THE IMPORTANCE OF SODIUM SILICATE SOLUTIONS AND THE POSSIBILITY OF THEIR MANUFACTURE FROM LOCALLY AVAILABLE RAW MATERIALS.

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Water glass is an important article of commerce. It is generally obtained as a 30 to 40% solution of sodium silicates having a specific gravity of 1·5 to 1·8. Its earliest application was in the soap industry, where it was largely used as fillers. It has also some detergent action of its own. Soluble silicates are extensively used in industry in the manufacture of paper, as adhesives in the manufacture of fibre containers and laminated wall board,[1] in the textile industry, in the manufacture of vitreous enamels[2] and ceramic glazes, in hardening concrete and for numerous other purposes.

Apart from direct applications, the soluble sodium silicate serves as the starting material for preparing a number of insoluble heavy metal silicates, which find applications in several technical processes. The addition of different salts to silicate solutions form precipitates in the wet way.[3] The exact nature of these insoluble silicates is not clear, as there is reason to believe that colloidal silica is simultaneously formed along with the insoluble silicate.[4] However, such precipitated silicates are useful for a number of technical processes. A precipitated lead silicate is used as compounding material for rubber.[5] The well-known sodium alumino-silicates are the most effective base exchange materials and are extensively used for water softening. Lately they are being used for the disposal of sewage.[6]

Sodium silicate solutions have some characteristic physical properties which make them suitable for certain industrial purposes. It appears that the silicate solution preferentially wets a solid surface. Because of this property silicate solution finds use in reclaiming oily cotton waste: in aqueous solution it sets free the oily drops and the cotton waste is rendered fit for further use. It is because of this preferential wetting of solid surfaces that silicate solutions have been used to accelerate the much desired separation between solid paraffin wax and liquid mineral oil.[7] Another characteristic of silicate solutions is that they possess good spreading properties. A comparison of the spreading properties of industrial alkalies by observing their spreading on glass surface has shown that sodium meta-silicate travels the farthest.[8] Because of this behaviour sodium meta-silicate solutions are preferred for washing glass containers used for storing milk. It has been shown that even a very small residue of oily matter in a milk bottle is a fruitful medium for harbouring bacteria.[9] Sodium meta-silicate solutions remove the last

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traces of grease and their use is more effective than that of caustic soda solutions of the same sodium oxide concentration.

Sodium silicates also act as inhibitors for certain chemical changes. This property is generally associated with the nature and type of film formed from sodium silicate solutions.[10] Thus the addition of a small amount of sodium silicate at once stops the action of warm sodium carbonate solution on a piece of aluminium foil[11] though in the absence of the silicate the metal dissolves completely with the evolution of hydrogen. The phenomenon is specifically characteristic of silicate solutions, and is connected with the formation of a protective film. Connected with this property is the use of silicate solutions in protecting aluminium tubes used for keeping alkaline cosmetics.[12] At low concentrations silica protects from corrosion pipe systems carrying potable and industrial waters. Waste of oxygen during bleaching is prevented in peroxide baths by means of silicate solution.[13] In these respects the silicate solutions act not by virtue of their alkalinity but on account of the action of silica and the nature of the film it forms.

Connected with their power of altering the interfacial tensions is the use of sodium silicate solutions as dispersion or deflocculating agents. A sufficiently stiff dough of clay can be made quite mobile by the addition of a small amount of silicate solution.[14] Advantage is taken of this property in settling out foreign minerals from clay suspensions and in freeing zinc ores from silicious constituents.[15] The ceramic industry depends a great deal on the supply of sodium silicates. Ceramic wares are decorated with glaze in the composition of which the silicate solution serves the double purpose of supplying its share of sodium oxide and silica, and of keeping the other ingredients in position till the sintering temperature is reached.[16] A plentiful supply of sodium silicates will bring its use more extensively in vogue in the making of artificial stones for flooring. By forcing silicate solutions underground loose earth has been consolidated to fit it for foundation.[17] There is no doubt that if the proper conditions be worked out sodium silicate solutions will be a valuable material for grouting structures damaged during earthquakes. Numerous other applications could be cited, but what has been stated in the foregoing paras. shows clearly that if a plentiful supply of sodium silicate be available very important uses could be made of it.

Certain amounts of sodium silicates are manufactured in India. Sodium silicates manufactured by the Imperial Chemical Industries (India), Ltd., samples of which were supplied to us by the factories from London, contain different proportions of sodium and silica varying from the composition of the meta-silicate to that containing four moles of silica per mole of sodium carbonate.[18] The demand for sodium silicates is large in view of their extensive use in soap, paper, textile, and other industries. It was, therefore, considered worth while to investigate the possibilities of manufacturing sodium silicates from materials easily available in Bihar.

