

Solubilities of Sodium Carbonate and Sodium Bicarbonate in Acetone-Water and Methanol-Water Mixtures

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Solubility data have been obtained for the NaHCO_3 -methanol- H_2O , NaHCO_3 -acetone- H_2O , Na_2CO_3 -methanol- H_2O , and Na_2CO_3 -acetone- H_2O systems, and plotted on triangular ordinates. Both Na_2CO_3 and NaHCO_3 are more soluble in methanol- H_2O than in acetone- H_2O . NaHCO_3 is slightly more soluble in both systems than Na_2CO_3 . The solubility of NaHCO_3 decreases with temperature in methanol- H_2O .

THE solubilities of sodium carbonate and sodium bicarbonate were obtained for water-acetone and water-methanol mixtures at 22° and 50° C., to determine if this would be a means of removing these salts from aqueous solutions. Both salts are reported as insoluble in 95% ethanol (3), but relatively soluble in water, particularly sodium carbonate (3). Bell (1) studied the system acetone-sodium carbonate-water at 25° C. His results were in agreement with those presented here; however, he used a maximum of only 30% acetone, which covers only about a third of the range covered here. A search of the literature did not reveal any studies similar to the systems reported in this paper.

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Acetone and methanol would be advantageous as desalting solvents on a commercial scale because of their low cost and ease of separation from water.

EXPERIMENTAL PROCEDURES

Apparatus. Samples were equilibrated in a shaking, constant temperature bath, a Model 2156-1 temperature-controlled water bath shaker, manufactured by Research Specialties Co., Richmond, Calif. Mineral oil was used as the bath liquid, and the temperature maintained at $\pm 0.5^\circ\text{C}$.

Reagents. Sodium carbonate, Mallinckrodt analytical reagent grade. Acetone and methanol, Merck reagent grade.

Sample Preparation and Sampling. An excess of either sodium carbonate or sodium bicarbonate was added to the water-acetone and water-methanol solutions. The quantities of water, acetone, and methanol used were carefully

Table I. Solubility of Sodium Bicarbonate and Sodium Carbonate in Water-Methanol

Solution Composition, Wt. %		
Salt	H ₂ O	Methanol
NaHCO₃, 22° C.		
10.02	89.98	...
8.33	81.96	9.71
7.18	77.48	15.34
6.80	75.28	17.92
5.56	67.65	26.79
4.77	58.28	36.95
4.13	53.50	42.37
2.75	28.81	68.44
2.75	19.61	77.64
3.07	14.81	82.12
2.13	...	97.87
NaHCO₃, 50° C.		
13.17	86.83	...
10.74	81.74	7.53
8.54	75.48	15.97
6.98	69.64	23.38
3.42	49.27	47.31
2.17	35.95	61.88
1.49	26.43	72.08
0.97	10.65	88.38
0.92	...	99.08
Na₂CO₃, 22° C.		
21.96	78.04	...
13.80	77.37	8.83
8.10	71.52	20.28
6.50	63.35	30.15
4.33	52.18	43.49
1.88	37.97	60.15
1.75	29.11	69.14
0.20	18.95	80.85
0.19	9.97	89.83
0.27	...	99.73

Table II. Solubility of Sodium Bicarbonate and Sodium Carbonate in Water-Acetone

Solution Composition, Wt. %		
Salt	H ₂ O	Acetone
NaHCO₃, 22° C.		
10.02	89.98	...
9.09	84.25	6.66
6.46	78.08	15.46
4.20	68.62	27.18
1.57	54.93	43.50
0.37	42.89	56.74
0.60	29.44	69.96
0.42	20.08	79.50
0.02	9.99	89.98
0.02	...	99.98
NaHCO₃, 50° C.		
13.17	86.83	...
10.31	81.72	7.97
5.57	68.27	26.16
0.94	35.00	64.06
0.29	25.53	74.18
0.24	...	99.76
Na₂CO₃, 22° C.		
21.96	78.04	...
12.89	80.92	6.18
2.86	72.65	24.49
0.73	59.19	40.07
0.98	55.25	43.77
0.96	43.67	55.37
0.67	38.44	60.89
0.63	29.43	69.94
0.20	6.30	93.50
0.02	...	99.98

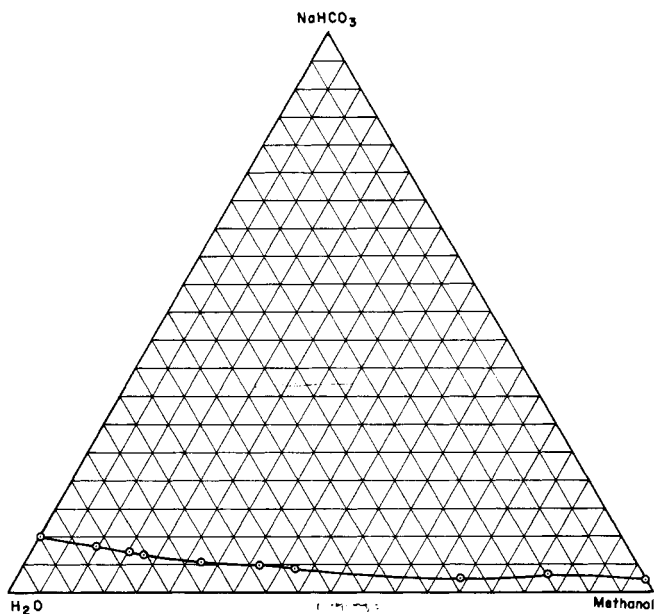


Figure 1. $\text{NaHCO}_3\text{-H}_2\text{O}$ -methanol system, 22°C .

