

Research Article

Phenomenon of Motion of Salt along the Walls of the Container

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Abstract

In this article we report the phenomenon of motion of salt along the walls of the container containing the salt solution. When a table salt solution is left exposed to the atmosphere, the water naturally evaporates in several days. It is observed that as the water evaporates a thin layer of salt starts to form on the inner walls of the glass. This layer, from the inception, tends to form above the original level of the solution. Surprisingly, the layer spreads to the top of the glass and continues on to the outer wall of the glass. This surprising behaviour of the salt motion is described in detail along with the photographs.

Keywords: Salt Solution, Sodium Chloride, Motion of Salt.

1. Introduction

Aqueous solutions of sodium chloride are of considerable interest as systems that can model ocean water and the physiological conditions in living systems. These have been well studied historically over the past century (Djamali and Cobble, 2009), (Hargreaves, *et al*, 2010), (Ho, *et al*, 1994), (Nielsen, *et al*, 1952), (Noyes and Falk, 1912), (Ozbek and Phillips, 1980), (Ramires, *et al*, 1994), (Smith Jr. and Dismukes, 1964), (Truesdell, 1968), (Uchida and Matsuoka, 2004), (Wadsworth, 2012), (Winsor and Cole, 1985), (Khan, 2007a). Examples include investigations of an array of thermodynamic properties via a variety of experimental techniques.

It is a common observation for aqueous solutions that the water evaporates leaving behind the substances dissolved in it. One would expect that when a glass containing a mixture of water and table salt is exposed to the atmosphere, the water would evaporate leaving the salt at the bottom of the glass and some on the inner walls of the glass up to the highest point of the solution. But contrary to this expectation, we have observed that as the water evaporates, a layer of salt tends to form *above* the highest point of the solution. It is further observed that this layer from the inception tends to form above the original level of the solution.

Surprisingly, the layer spreads vertically along the inner walls of the glass to the top of the glass and continues on to the outer wall of the glass. This surprising behaviour of the salt motion, which we have termed motion of salt, is described in detail.

2. Experimental Section

2.1 Materials

Iodized salt with a minimum percentage by mass of 99.9% sodium chloride was used. It contained potassium iodide (0.01% by mass) and yellow prussiate of soda (0.0004% by mass). Mineral water contained the following ions, in ppm in parentheses: Calcium (5.2); magnesium (3.0); sodium (11.5); potassium (0.8), bicarbonate (18.4); sulfate (5.0); chloride (14.0) and nitrate (1.8), such that the total dissolved solids were 120ppm.

2.2 Methods

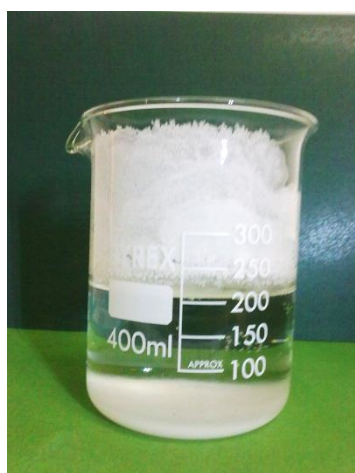
The experimental setup for the observations is straightforward. Throughout our study, we have used iodized table salt and potable mineral water. In order to make detailed observations, we used a variety of geometries and varying concentrations. The geometries studied included common measuring jars (right circular cylinders, found in any chemistry laboratory); tumblers (frustums of cones) and a spherical container (sphere with the cap removed).

For the data reported in the following section in Figures 1 and 2, a 400mL beaker (7.5cm in internal diameter) made out of heat-resistant borosilicate glass was used. Iodized salt was heated at 100°C in an oven repeatedly to achieve constant mass. Subsequently, 1.00L of 0.100M stock solution was prepared (assuming the molar mass of sodium chloride). We note that any trace quantities of residual water of crystallization will only minimally affect the concentration.

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a



b



c

Fig. 1 The photographs of solutions that exhibit motion of salt. The photographs represent the following (a) start of the experiment; (b) motion of salt (c) climb down.

The beaker was filled up to the 275mL mark at ambient temperature (25°C to 30°C), leaving a gap of 3.3cm from the rim of the beaker. The solution was left on a table inside a room to evaporate naturally. This was for a duration ranging from several days up to two months.

