# *Adsorption of Congo Red and Fuchsine Base by Hydrous Beryllium Oxide Aged for Different Periods*

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It is well known that hydrous oxides like those of iron, chromium and aluminum are well known to possess a high adsorptive capacity. Mokuskin and Esin, White, Gorden and Porter studied the association of several dyes[1] by these hydrous oxides. Weiser[2] and Sen[3] also made a comparative study of adsorption capacity of the hydrous oxides of chromium, aluminum and iron for different inorganic ions. They are of the opinion that the adsorption process depends on valency of ion, pH of the medium, chemical activity and reactivity of the adsorbent, etc. The aging of hydrated oxides of aluminum, iron, nickel and cobalt has been studied by Lottermoser[4] who performed sedimentation experiments and X-ray studies, and ascribed the changes to be due to (a) the rate of growth of the secondary particles and (b) the rate of orientation of the structural units of the secondary particles. Similar observations were also made by Tewari, Dey and Ghosh[5] who discussed the mechanism of aging of the hydrous oxides of iron, aluminum and chromium.

It has been shown from these laboratories that aging of hydrous oxide has a marked effect on the role of adsorption. But, it can clearly be mentioned here that very little work appears to have been done on the subject, specially on the adsorption of dyes and ions on hydrous beryllium oxide of different characters, aged for different lengths of periods. Hence, in this paper the adsorption of Congo red and fuchsine base by hydrous beryllium oxide aged for different lengths of periods, have been studied and the results are represented in the following tables.

## Experimental

Three samples of hydrous beryllium oxide were prepared by adding different quantities of 0.2 N sodium hydroxide solution to a fixed volume of 0.2 N beryllium sulfate solution as follows:

Sample A: precipitated with equivalent sodium hydroxide

Sample B: precipitated with 10% deficient sodium hydroxide

Sample C: precipitated with 10% excess sodium hydroxide.

These samples were then washed thoroughly with distilled water by decantation and allowed to age progressively by standing as a suspension at 30°C.

**Adsorption Experiment.**—In several 25 ml. jena flasks, containing 5 ml. of 0.001 g. of beryllium oxide and 5 ml. of (0.55 M : 0.1 M) boric acid-borax buffer solution of pH 8.5, varying amounts of the prepared dye solutions of known concentrations were added and the volume of the solutions was raised upto the mark in each case. The dyes used for adsorption were all B. D. H. AnalaR grade and purity was 98% and above. Each sample of the aged hydrous oxid was then kept in contact with the dye solution for 24 hr. at 30°C to attain equilibrium. An aliquot portion was then centrifuged and a measured volume was diluted as required for the estimation.

The residual concentration of the dye solution in the supernatant liquid was estimated by using Klett-Summerson photo-electric colorimeter. Filter number 54 (transmission 520~580 m$\mu$) was found to be suitable for the dye. Before using colorimeter the applicability of Beer's law was tested in the range of pH maintained by the buffer. It was observed that Beer's law only holds good in low concentrations of the dye solution as far as $1\times10^{-6}$. Therefore, for the purpose of estimation, the dye solution present in the supernatant liquid was diluted to the requisite concentration, where Beer's law holds good, for its estimation.

The concentration of the residual dye solution was calculated by comparing with that of the same concentration, so that:

$$\text{Concn. of unknown dye soln.} = \frac{\left(\begin{array}{c}\text{Colorimetric reading of}\\ \text{unknown dye solution}\end{array}\right)\times\left(\begin{array}{c}\text{Concn. of}\\ \text{standard dye solution}\end{array}\right)}{\text{Colorimetric reading of standard dye solution}}$$

In the following tables the results are recorded in gram moles of the dye adsorbed by the different samples, containing the same hydrous oxide in the system, where $x$ is the amount of adsorbed dye in gram mole, and $m$ is the amount of adsorbent in gram.

## Discussions

The results for the adsorption of Congo red and fuchsine base by three samples of hydrous

1) Marker and Gorden, *Ind. Eng. Chem.*, **16**, 1186 (1924); C. E. White and Gorden, *J. Phys. Chem.*, **31**, 1764 (1927).
2) H. B. Weiser, ibid., **26**, 401 (1922).
3) K. C. Sen, ibid., **31**, 1840 (1927).
4) A. Lottermoser, *Kolloid. Beih.*, **38**, 1 (1933).
5) S. N. Tewari, A. K. Dey and S. Ghosh, *Z. anorg. u. allgem. Chem.*, **271**, 150 (1952).

