

ON SOLUBILITY OF ALUMINIUM IN DISTILLED WATER HEATED TO DIFFERENT TEMPERATURES

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ABSTRACT

Double distilled water, prepared from an all glass apparatus and heated to 30°, 60° and 90°C separately was made to flow over the aluminium channel and tubes at a uniform rate (2 ml min^{-1}) and analysed for dissolved aluminium content. The solubility was found to range between 9-89 $\mu\text{g/litre}$ depending upon the temperature of the flowing water and it showed a negative trend with rise in temperature.

Water is known as the best ionising solvent (Parkes, 1963). Therefore, it has the property of dissolving a part of almost everything with which it comes in contact. Aluminium is one of the few metals whose alloys are mostly used in the fabrication of tubes and utensils for transferring and storing water. Besides these, different types of channels and supporting structures made of aluminium are mostly used in the construction of solar stills (Howe, 1974). Anand (1977) has reported that the impurity in the distilled water obtained from a solar still is solely caused by its metallic condensate collection channel. In it, the distilled water remains exposed to solar heat for long duration prior to its collection into a storage vessel placed outside the still. But channels made of copper only were tried and tested by him. Therefore, a study was planned to know to what extent aluminium gets dissolved in water when it is heated to different temperatures below its boiling point.

Eight aluminium channels were fabricated from four different sheets with two channels from each sheet. Each channel was semi-circular in section and moulded by hand tools with dimensions: length 100 cm, diameter 2.5 cm and thickness 0.1 cm. Besides, two tubes equal in length and diameter of the channels were cut from each of three different aluminium pipes. Two channels or tubes made from the same sheet or pipe were set for one experiment (Fig. 1) at a time. By means of siphon distilled water prepared by double distillation from an "all glass apparatus" and heated to 30°, 60° and 90°C separately was passed over the channels or tubes with a uniform flow rate of 2 ml per minute. After the flow the samples were collected in acid rinsed bottles and analysed for their dissolved aluminium contents using modified 'Aluminon' method (Anon, 1960). A portion (300 ml) of few samples was concentrated to one third volume and its dissolved aluminium content determined using the same method. The values thus estimated were divided by a factor of three to work out the concentrations in the original samples. The concentrations estimated in samples collected from duplicate channels or tubes in most of the experiments showed maximum variation of $7 \mu\text{g l}^{-1}$. Hence mean value of two collections was taken into consideration for the study. Dissolved aluminium contents in samples thus analysed are presented in Table I.