The detailed observations were carried out in the coastal city of Salalah (Latitude: 16°56'N and Longitude: 53°59'E) in southern Oman. The average humidity was around 20%. The average temperature varied from 25°C to 30°C. The containers were observed and the data recorded at intervals of several hours.

3. Results and Discussion

This phenomenon was accidentally observed while conducting experiments on crystal growth. The results are depicted pictorially in Figure 1 for a 0.10M solution of salt, observed over a period of 60days. The *motion of salt* was observed within 72hours, above the *initial* level of the solution. The salt motion was found to increase progressively, reach the rim, and eventually occur on the outer wall. We have termed this phenomenon as *climb down*.

The observations are also shown graphically. The change in the level of water is shown in Figure 2a, and occurs monotonically. The motion of salt is shown in Figure 2b, with the climb down depicted by open circles.

All the measurements reported in Figure 2 were made in terms of distances from the rim. Thicknesses were not measured. There is a thickening of the salt on the walls (both inner and outer walls) of the beaker; thus, the heights measured on days 5-12 do not show a monotonic change in Figure 2b. We note that once the salt has climbed the walls of the beaker it does not get back into the diminishing quantity of water.

In additional experiments, whose quantitative data are not reported here for brevity, a set of observations was made for a variety of geometries. The geometries included common measuring jars (right circular cylinders); domestic glasses (tumblers, which are frustums of cones); beakers (right circular cylinders) a spherical container (sphere with the cap removed). It was observed that the said *motion of salt* occurs in all the above geometries and for a range of sizes with the same geometry. It appears as if the evaporating water lifts the salt! This leads to the intriguing question: Do water molecules carry the salt molecules with them?

In subsequent experiments, we have systematically varied the concentration of the salt over the range of 0.050 to 1.0M. The data indicate that in solutions with higher concentrations, the growth of the salt layer is faster. Additional considerations, the ambient pressure, humidity, isotope effects, and the presence of acoustic and electric/magnetic fields are of interest and will be investigated in future.

Additionally, a microscopic and crystallographic study of the salt flakes constituting the growing salt layer(s) would be of interest. A study of the thickness of the salt layers would also be worthwhile. Of course, there needs to be a model to explain the phenomenon itself. It would be worthwhile to extend the study to other salts and other solutions in general.

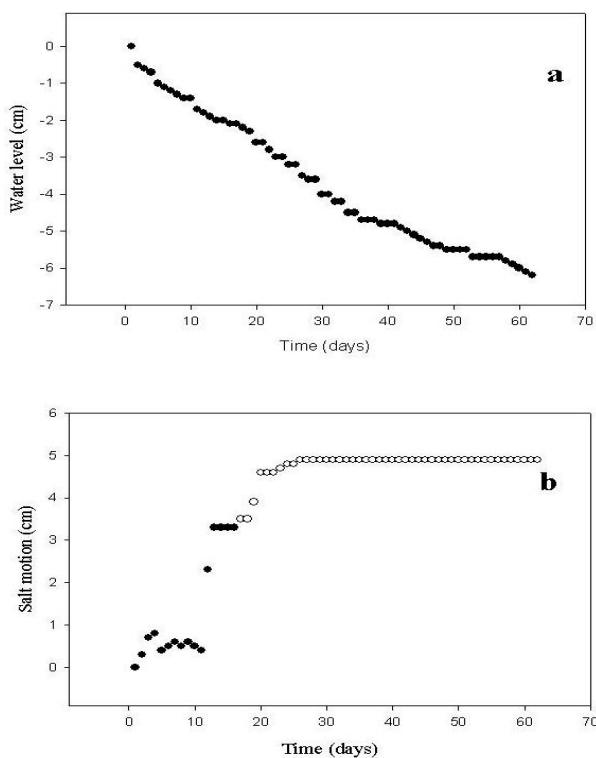


Fig. 2: (a). The level of water; (b). The motion of salt (filled circles) and climb down (open circles).

4. Conclusions

In this article we have described the phenomenon of motion of salt along the wall of the container containing the salt solution. When a table salt solution is left exposed to the atmosphere, the water naturally evaporates in several days. It is observed that as the water evaporates a thin layer of salt starts to form on the inner walls of the glass. This layer, from the inception, tends to form *above* the original level of the solution. The layer spreads to the top of the glass and continues on to the outer wall of the glass. The graphs in this study were obtained using the Microsoft EXCEL (Al Rawahi, *et al*, 2006), (Khan, 2007b), (Khan, 2007c), (Khan, 2007d).

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