TABLE I. ADSORPTION OF CONGO RED BY HYDROUS BERYLLIUM OXIDE AT 30°C

| Age of the hydrous oxide | Initial concn. $\times 10^6$ mol. | Amount adsorbed $x/m \times 10^3$ Sample A | Sample B | Sample C |
|---|---|---|---|---|
| 5 days | 75.2 | 35.36 | 47.00 | 18.97 |
| | 56.4 | 24.82 | 41.96 | 15.23 |
| | 37.6 | 19.50 | 28.60 | 10.15 |
| | 18.8 | 16.92 | 18.61 | 4.51 |
| 10 days | 75.2 | 20.10 | 24.80 | 4.70 |
| | 56.4 | 16.30 | 22.55 | 4.51 |
| | 37.6 | 16.92 | 20.90 | 3.94 |
| | 18.8 | 2.28 | 17.57 | 3.76 |
| 20 days | 75.2 | 14.30 | — | 2.26 |
| | 56.4 | 13.10 | | 2.82 |
| | 37.6 | 10.15 | | 1.68 |
| | 18.8 | 10.04 | | 0.75 |
| 30 days | 75.2 | 11.30 | 19.70 | 1.89 |
| | 56.4 | 8.27 | 19.00 | 2.06 |
| | 37.6 | 7.30 | 17.80 | 2.00 |
| | 18.8 | 7.80 | 17.87 | 0.81 |

TABLE II. ADSORPTION OF FUCHSINE BASE BY HYDROUS BERLLIUM OXIDE AT 30°C

| Age of the hydrous oxide | Initial concn. $\times 10^7$ mol. | Amount adsorbed $x/m \times 10^4$ Sample A | Sample B | Sample C |
|---|---|---|---|---|
| 5 days | 34.4 | 20.29 | 7.57 | 23.50 |
| | 25.8 | 12.92 | 5.94 | 17.80 |
| | 17.2 | 8.70 | 4.13 | 11.53 |
| | 8.6 | 4.30 | 2.07 | 5.85 |
| 10 days | 34.4 | 12.40 | 5.16 | 21.70 |
| | 25.8 | 8.55 | 3.56 | 16.27 |
| | 17.2 | 6.36 | 1.94 | 10.84 |
| | 8.6 | 2.95 | 1.64 | 5.35 |
| 20 days | 34.4 | 8.94 | 4.47 | 12.50 |
| | 25.8 | 4.81 | 2.10 | 15.70 |
| | 17.2 | 3.27 | 1.70 | 10.33 |
| | 8.6 | 2.15 | 1.30 | 4.87 |
| 30 days | 34.4 | 4.76 | 3.79 | 20.64 |
| | 25.8 | 3.86 | 1.90 | 14.45 |
| | 17.2 | 2.41 | 0.80 | 9.46 |
| | 8.6 | 1.12 | 0.60 | 4.64 |

beryllium oxide are given in Tables I and II, and the amounts adsorbed have been plotted (not shown here) against the end concentrations of the adsorbate. It would be seen that most of the curves are convex to the concentration axis as in the case of Freundlich's adsorption isotherm and, therefore, similar to those obtained for the adsorption of bromine (at 79°C) or iodine by a silica gel.

The adsorption data for different dye-stuffs reveal that the three samples possess different adsorptive capacities. Thus, for the adsorption of Congo red it is maximum for the sample B but in the case of fuchsine base it is maximum for sample C, obtained by adding excess of an alkali for precipitation. These results are quite in good agreement with the view of Ghosh and co-workers. According to them the hydrous oxides, specially of amphoteric nature, should develop a large adsorptive capacity for anions, when precipitated with deficient quantity of an alkali and the adsoption of cation should be more marked for the precipitate obtained by the addition of an excess of an alkali.

It will be further seen that the same sample of hydrous beryllium oxide, aged for different period, have decreasing adsorptive capacity for dye-stuffs. The decrease in the adsorptive capacity with aging, may be due to the following two reasons.

(i) Hydrous beryllium oxide when freshly prepared, shows a high adsorptive capacity for ions and dye-stuffs from the solution due to the size of the particles of the hydrous oxide, which on aging tend to grow larger in size, causing a diminution in the total surface area of the particles and consequently the adsorptive capacity is decreased.

(ii) Adsorptive capacity also decreases, with aging, due to the formation of an inert substance, produced by the internal neutralization of the acidic and basic character of the amphoteric hydroxide, as given below:

$$Be(OH)_2 \rightleftarrows Be(OH)^+ + OH^-$$

$$Be(OH)_2 \rightleftarrows Be\cdot O\cdot (OH)^- + H^+$$

$$Be\cdot O\cdot (OH)^- \cdot Be(OH)^+ \rightarrow 2BeO + H_2O$$

$$H^+ + OH^- \rightarrow H_2O$$

**Summary**

Three samples of hydrous beryllium oxide, of different character, were prepared by adding different quantities of an alkali to a fixed volume of beryllium sulfate solution for precipitation. These samples were allowed to age progressively and there adsorptive capacities for dye-stuffs were studied. It has been found that the adsorptive capacity of the samples decreases with aging of the hydroxide and the adsorption data dye-stuffs reveal that the three samples possess different adsorptive capacities.

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