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Use of Copper Chloride in Thermoelectrochemical Cell for Solar Energy Conversion

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A thermoelectrochemical cell containing copper chloride for solar energy conversion has been investigated. Effect of various parameters on the electrical output of the cell was also investigated. Current-voltage characteristics of the cell have been studied.

INTRODUCTION

Thermal collection and conversion of solar energy had been the subject of investigation for many years; however, it lacks the storage part. Sensible heat storage[1], latent heat storage[2] and thermochemical storage[3,4] are various methods developed for heat storage. Abraham and Schreiner[5] and Moss[6] have discussed the low temperature thermal decomposition of water. Chemists[7,8] were then attracted towards phase change materials. These materials can be used to store thermal energy. Kimmil and Tomkins[9] have used phase transition reaction between cobalt chloride and *iso*propyl alcohol for this purpose. This reaction is completely reversible and the process can be repeated indefinitely. The reaction involving phase change is still obscure as no systematic trends have been established so far. These reactions are also accompanied by some electrical changes but a little is known in this direction[10] and, therefore, the present work was undertaken.

EXPERIMENTAL

Copper chloride EM, methanol SM 'GR' and hydrochloric acid SM 'GR' were used in the present work. The solution of copper chloride was prepared in methanol. A mixture of solutions of copper chloride and hydrochloric acid was taken in a H-type tube. A platinum electrode (1.0×1.0 cm^2) was immersed in one arm of H tube and saturated calomel electrode was kept in the other. The platinum electrode was illuminated with a 200 W tungsten lamp. A water filter was used for cutting infra-red radiations, whereas visible radiations were cut off by combination of red and blue cellophane papers. The temperatures of the two limbs of the cell were also recorded.

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RESULT AND DISCUSSION

Effect of pH on Electrical Output of the Cell

The effect of variation of pH on the electrical output of the cell was observed and results are summarised in Table 1.

TABLE 1

VARIATION OF pH

[Copper chloride] = 8.3×10^{-2} M
T_l = 318 K

Solvent = Methanol (aq)
Intensity = 13.2 mW cm^{-2}
T_d = 313 K

pH	Thermopotential (mV)	Thermocurrent (μA)
1.1	45.0	16.0
1.3	51.0	29.0
1.5	58.0	52.0
1.6	70.0	96.0
1.7	56.0	39.0
1.8	44.0	21.0
2.0	43.0	14.0

Thermopotential and thermocurrent both increase with increase in pH value, reaching an optimum at pH = 1.6. Further increase in pH resulted in the decrease in a electrical output of the cell.

Effect of Salt Concentration

The effect on thermopotential and thermocurrent was also studied with variation of copper chloride concentration and results are reported in Table 2.

TABLE 2

EFFECT OF VARIATION OF COPPER CHLORIDE CONCENTRATION

pH = 1.6
T_l = 318 K

Solvent = Methanol (aq)
Intensity = 13.2 mW cm^{-2}
T_d = 313 K

[Copper chloride] $\times 10^2$ M	Thermopotential (mV)	Thermocurrent (μA)
7.25	11.0	53.0
7.77	15.0	65.0
8.30	70.0	96.0
8.83	30.0	63.0
9.35	26.0	48.0
9.88	21.0	37.0

As the concentration of copper chloride was increased, there was a corresponding increase in thermopotential of the cell till it reached a maximum. Further, on increase in the concentration of copper chloride, thermopotential was found to decrease.

Effect of Nature of Solvents

The effect of nature of solvents on thermopotential and thermocurrent was also studied; however, there was no regular trend in this variation. The results are mentioned in Table 3.

TABLE 3

EFECT OF THE NATURE OF SOLVENTS

[Copper chloride] = 8.3×10^{-2} M
Intensity = 13.2 mW cm^{-2}
T_i = 318 K

pH = 1.6
T_d = 313 K

Solvents	Thermopotential (mV)	Thermocurrent (μA)
Methanol	70.0	96.0
Ethanol	27.0	105.0
Propanol-1	52.0	39.0
Propanol-2	39.0	36.0
Butanol-1	61.0	28.0
Butanol-2	49.0	25.0

Effect of Diffusion Length

To study the effect of variation of diffusion length on the electrical output of the cell, H-cells of different dimensions were used. The results are reported in Table 4.

