Thermal Effect of Several Chemicals In Reaction With Water

A.Sivasakthi[1], Dr.T.Nagalakshmi[2]
[1, 2] Dept of Petroleum Engineering
[1, 2] AMET UNIVERSITY, Chennai, India

Abstract- *In this research article, the specific chemical compounds were reacted with water at ambient and hot temperatures; in order to analysis their heat effects. The most commonly practising industrial chemicals were chosen for the research investigation. Same amount of chemical compounds was taken and examined with different volume of ambient and hot water. In ambient temperature of water, sodium hydroxide and calcium chloride found to have a great exothermic reaction on water. Sodium chloride has the ability to reduce the initial temperature of water by a single degree Celsius and stable for a particular period of time. SDS, Triton X-100 and Detergent was slightly increased the ambient temperature of the water. The same chemical compounds were tested in hot water to analyse the delay intemperature of the hot water loss to the surrounding. The dissolving of chemical compound in hot water can faintly delay the temperature of the hot water loss to the environment.*

Keywords- Chemicals, Cold water, Hot water, Heat effect, Sodium chloride, Calcium chloride and Exothermic reaction

I. INTRODUCTION

Water is the essential element in the earth for all living life. We know that the water is a necessary supply for growth of plants, daily bathing, drinking, washing, cooking and electricity production [6]. Apart from our daily needs, water is used in industrial scale for the all plant processing such as freezing, cooling water circulation, recycled water andchemical reactions involved in various purposes [6].

The thermal effects of chemical compounds with the water can be simply explained by the two main reactions namely exothermic and endothermic reactions. Exothermic reactions are chemical reactions in which the heat is released from the system to the surrounding. The energy stored in the chemical bonds of theproduct is lesser than the energy stored in the chemical bonds of the reactant [4, 5]. Endothermic reactions are chemical reactions in which the heat is absorbed from the surrounding to the system. The energy stored in the chemical bonds of the product is greater than the energy stored in the chemical bonds of the reactant. The neutralization reaction is a kind of chemical reaction in which either exothermic or endothermic reaction can take place [3].

The most frequently using chemicals namely Sodium Carbonate (Na_2CO_3), Sodium Hydroxide (NaOH), Sodium Chloride (NaCl), Calcium Chloride ($CaCl_2$), Sodium Bicarbonate ($NaHCO_3$), Sodium Lauryl Sulphate (SDS), Triton X-100 And Detergent. This chemical compounds are allowed to react with water molecule (H_2O) to give either an energy released or absorbed reactions.

In this research article, the heat release and changes in the temperature of water was analysed when certain selected chemical compounds were added to the water. This investigation helps to differentiate the chemical compounds reaction with waterat ambientas well as hot conditions.

II. MATERIALS AND METHODS

Materials Required:

The chemicals namely Sodium Carbonate, Sodium Hydroxide, Sodium Chloride, Calcium Chloride, Sodium Bicarbonate, Sodium Lauryl Sulphate, Triton X-100 and Detergent were purchased from the private chemical company. Heating mantle is necessary to raise the temperature of water.

Methodology:

Thermal Effects of Chemical Compounds on Water at Ambient Temperature:

The experiment was carried out initially with 100 ml of water at ambient temperature (28 ˚C) to 1 g of each chemical in different steps. The temperature was noted in different time intervals up to 30 mins after mixing chemical to water. Then, the volume of water was changed from 100 ml to 50 ml along with 1 g of chemical and the temperature was noted. Again, the experiment was conducted with 10 ml of water to 1 g of chemical and the difference in temperature at each time period was recorded.

Thermal Effects of Chemical Compounds on Water at Hot Temperature:

The testing was performed with 100 ml of hot water at 100 ˚C to 1 g of each chemical in various stages. The temperature reduction in different time period was noted and the physical appearance along with the dissolved salt in hot water has the ability to hold the heat effects were observed.

III. RESULTS AND DISCUSSION

Thermal Effects of Chemical Compounds on Water at Ambient Temperature:

Initial temperature of the water was 28 ˚C before adding chemical compound for all the ambient temperature experiments.The thermal effects of different chemical compounds on different volume of water were tabulated individually in table 1, 2 and 3. To study the comparative heat effects of chemical compounds on different volume of water the table 4 was constructed with the initial and final temperatures of the each chemical reaction.

The chemical reaction of different chemical compounds selected with water can be explained by the below chemical equations.

1. $Na_2CO_3 + H_2O \rightarrow 2NaOH + CO_2$
2. $NaOH + H_2O \leftrightarrow Na^+ + OH^- + H_2O$
3. $NaCl + H_2O \leftrightarrow Na^+ + Cl^- + H_2O$
4. $NaHCO_3 + H_2O \rightarrow 2NaOH + H_2CO_3$

The commonly used washing soda is the sodium carbonate and dissolving in water produce heat. The sodium carbonate reaction on water will produce sodium hydroxide and carbon di oxide. This chemical reaction is not used for marketable production of sodium hydroxide due to the low concentration of sodium hydroxide, very slow reaction and contamination of sodium carbonate [2].

