

COLLOIDAL HYDROUS BERYLLIUM OXIDE*

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Ever since 1861, when Thomas Graham¹ first drew a distinction between the two classes of solutes which he termed crystalloids and colloids the scope of colloid chemistry has increased until today it is associated with practically every branch of applied science. Consequently the definition of colloids and colloidal systems has become increasingly complicated. It is impossible to formulate any direct statement which will include even a few of the common colloids, such as milk, rubber, gelatin, clay, concrete, varnishes and cellulose esters. Today it is more or less arbitrarily considered that particles with diameters between 1 *mu* and 100 *mu* (10^{-7} and 10^{-5} cm.) are colloids. It must be remembered that these limits are not definite.

There has been much controversy concerning the stability factors of various colloidal systems, notably colloidal hydrous ferric oxide and the announcement by Sorum² of his so-called "chloride-free" ferric oxide sols. Therefore the author, under the direction of Professor Krauskopf, began the study of the preparation and properties of hydrous beryllium oxide sols in the hope of proving or disproving some of the stability theories.

Hydrous beryllium oxide sols³ were made by heating syrupy beryllium chloride in large casseroles, using a small flame of an adjustable burner. When the material was nearly dry, that is, when only a few syrupy bubbles were forming, the flame was turned up to full height. When the redness of the flame could be seen through the bottom of the casserole, one liter of boiling water was added, the sol boiled for a minute and afterward allowed to cool in the air. If the water was not added at the proper time no sol resulted which showed that the chloride had to be quickly decomposed in order to produce the "oxychloride" apparently necessary for the preparation of a stable sol. Lately the writer has prepared sols which were about seven times as concentrated as those formerly produced. About eight grams of syrupy beryllium chloride were placed in a 150 cc. quartz evapor-

²³Jour. Am. Chem. Soc. 52, 36, 132, 553, 557 (1930).

²⁴Jour. Am. Chem. Soc. 52, 1443, 2347 (1930); 53, 1283 (1931).

²⁵Compt. Rend. 192, 1220, 1372 (1931).

*Contribution from the Chemical Laboratory of the University of Illinois.

¹Graham, Trans. Roy. Soc. 51, 183 (1861).

²Sorum, J. Am. Chem. Soc. 50, 1263 (1928).

³Madson and Krauskopf, J. Chem. Edu. 6, 334 (1929); J. Phys. Chem. 35, 3237 (1931).

ating dish and heated with a small flame until the material was nearly dry. Then the dish and contents were quickly heated to redness and immediately plunged into a liter of boiling water. The sols thus formed were treated as before. After purification they were stable for only a few weeks.

The sols were purified by dialysis at about 75° C, for 12 to 168 hours in a Sorum dialyzer⁴ using collodion membranes. The hydrogen-ion concentrations of the sols were measured by means of a glass electrode⁵. The pH values of the sols increased rapidly during the first few hours of dialysis due to the removal of free acid which had been formed by the hydrolysis of the beryllium chloride. The hydrogen-ion concentration decreased to a pH of 7.0 at fifty hours and then remained constant even though the sols were dialyzed for a week. This indicated that the sols were very stable.

Hydrous beryllium oxide sols belong to the class of sols known as lyophobic or suspensoid colloidal systems. Flocculation values give a relative indication of the stability of the various sols, especially if the values are determined under conditions for comparable work in the coagulation of colloids by electrolytes as outlined by Murray⁶. The flocculation values have been determined for sixteen inorganic electrolytes using purified beryllium oxide sols. Since the beryllium oxide sols were prepared from beryllium chloride it might be expected that they were stabilized by an excess of the salts. The amount of chloride present in the sols continued to decrease during more than one hundred hours of dialysis while the flocculation values were constant after twelve hours of dialysis. Therefore it seemed apparent that the sols were not the result of simple hydrolysis nor was the stability due only to adsorbed beryllium chloride. The stability of the systems has been attributed to: (1) some minute amount of beryllium chloride or oxychloride, (2) some minute amount of basic beryllium acetate, (3) the character of the hydrolysis, (4) the slight hydration of the oxide, and (5) the amphoteric nature of the oxide.

The size of colloidal hydrous beryllium oxide particles has been determined by the direct particle count method⁷ using an ultra-microscope. Assuming that the particles were cubes, the average cube edge was 153.5 *mu*; assuming the particles to be spherical, the average radius of the particles was 95.3 *mu*. This large particle size together with the slight hydration of the oxide may explain why only dilute sols of beryllium oxide have been prepared. Apparently if concentrated stable sols of hydrous beryllium oxide are to be prepared, conditions must be developed which will produce smaller particles, increase the hydration, or both. The particle sizes of the more concentrated sols previously mentioned have not been determined but it is expected that they would be much smaller in size than those formerly prepared.

⁴ Sorum, J. Am. Chem. Soc. 50, 1263 (1928).

⁵ Hazel and Sorum, J. Am. Chem. Soc. 53, 49 (1931).

⁶ Murray, Chem. News 123, 277 (1921).

⁷ Madson, J. Phys. Chem. 36, 855 (1932).