspend the crucible containing the residue in a small beaker of concentrated sulfuric acid and allow it to remain on a water bath for 2 hrs. Filter through the same crucible and wash with 80 per cent sulfuric acid. The sulfuric acid extract is poured into 0.5 l. of water and the whole put aside for several hours. At the end of that time a brown precipitate will be found to have collected on the bottom of the beaker and may be filtered off through a fine filter. It is almost impossible to wash this precipitate, because it becomes colloidal as soon as the sulfuric acid is removed.

This extracted material is the active decolorizing agent of the bone-black, for a few drops of its concentrated suspension

in water are equal in decolorizing action to several grams of good bone-black.

The next and most important step was to determine whether by the precipitation of this substance on wood charcoal, or other porous material, an active charcoal could be produced. The precipitation was carried out by mixing wood charcoal in the sulfuric acid suspension of the extract, adding water, and filtering. The material thus prepared was found to be about twice as active as the original bone-black, but this is easily explained by the fact that the extract from about 15 g. of bone-black was suspended on about 6 g. of wood charcoal.

DISCUSSION

It may be concluded that the decolorizing action of bone-black is entirely due to a mixture of nitrogenous decomposition products of bone cartilage, etc., which are carried by the charcoal proper. These compounds are described by Patterson, and his results have been confirmed by the author. The compounds are insoluble in ethyl alcohol, ether, benzene, and chloroform, soluble in ammonium hydroxide, concentrated sulfuric acid, and concentrated hydrochloric acid, from the latter two of which they are precipitated by water. They have the empirical formula $C_{25}H_{20}N_4O_6$.

The real nature of these bodies and the mechanism of the reaction, however, still remain a mystery.

School for Water Plant Operators

During the week of January 16, 1922, a course on "Wholesome Water Production" is to be given in Dallas, Texas, under the auspices of the city Health Department, with the cooperation of the Texas State Board of Health and the Texas Water Works Association. This is the fourth short course offered free of charge to water plant operators. The work is not highly technical, but will cover comprehensive and practical points in the purification of water.

¹ Presented before the Division of Physical and Inorganic Chemistry at the 62nd Meeting of the American Chemical Society, New York, N. Y., September 6 to 10, 1921.

² *This Journal*, **13** (1921), 155.

³ *J. Phys. Chem.*, **24** (1920), 201.

⁴ *J. Soc. Chem. Ind.*, **28** (1909), 700.

⁵ *Ibid.*, **22** (1903), 608.