Commercial sodium silicates can be prepared mainly by two processes. In the dry process silicious sand is mixed with sodium carbonate and heated to 1000–1100°C. for about 4-5 hours. The molten mass is cooled to solidify, powdered and extracted with water under pressure. A reducing agent like carbon helps the process. In the wet process alkaline lye is heated with infusorial earths in an autoclave. Extraction by sodium carbonate was attempted by this process. Infusorial earths were treated with a concentrated sodium carbonate solution in an autoclave under 100 pounds pressure. Only a fraction of the silicate had gone into solution. Sodium carbonate cannot be an effective substitute for caustic alkali in this method. The dry process is thus more suitable for adoption.

As a source of silica sandstone appears to be the best. River sand is not suitable for the purpose. The sand from the bank of the Sone river contains too much iron and other impurities and when fused with sodium carbonate gives an insoluble glass. The Ganges sand near Patna contains too much aluminium and carbonate. Sandstone of a suitable quality and silica content is available in Sahabad District, and in Manbhum.[19]

As the source of sodium carbonate the utilisation of the large supply of alkali earth (Sajji) available in North Bihar is intended. Extensive deposits are available in Bihar and in many districts of the United Provinces. The United Provinces deposits were examined by Watson and Mukerji[20] who have estimated that four million tons of alkali might be made available per year from this source.

The economic recovery of alkali from Sajji is a problem by itself. Some work is in progress in this laboratory on the possibility of working the Sajji so that it might be an alternative source of sodium carbonate in addition to the soda ash. The deposits available in Bihar have been analysed. They contain about $4\frac{1}{2}\%$ of soluble matter and about $2\frac{1}{2}\%$ of sodium carbonate. The easiest method of extraction is to collect the sodium carbonate as an efflorescent deposit from the surface of a moistened stack. The question of developing the method into an organised indigenous process is well worth a careful examination.

Some preliminary trials have given quite satisfactory results. The question of a suitable furnace for the purpose is important as the economic production of the material depends primarily on the efficiency of the furnace.

Of the many commercially important substances that are obtained from sodium silicates, silica gel and artificial zeolites or permutites are of special interest. The silica gel has been extensively used in America and England in the last decade and is finding more and more new applications every year. Its use in Indian industries has been rather meagre. In view, however, of its extensive and varied applications, attempts were made to produce a sample of silica gel in this laboratory. A specimen has been obtained which has practically the same adsorptive capacities as the commercial products.

The silica gel of commerce is a hard glassy material, which looks like large grains of clear quartz sand. These grains are full of fine capillary pores and because of their unique structure are extremely capillary active.[21] It has been estimated that one cubic inch of gel has an internal surface of over an acre. Silica gels find use wherever a solid with a large adsorptive power is desired. They are used as dehydrating agents where large quantities of gases have to be purified and dried as, for example, in the production of solid carbon dioxide. In the control of humidity in air-conditioning plants, in refrigeration, in solvent recovery processes, in the refining of petroleum and as a carrier for many catalysts, silica gels find extensive applications. A unique advantage attaching to the use of silica gel is the ease with which the activity of the gel is regenerated.

The gel can be prepared from sodium silicate by neutralisation by an acid. Prepared in the ordinary way, the mass on drying crumbles to a light opaque powder, which has low adsorptive capacity. By proper control of pH [22] of the solutions after admixture and of concentrations a gel of the desired consistency could be obtained. If dried under controlled conditions, it is obtained in the form of granular glass-like transparent particles. A sample of gel prepared in this laboratory was activated by drawing a current of carbon dioxide free dry air through the heated gel and its adsorptive power was studied by determining the quantity of sulphur dioxide adsorbed. The amount of adsorption compared quite favourably with the data given by Patrick and McGavack.

Another purpose for which sodium silicate solutions were used in this laboratory was in the preparation of a sample of permutite. Sodium permutite used to be prepared by fusion of a mixture of sodium carbonate, alumina and silica. It is now manufactured from sodium silicate and sodium aluminate and obtained in the form of coarse granules. Apart from the use of permutites for the softening of drinking and industrial water, they can be used with great advantage to a problem of great interest to Indian sugar industry. Till the manufacture of power alcohol from molasses develops to its full extent, a large quantity of molasses will still remain unworked. The use of molasses for cattle food has often been suggested but the practical adoption of the method has not been possible so far because of the unsuitability of the untreated molasses for the purpose. Molasses contain about 4 to 5% potash. If the potash could be removed the molasses would serve as cattle food without any injurious effects. The potash could be recovered from the molasses by base exchange with sodium by running a solution over a layer of permutite.

It will thus be seen that on the practical side sodium silicate solutions open up a field vast in extent and fertile in possibilities. On the theoretical side also, its unsolved problems are numerous and fascinating. The variety and scope of enquiries in which soluble silicates are concerned depend partly upon the range of properties inherent in the material and partly upon the diversity of industrial processes in which these characteristics have found use.

There seems reason to hope that the manufacture of sodium silicates will yield fruit from which Indian industries may derive some benefit.

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