The sodium hydroxide in water cannot have any chemical reaction but the dissociation of sodium and hydroxide ion will release an enormous amount of heat to the surroundings. Similarly, the sodium chloride in water has no chemical reaction and a slightly increases or decreases the temperature of the reaction [1, 2].

The baking soda used in daily process is made up of sodium bicarbonate and the temperature may be uplifted or reduced depending upon the conditions. Calcium chloride on dissolving in water will give rise to hydrated calcium chloride, which will create exothermic reactions. The SDS, Triton X-100 and detergent can produce a considerable amount of heat on dissolving in water.

Table 1.Thermal Effects of Chemical Compounds on 100 ml Water

Water and chemical compounds	At 0 mins	At 2 mins	At 5 mins	At 10 mins	At 20 mins	At 30 mins
Na_2CO_3	28 °C	28 °C	28 °C	28 °C	28 °C	28 °C
NaOH	30 °C	29.7 °C	29.5 °C	28 °C	28 °C	28 °C
NaCl	26.5 °C	26.8 °C	27 °C	27 °C	27 °C	27 °C
$CaCl_2$	28.3 °C	28.2 °C	28.1 °C	28 °C	28 °C	28 °C
$NaHCO_3$	28 °C	28 °C	28 °C	28 °C	28 °C	28 °C
SDS	28 °C	28 °C	28 °C	28 °C	28 °C	28 °C
Triton X-100	28 °C	28 °C	28 °C	28 °C	28 °C	28 °C
Detergent	28 °C	28 °C	28 °C	28 °C	28 °C	28 °C

Table 2.Thermal Effects of Chemical Compounds on 50 ml Water

Water and chemical compounds	At 0 mins	At 2 mins	At 5 mins	At 10 mins	At 20 mins	At 30 mins
Na_2CO_3	28.3 °C	28.2 °C	28.1 °C	28 °C	28 °C	28 °C
NaOH	33 °C	32.5 °C	31.5 °C	30.2 °C	29 °C	28 °C
NaCl	27.1 °C	27 °C	27 °C	27 °C	27 °C	27 °C
$CaCl_2$	29 °C	29.7 °C	29.3 °C	28.7 °C	28.2 °C	28 °C
$NaHCO_3$	27.3 °C	27.1 °C	27 °C	26.5 °C	26.3 °C	26.1 °C
SDS	28 °C	28 °C	28 °C	28 °C	28 °C	28 °C
Triton X-100	28 °C	28 °C	28 °C	28 °C	28 °C	28 °C
Detergent	28 °C	28 °C	28 °C	28 °C	28 °C	28 °C

Table 3.Thermal Effects of Chemical Compounds on 10 ml Water

Water and chemical compounds	At 0 mins	At 2 mins	At 5 mins	At 10 mins	At 20 mins	At 30 mins
Na_2CO_3	39 °C	35.5 °C	33.5 °C	31 °C	29.3 °C	28.7 °C
NaOH	69 °C	59 °C	48.5 °C	41 °C	32 °C	29 °C
NaCl	27 °C	27 °C	27 °C	27 °C	27 °C	27 °C
$CaCl_2$	45 °C	39 °C	34 °C	31.5 °C	29 °C	28 °C
$NaHCO_3$	25 °C	26 °C	27 °C	28 °C	28 °C	28 °C
SDS	28.9 °C	28.6 °C	28.5 °C	28.2 °C	28 °C	28 °C
Triton X-100	28.7 °C	28.6 °C	28.3 °C	28 °C	28 °C	28 °C
Detergent	29 °C	28.9 °C	28.7 °C	28.5 °C	28 °C	28 °C

Table 4. Initial andFinal Temperatures of Various Chemical Compoundson Different Volume of Water

Water and chemical compounds	Initial temp. (°C)	Heat effects on 100 ml water	Heat effects on 50 ml water	Heat effects on 10 ml water
		Final temp. (°C)	Final temp. (°C)	Final temp. (°C)
Na_2CO_3	28	28	28.3	39
NaOH	28	30	33	69
NaCl	28	26.5	27.1	27
$CaCl_2$	28	28.3	29	45
$NaHCO_3$	28	28	27.3	25
SDS	28	28	28	28.9
Triton X-100	28	28	28	28.7
Detergent	28	28	28	29

The fig. 1.Shows the initial and final temperatures of various chemical compounds on different volume of water such as 100 ml, 50 ml and 10 ml.The fig. 1. Clearly represent the individual chemical compounds reaction on water and the sodium chloride was found to have a great thermal effect on water at different volumes. Then, calcium chloride and sodium carbonate has better heat effects on 10 ml of water. The sodium carbonate and sodium bicarbonate on addition to water slightly decreases the ambient temperature of water. The SDS, Triton X-100 and detergent can rise a very low degree temperature to the water on dissolving condition.