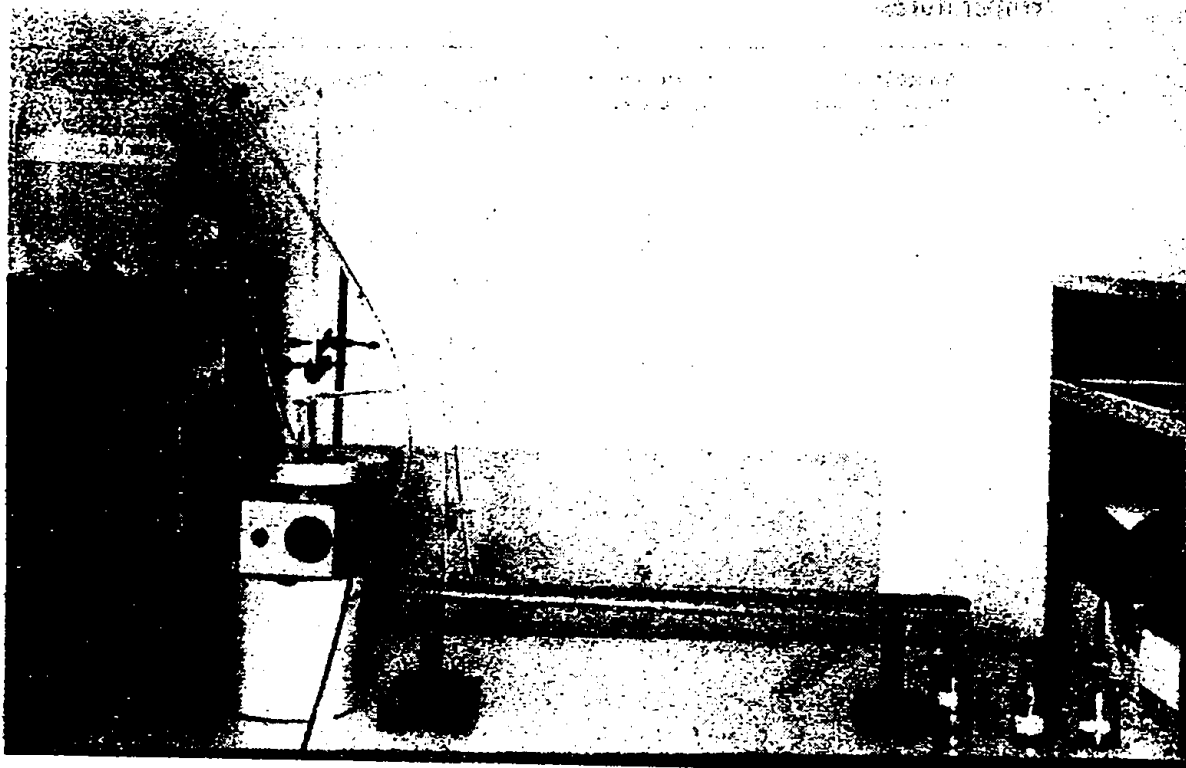


Fig. 1. Experimental set-up to study solubility of aluminium in distilled water heated to different temperatures.

The results indicate that distilled water has the property of dissolving aluminium in traces and the degree of solubility varies with the temperature of water in the negative order. Its average solubility is found to be 71, 47 and 36 μg per litre at 30°, 60° and 90°C respectively. Thus a reduction of 34 and 49 per cent at 60° and 90°C respectively is noticed. Further, in case of the channels the reduction works out to be 30 and 48 per cent whereas in tubes, it is 34 and 48 per cent. This shows that the tubes are nearly of the same composition as the channels but less prone to dissolution in distilled water.

Also keeping in view, the precision and accuracy ($20 \mu\text{g litre}^{-1}$) of the method employed (Anon, 1960) the contents of dissolved aluminium in water samples and the derived values from the concentrated samples (samples 1 & 2) appear to agree fairly well with each other. Accordingly, the contents estimated indirectly in samples 17, 18 and 19 appear to be quite reliable.

Protection against corrosion observed in the case of aluminium structures is reported to be due to the presence of 'superficial' oxide films over their surfaces (Anon, 1966). From X-ray diffraction studies it has been reported that the oxide exists in not less than seven crystalline forms (Durrant and Durrant, 1962). Among these the most familiar ones are the alpha and the gamma oxide. The alpha oxide crystals are very hard and resistive to hydration and acids whereas in gamma oxide the crystals are different in shape, *i. e.*, 'defect rock-salt structures' and readily soluble in water and acids. Cotten and Wilkinson (1969) have stated that the protective films mostly belong to some other form of oxide resembling the gamma form. Mark, Ketta, Othmer and Standen (1963) have reported that the gamma oxide consists of three different

Table I. Concentrations of dissolved aluminium in distilled water heated to different temperatures.

Sample No.	Sample from channel/tube Set No.	Temperature of water (°C)	Nature of samples W.C./C.	Dissolved Al in C-samples ($\mu\text{g litre}^{-1}$)	Dissolved Al in W.C. sample ($\mu\text{g litre}^{-1}$)	
1	I	—	30	W. C.	—	89
2	I	—	30	C.	230	77*
3	I	—	60	W. C.	—	89
4	I	—	90	C.	110	37*
5	II	—	30	W. C.	—	71
6	II	—	60	W. C.	—	26
7	II	—	90	W. C.	—	26
8	III	—	30	W. C.	—	80
9	III	—	60	W. C.	—	50
10	III	—	90	W. C.	—	50
11	IV	—	30	W. C.	—	97
12	IV	—	60	W. C.	—	65
13	IV	—	90	W. C.	—	60
14	—	I	30	W. C.	—	70
15	—	I	60	W. C.	—	26
16	—	I	90	W. C.	—	25
17	—	II	30	C.	74	25*
18	—	II	60	C.	66	22*
19	—	II	90	C.	26	9*
20	—	III	30	W. C.	—	56
21	—	III	60	W. C.	—	50
22	—	III	90	W. C.	—	45

*—derived values; W. C.—without concentration; C.—concentrated.

forms of crystals, viz. χ (Chi), η (eta) and γ (gamma). All these forms are metastable in nature and have been termed as 'transitional aluminas'. The negative solubility character observed in case of channels and tubes suggests that the oxide films in both cases belong to the transitional aluminas having a tendency towards stability with rise in temperature. Since the negative solubility is more prominent in tubes than channels the anodising process helps in changing the metastable oxides into stable ones. Hence anodising of aluminium structures after fabrication would further improve their resistivity. However, this remains to be studied separately in detail.

At present in most industries, tubings made of copper or copper alloys are used for transferring the pure water from one reservoir to another. As the solubility of copper is known to increase with rise in temperature (Rainwater and Thatcher, 1960), the use of aluminium tubes on account of their negative trends in solubility could be tried.

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