IJISET - International Journal of Innovative Science, Engineering & Technology, Vol. 2 Issue 1, January 2015.
www.ijiset.com
ISSN 2348 – 7968

Effect of anhydrous Magnesium Sulphate on eutectic mixture of Magnesium thermal cell

Samaa Saadi Mahmood and Abbas A-Ali Drea*
Babylon University - College of Science - Chemistry Department
Hilla -Iraq
*E-mail: aadreab22@yahoo.com

Abstract

Effect of additive salt on eutectic mixture of Magnesium thermal cell (Lithium Chloride - Potassium Chloride) upon the performance of voltage production using anhydrous magnesium sulphate have been done by the mechanism of open thermodynamic system. Different weights of anhydrous magnesium sulphate have been used within eutectic mixture in presence constant amount of vanadium pent oxide. Different ratios of new eutectic mixtures have been examined relatively to the ambient operating temperatures and the activity of producing voltage of electrochemical systems in new system of thermal cells. Optimized ratio of eutectic mixture for voltage production have been choice relative to minimum ambient temperatures, and its operating temperature. Optimized weight of depolarizer in eutectic mixture of new Magnesium thermal cell have been studied.

High effect have been found due anhydrous magnesium Sluphate additions, as well as the thermodynamic and conductivity activity for eutectic mixture of Magnesium thermal cell, since the optimized weight ratio of new eutectic mixture Lithium Chloride : Potassium Chloride : anhydrous magnesium Sluphate is consisted from 5.5 :4.5 : 1. ratio .Operating temperature is 400˚C, Open system cell produced 1.5 volte in presence 0.5 optimized weight ratio of depolarizer relative to weight ratios of new eutectic mixture components. The new thermal cell is sensitive to ambient temperatures and produce electrical energy when ambient temperature raise to 35 into 350˚C by voltage range from 0.3 into 1.5 volte respectively. Electrical discharge of open circuit occurs in 400˚ C as ambient operating temperature by 13 mints of elapsed time.

Key Words: - Magnesium thermal cell, Eutectic mixture, Open Cup cell, Anhydrous magnesium Sulphate.

1. Introduction

Thermal battery is provided with solid electrolyte and non-active at ordinary temperature, which is divided into two class, the primary battery and secondary battery. The electrolyte becomes molten by using a pyrotechnic heat source which is essential of the battery cell stack [2-3]. Thermal batteries are used for high power applications that requiring fast runtimes from a few seconds to a few hours, and these batteries are used for multifunctional propose to provide power for electronic systems devices and guidance systems [4]. All batteries are composed of some thermal cells provided with two electrodes connected by an ionically conductive material as electrolyte. The two electrodes have different chemical potential. When these electrodes are connected by means of an external device, electrons spontaneously flow from the more negative to the more positive potential. Ions are transported through the electrolyte, and electrical energy can be tapped by the external circuit. In secondary, or rechargeable batteries, a larger voltage applied in the opposite direction can cause the battery to recharge [5]. Magnesium batteries is the luckiest

ISSN 2348 – 7968

technology in order to achieve substantially greater energy density than Li-ion due the divalent nature of Mg^{2+}. Magnesium batteries can obtain higher energy density (energy per unit volume) and specific energy (energy per unit weight) than state of the art lithium batteries. Magnesium metal anode has a greater volumetric capacity than graphite or lithium metal, it's inexpensive, environmentally friendly and safe to handle [6-8].

2. Experimental

The study of salt effect needed some evaluation experiments to estimate the optimum conditions of newest thermal cell according to the ratio of anhydrous Magnesium Sulphate salt additive to the composition of original eutectic mixture of magnesium cell.

2.1 Preparation of molten salts

The new eutectic of cell were prepared by mixing different percentages of anhydrous magnesium sulfate with the original fixed percentage of potassium chloride and lithium chloride that includes (LiCl:KCl:45:55) [9]. Constant weight of depolarizer V_2O_5 has been used for each experiments, to get the optimal weight for the anhydrous magnesium sulfate salt. In each experiments the mixture was crushed to a powder and then moved to the furnace whose temperature had been raised from 35 to 600 ℃ till get melted the powder. The furnace get turn off and leave it until gets cool down to 100 ℃. the mixture moves to a dry box and leave it there until it gets cool down to solidifies then grind to a powder again and get used for electrical measurements.