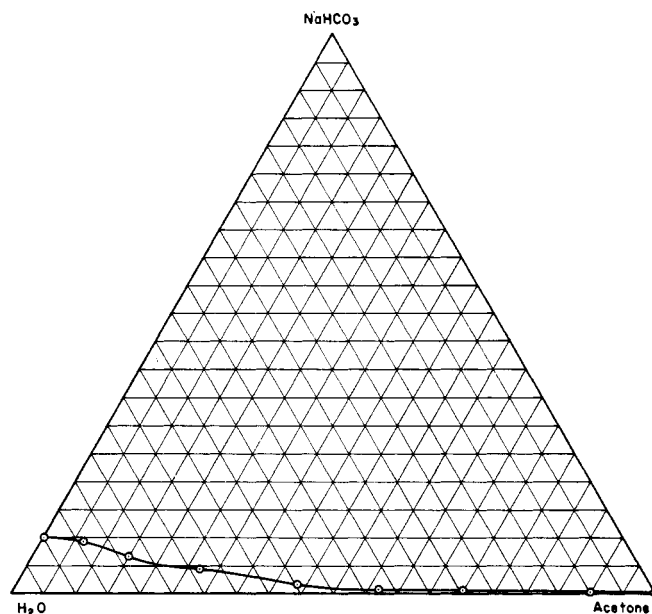


Figure 3. $\text{NaHCO}_3\text{-H}_2\text{O}$ -acetone system, 22°C .

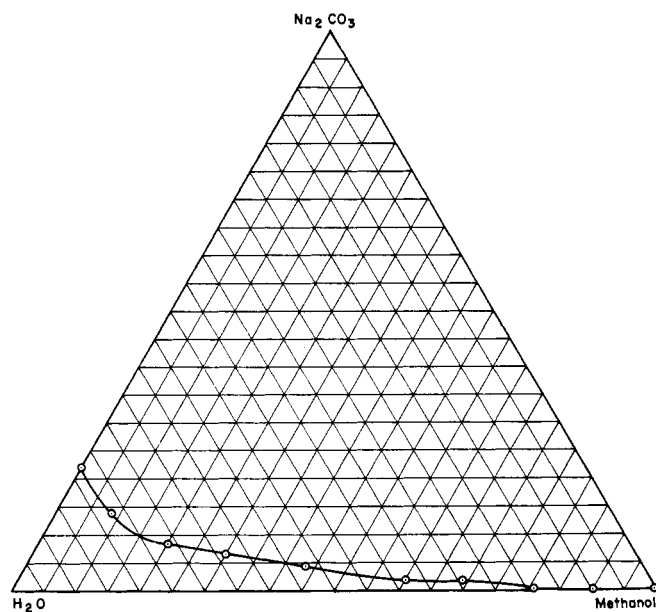


Figure 2. $\text{Na}_2\text{CO}_3\text{-H}_2\text{O}$ -methanol system, 22°C .

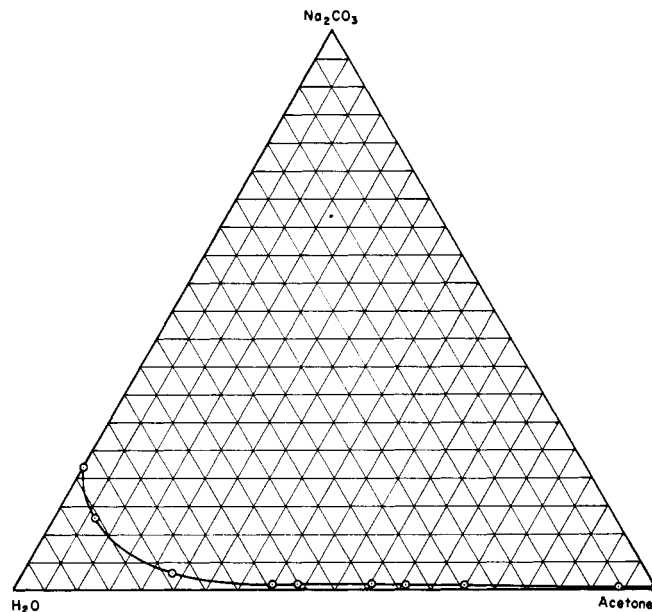


Figure 4. $\text{Na}_2\text{CO}_3\text{-H}_2\text{O}$ -acetone system, 22°C .

weighed prior to the addition of the salt. Aliquots were taken for analysis every day after 5 days until equilibrium was reached.

Chemical Analyses. The percentages of water, acetone, and methanol were obtained from the weights of the components used to prepare the solutions prior to addition of the carbonate or bicarbonate.

The sodium carbonate was determined volumetrically by titrating an aliquot of the sample with standard hydrochloric acid to the phenolphthalein end point (2).

Sodium bicarbonate was determined by a potentiometric titration with standard hydrochloric acid as the titrant. The electrodes used were glass and saturated calomel. A plot of pH against the volume of hydrochloric acid was used to obtain the end point.

RESULTS

Table I gives the data obtained for the solubility of sodium carbonate and sodium bicarbonate in water-methanol mixtures. These data are also plotted on triangular coordinates in Figures 1 and 2. The solubility of sodium bicarbonate decreases slightly with increasing temperature.

Initially, sodium carbonate is more soluble than the bicarbonate, but the carbonate solubility drops rapidly with increasing quantities of methanol and becomes less soluble than the bicarbonate.

The solubilities of sodium carbonate and bicarbonate in water-acetone mixtures are shown in Table II, and Figures 3 and 4. Again, the sodium carbonate solubility decreases rapidly as the amount of water in the solution decreases.

Both sodium carbonate and bicarbonate are less soluble in water-acetone than in water-methanol. The solubility of sodium bicarbonate does not appear to be temperature-sensitive in water-acetone over the range covered.

LITERATURE CITED

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