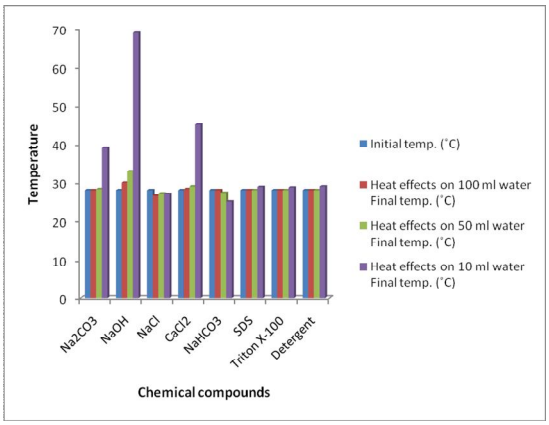

Fig. 1. Initial andFinal Temperatures of Various Chemical Compoundson Different Volume of Water

Thermal Effects of Chemical Compounds on Water at Hot Temperature:

Initial temperature of the hot water was 100 ˚C, when chemical was mixed at each different stages. Then, the hot water and chemical mixture was placed in the atmosphere temperature to find the reduction in hot water temperature at each interval and the chemical effects was visually observed.

Table 5.Thermal Effects of Chemical Compounds on 100 ml Hot Water

Water and chemical compounds	At 2 mins	At 5 mins	At 10 mins	At 20 mins	At 30 mins	Visual Observation
Hot Water alone	82 °C	70 °C	58 °C	46 °C	40.5 °C	-
Na_2CO_3	81 °C	69 °C	58 °C	42.3 °C	39.5°C	Dispersed separately from water and settled at the bottom
NaOH	85 °C	68 °C	54 °C	44 °C	37 °C	Dispersed separately from water and settled at the bottom
NaCl	80.2 °C	64 °C	51 °C	42 °C	38 °C	Completely mixed
$CaCl_2$	79.5 °C	66 °C	54 °C	43 °C	36 °C	Completely mixed
$NaHCO_3$	84 °C	67 °C	55 °C	44 °C	37 °C	Completely mixed
SDS	79 °C	66 °C	58 °C	40 °C	35 °C	Changed colour from whitish to colourless
Triton X-100	79 °C	68 °C	54 °C	45 °C	39 °C	Changed colour from colourless to whitish
Detergent	74 °C	59 °C	47 °C	40 °C	34 °C	Completely mixed

The table 5 shows the heat effects of specific chemical compounds on water. The tabulation explains the dissolved chemical compounds can reduce the steep decrease of heat loss to the surroundings to a little. On hot water reaction with sodium carbonate and sodium hydroxide has caused the chemical compounds to precipitate at the bottom of the beaker. The dissolved salts in water generally increase the boiling point of water and completely dissolved in water without separation. The SDS and Triton X-100 have changed their appearances and the colour was reappeared on cooling process. The detergent will work in better way with hot water than in cold water.

IV. CONCLUSION

Water is the main component in almost all the industrial processes. Water is the chief ingredient in the chemical production route and the reaction of any chemical compound with water may either follow an exothermic or endothermic reaction. The exothermic reaction is mainly preferred then endothermic reaction due to the liberation of heat than the absorption of heat.

Sodium hydroxide with different volume of water was found to be superior in heat liberation than the other selected chemicals for the study. Sodium carbonate and calcium chloride showed a considerable amount of heat release on 10 ml of water at ambient temperature. Sodium chloride happens to decreases the initial temperature of the water by 1 ˚C while the temperature was maintained for a particular time of period and this effect was observed to be

same on different volume of water. Sodium bicarbonate dissolving on water certainly decreases the temperature of the water at various volumes. SDS, Triton X-100 and Detergent showed a slight increase in temperature of the water at varying volumes.

The chemical compounds on hot water was investigated and found to delay the hot water temperature loss to the surrounding to a very little extent. Sodium carbonate and sodium hydroxide cannot be reacting with hot water due to the scattering of compound in the water and settling down at the bottom, which was not the case in the cold water. SDS, Triton X-100 and Detergent happened to change their colour appearance during the course of heating.

REFERENCES

[1] Bulens M and Delmon B, "The Exothermic Reaction of Metakolinite in the Presence of Mineralizers Influence of Crystallinity," Clay and Clay Minerals, Vol. 25, pp. 271 – 277.
[2] Catherine E. Housecroft and Alan G. Sharpe, "Inorganic Chemistry," Pearson Education Limited 2001, 2005.
[3] John D. Roberts, Ross Stewart and Marjorie C. Caserio, "Organic Chemistry", W. A. Benjamin, INC. New York 1971.
[4] Kh. Abdul Maleque, "Effects of Exothermic/Endothermic Chemical Reactions with Arrhenius Activation Energy on MHD free Convection and Mass Transfer Flow in Presence of Thermal Radiation," Journal of Thermodynamics, Vol. 2013, pp. 11. May 2013.
[5] Taro Saito, "Inorganic Chemistry," Kanagawa University, May 10, 2004.
[6] V.A. Vaclavik and E.W. Christian, "Water," Essentials of food science, 4th Edition, Food Science Text Series, 2014.