2.2 Determination the weight percent of depolarizer

Choose the best of weight ratio for (anhydrous magnesium sulfate) that it was added to the molten salts that it has formed from the two salts (potassium chloride and lithium chloride) with the fixed ratio of depolarizer V_2O_5. Different weight ratio have been added of depolarizer substance V_2O_5 .Observations are recorded about the molten salts and choose the best ratio for this substance, that's gives the highest voltage for the mixture.

2.3 Operation of the thermal cell

Newest eutectic mixture has transferred to the pottery basin inside the electric muffle furnace and connected the two electrodes of this cell to the multi electronic voltmeter. Operating temperature has been recorded for the cell operation, through raising the temperature from 35 to 600℃.

2.4 Optimum temperature of thermal cell operation.

The optimum temperature was determined by taken the pottery basin that contained the best ratios of molten salts, that's putted it inside the furnace and connected to the voltmeter, the temperature was gradually raised from 35 to 600℃ with recorded the temperatures rather than resulted voltage.

2.5 Effect of Temperature

Effect of temperature on the voltage of thermal cell has been showed by setting the pottery basin of best ratio of molten salts and putted inside the furnace, that's connected to the voltmeter. Temperature been raised from 35 to 400 ℃, when reach the temperature to 400 ℃, starts running the stopwatch and monitoring the voltages resulting with time up to the low voltage to zero.

3. Results and Discussion

3.1 Components of thermal cell

Magnesium thermal cell is consisted from Mg-metal as anode with thickness 0.15-0.2 mm and width 3mm. Surface impurities of magnesium has been removed by washing with diluted nitric acid (1M) and later, washed up with distilled water for several times then drying [10,11] . Cathode is composed from depolarizer (V_2O_5), that's provided with local metal clip

alloy is consisted from nickel, iron and chromium, that's available with very low cost and been used as positive current collector. Eutectic mixture is consisted from the LiCl salt KCl salt by 45:55 ratio respectively. This eutectic is common used as electrolyte in thermal cells [12]. The purpose of anhydrous magnesium sulfate addition to original eutectic mixture to improving a new properties and accelerate voltage production at lower temperature than ordinary operating temperature of thermal cell. The components of the thermal battery (electrodes and eutectic mixture) are putted in the pottery basin that using for all experiments according to the open thermodynamic system.

Table 1 and fig 1 shows that weight ratios of anhydrous magnesium sulfate were added to the original molten salt with the constant weight of the depolarizer (1.5 gm. for all these experiments) and they found the best ratio of anhydrous magnesium sulfate was 1gm. that given the maximum voltage 1.5 volt for the mixture in the 350℃ .

Table 1**:** Optimize weight ratio investigation of anhydrous magnesium sulfate of new eutectic mixture.

Temp. C°	wt. /0.25 gm.	Wt. 2 /0.5gm.	wt. 3 /o.75 gm.	wt. 4 /1 gm.
50	0.1	0.2	0.3	0.52
100	0.3	0.25	0.35	0.58
150	0.3	0.3	0.4	0.65
200	0.35	0.35	0.45	0.7
250	0.4	0.41	0.6	0.9
300	0.48	0.5	0.7	1.3
350	0.55	0.7	0.88	1.5
400	0.6	0.85	1	1.1
450	0.5	0.7	0.65	0.99
500	0.5	0.5	0.4	0.75
550	0.4	0.15	0.3	0.3
600	0.25	0.1	0.2	0.1

Temp. C°	wt. 5 /1.25 gm.	wt. 6 /1.5 gm.	wt. 7 /1.75 gm.	wt. 8 /2 gm.
50	0.4	0.3	0.3	0.1
100	0.5	0.45	0.4	0.11
150	0.55	0.5	0.5	0.15
200	0.7	0.65	0.55	0.2
250	0.75	0.73	0.6	0.28
300	0.82	0.8	0.72	0.35
350	1	1.2	0.8	0.5
400	0.95	0.98	0.9	0.75
450	0.91	0.6	0.7	0.5
500	0.4	0.55	0.35	0.21
550	0.25	0.4	0.3	0.1
600	0.2	0.2	0.25	0.1