TABLE 4

EFFECT OF VARIATION OF DIFFUSION LENGTH

[Copper chloride] = 8.3×10^{-2} M
pH = 1.6
T_i = 318 K

Solvent = Methanol (aq.)
Intensity = 13.2 mW cm^{-2}
T_d = 313 K

Diffusion length (D_L) (mm)	Thermopotential (mV)	Thermocurrent (μA)
30.0	63.0	110.0
35.0	68.0	102.0
40.0	70.0	96.0
45.0	74.0	91.0
50.0	78.0	84.0

The current decreases with an increase in diffusion length whereas a reverse behaviour was observed in case of thermopotential.

Effect of Electrode Area

The effect of electrode area on the thermopotential and thermocurrent was also observed. The results are reported in Table 5.

TABLE 5

EFFECT OF ELECTRODE AREA

[Copper chloride] = 8.3×10^{-2} M; pH = 1.6; T_i = 318 K

Solvent = Methanol (aq.); Intensity = 13.2 mW cm^{-2}; T_d = 313 K

Electrode surface area (A) cm^2	Thermopotential (mV)	Thermocurrent (μA)
0.36	64.0	93.7
0.64	68.0	94.9
1.00	70.0	96.0
1.44	73.0	97.1
1.96	78.0	99.0

The values of thermopotential and thermocurrent were found to increase with the increase in the area of electrode.

Effect of Temperature Difference

The effect of temperature difference on electrical parameters of the cell is reported in Table 6.

TABLE 6

EFFECT OF TEMPERATURE DIFFERENCE

[Copper chloride] = 8.3×10^{-2} M; pH = 1.6

Solvent : Methanol (aq.); Intensity = 13.2 mW cm^{-2}

Temperature difference K ($T_i - T_d$)	Themopotential (mV)	Thermo-current (μA)	Power (μW)
3.0	73.0	92.0	6.53
5.0	70.0	96.0	6.72
7.0	68.0	100.0	6.80
10.0	66.0	104.0	6.86
13.0	64.0	110.0	7.04

The value of thermopotential showed a rapid fall with the rise in temperature difference whereas the current was found to increase.

Current-Voltage (i-V) Characteristics, Conversion Efficiency and Performance of the Cell

The open circuit voltage (V_{oc}) and short circuit current (i_{sc}) of the thermoelectrochemical cell were measured from a digital pH meter (keeping the circuit open) and from a multimeter (keeping the circuit closed), respectively. The current and potential values in between these two extremes were determined with the help of a carbon pot (long 500 K) connected in the circuit of multimeter through which an external load was applied.

It was observed that the i–V curve of the cell deviated from its ideal rectangular shape. A point in i–V curve, called the power point (PP) was determined, where the product of potential and current is maximum. The values of potential and curve current at power point are represented as V_{pp} and i_{pp}, respectively*.

The performance of the cell was studied by applying the external load (necessary to have current and potential at power point) and removing the source of light. It was observed that the cell can be used in dark for fifteen minutes at its power point.

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REFERENCES

1. J. Shelton, *Solar Energy*, **17**, 138 (1975).
2. M. Telkes, Solar Energy Research, Univ. Wisconsin, Wisconsin (1955).
3. Electric Power Research Institute, EPRLEM–256, Final Report I Project 788–1 (1976).
4. W. E. Wentworth and E. Chen, *Solar Energy*, **18**, 205 (1976).
5. B. M. Abraham and F. Schreiner, *Science*, **180**, 959 (1973).
6. L. R. Moss, *Science*, **180**, 1372 (1973).
7. Philips Chen, Entertaining the Educational Chemical Demonstrations, Chemical Elements Pub. Co., Carmarillo, California, p. 36 (1974).
8. R. B. Shiflet, *J. Chem. Educ.*, **55**, 103 (1978).
9. H. S. Kimmil and R. P. T. Tom Kins, *J. Chem. Educ.*, **56**, 615 (1979).
10. Suresh C. Ameta, P. K. Jain and Deepali Sharma, *Z. Phys. Chem.* (Leipzig) (in press).

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*The fill factor and conversion efficiency of the cell were determined as 0.12 and 0.1560% respectively.