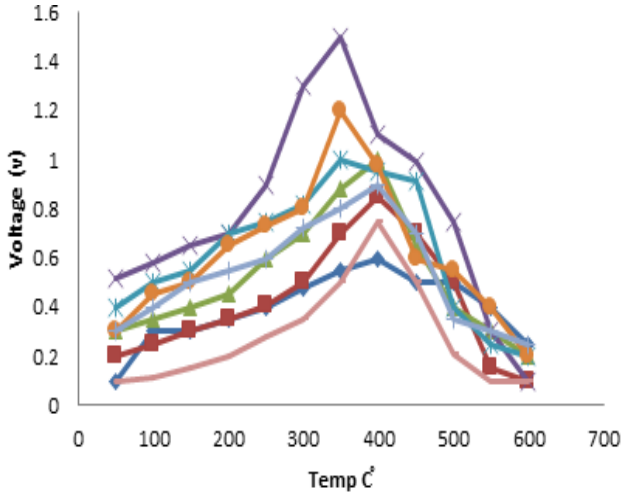

Fig. 1 Effect of anhydrous magnesium sulfate on voltages production of magnesium thermal cell.

After determined the optimize weight of anhydrous magnesium sulfate, Effect of the depolarizer V_2O_5 has been studied on the voltage production of magnesium thermal cell by different weight ratio to the molten salts that has been weighted from anhydrous magnesium sulfate. Vanadium pentoxid been choiced as depolarizer that used in magnesium thermal cell. Table 2. and Fig 2. Shows that weight ratios of V_2O_5 were added to the molten salts (LiCl: KCl:

ISSN 2348 – 7968

$MgSO_4$:45:55:1). They found the best weight of V_2O_5 was 0.5 gm., that given the higher voltage 1.6 volt for the eutectic mixture in 400 C°.

Table 2.Optimize weight of V_2O_5 of eutectic effecting on voltage of the electrochemical system.

Temp. ℃	0.1gm V_2O_5	0.2gm V_2O_5	0.3gm V_2O_5	0.4gm V_2O_5	0.5gm V_2O_5
50	0.1	0.15	0.1	0.1	0.1
100	0.11	0.2	0.2	0.1	0.2
150	0.2	0.35	0.25	0.15	0.25
200	0.33	0.4	0.3	0.25	0.3
250	0.51	0.5	0.41	0.42	0.35
300	0.65	0.85	0.5	0.5	0.6
350	0.75	0.95	0.65	0.8	1.2
400	0.7	0.8	0.88	1.1	1.6
450	0.45	0.65	0.6	0.8	1
500	0.4	0.3	0.2	0.6	0.65
550	0.3	0.29	0.1	0.4	0.2
600	0.25	0.25	0.1	0.24	0.12

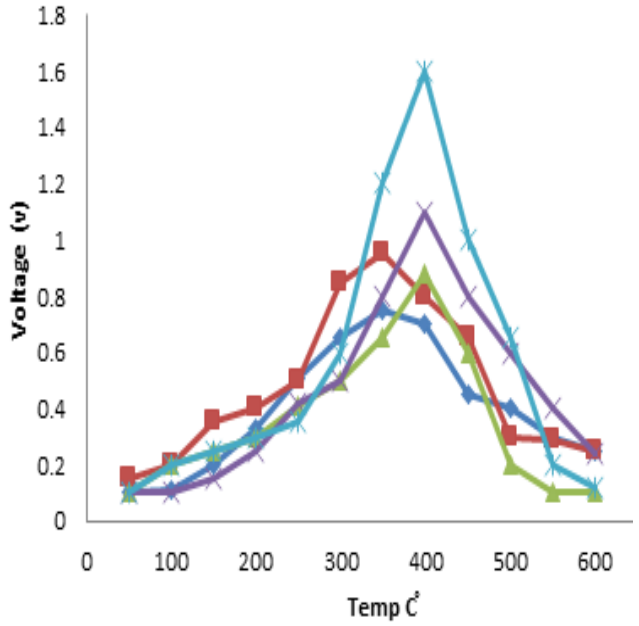

Fig2. Effect of depolarizer on voltage production of magnesium thermal cell.

3.2 Operating Temperature

Fig 3. Shows the operating temperature of thermal cell with maximum efficiency at 400℃, where the voltage is 1.5 volt. The temperature degrees were raised from 35 to 600℃ and the rising in the voltage was noticed from 0.3 volt at 50℃ and continue to raise until reach the voltage to 1.5 volt at 400℃, this demonstrates the effectiveness of these thermal cell at the ambient temperature, after that observed the rapid dropping in voltage, due consumption of the reactants in the thermal cell.

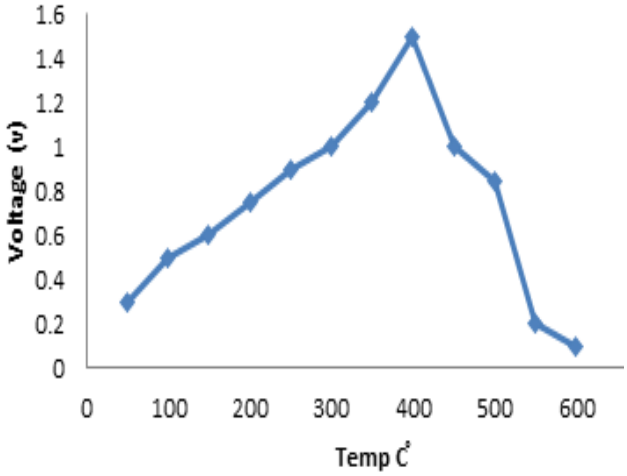

Fig 3. The operating temperature of the laboratory thermal cell.

3.3 Effect of temperature on voltage production.

Fig 4. Shows effect of ambient temperature on the thermal cell and that explain the regularly electric discharge in the 400℃, with the lifetime equal to 13 minutes.

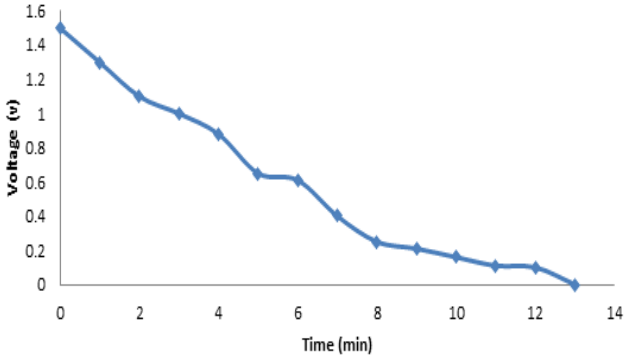

Fig4.Voltage consumption of magnesium thermal cell.

ISSN 2348 – 7968

4. Conclusions

Anhydrous magnesium sulfate has significant effect on the specifications of the eutectic mixture of magnesium thermal cell, since the maximum voltage production is 1.5 volt with activation ambient temperature equal to 35° C. Operating temperature of magnesium cell equal to 400°C and the half lifetime of maximum voltage production equal to 13 minutes.

5. References

[1] David L. and Thomas B.R. "Handbook of Batteries". 3rd edition, McGraw-Hill Companies, USA, 2001.
[2] Patrick B.D. and Clinton S.W. Limiting factors to advancing thermal battery technology for naval applications, 1991.
[3] Helena L.C. and Robert A.O. Review of thermally regenerative electrochemical systems. NEW YOURK, 1981.
[4] Rebecca M. Thermal battery development project. American competitiveness institute, 2005.
[5] Armand M. and Tarascon J.M. Building better batteries. *Nature*, 2008, 451, 652-657.
[6] Lu Z., Schechter A., Moshkovich M. and Aurbach D. On the electroanalytical behavior of magnesium in a polar aprotic electrolyte solution. Journal of electroanalytical chemistry, 1999, 466,203-217.
[7] Aurbach D., Lu Z., Schechter A., Gofer Y., Gizbar H., Turgeman R., Cohen Y., Moshkovich M. and Levi E. Prototype systems for rechargeable magnesium batteries *Nature*, 2000,407, 724-727.
[8] David .J.B., Hojong K., Aislinn H.C.S. and Donald R.S. Magnesium-antimony liquid metal battery for stationary energy storage. *Journal of American chemical society*, 2012, 134, 1895-1897.
[9] Vincent C. A. and Scrosati B. "Modern batteries", 2nd Edition, Edward Arnold, London, 1997, 302.
[10] Aurbach D., Suresh G.S., Levi E., Mitelman A., Mizrahi O., Chusid O. and Brunelli M. Progress in rechargeable magnesium battery technology. Advanced material, 2007, 19, 4260-4267.
[11] Li Y., Nuli Y., Yang J., Yilinuer T. and Wang J., *Chinese Sci. Bull.*,2011, 56 ,1 ,386-390 .
[12] George C. B., U.S. pat., 3, 980, 888, Jan., 6, 1976.