Chemistry IA

Solubility in Alcohols

How does Temperature affect the solubility of Oxalic acid in different solutions of alcohols?

***Word Count**: 2000*

Contents

Abstract

We will discuss the effects of change in the magnitude of ***temperature*** *on the* ***solubility*** *of* ***Oxalic acid*** *in a solutions of different alcohols. We shall accomplish this by collecting raw data on the measurement of* ***TDS (Total Dissolved Solids (Dissolved Oxalic acid))*** *in various alcohols with respect to change in* ***temperature*** *under certain controlled spaces.*

1 *Introduction*

I have chosen this research question as I was highly interested in Medicinal Chemistry and Medicine, in general. I very well wanted to investigate something that had its application in the medical sciences. I had initially thought to investigate the Solubility of Acetaminophen (Paracetamol) in various Alcohols; this further led me to study and analyse the temperature dependence on the acid hydrolysis of Acetaminophen (Paracetamol).

Preliminary research and data collection have shown me that this is not a feasible topic of study. Observing the hydrolysis on the microscopic level is excruciatingly challenging due to the lab constraints at a high-school level. With the assistance and guidance of my teacher, I decided to study the ***Temperature dependence of the Solubility of Oxalic Acid in various Alcohols*** *as I had previously researched and studied a lot on the solubility of Alcohols.*

2 *Methodology*

2.1 *Method*

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2.2 *Variables*

Independent Variable	*Dependent Variable*	*Controlled Variable*
Temperature	*TDS*	*Concentration of Alcohol* $\approx 98\%$

Table 1: *Segregation of employed variables as IV, DV or CV*

2.3 *Apparatus Required*

- *Pasco Conductivity & Dissolved Solids Sensor*
- *Digital Thermometer*
- *Pipette & Pipette Filler*
- *25, 100 ml Beakers*
- *Water Bath*
- *Petri Dish*
- *Weighing Machine*

2.4 *Materials Required*

- *80 ml of Methanol*
- *80 ml of Ethanol*
- *80 ml of Propanol (Isopropanol)*
- *80 ml of Butanol*
- *80 ml of Pentanol*

2.5 *Procedure*

Step 1: *Measure (using Pippetette) and Pour 20 ml of a type of alcohol into a 100 ml beaker*

Step 2: *Measure (using Weighing Machine) 20 g of Oxalic Acid in a Petri Dish*

Step 3: *Add the 20 g of Oxalic Acid into the 100 ml beaker with the 20 ml alcohol*

Step 4: *Using a glass rod, mix and dissolve the Oxalic acid at room temperature until saturation point at room temperature (20° Celsius/293.16 K)*

Step 5: *Measure the TDS reading using the Pasco Conductivity Dissolved Solids Sensor at 20° Celsius/293.16 K.*

Step 6: *Immerse the beaker in a water bath set at 100° Celsius.*

Step 7: *Immerse a digital thermometer in the solution (beaker) and measure the TDS reading at various temperature values (for our experiment, temperature data points are at 20°, 30°, 40°, 50° and 60° Celsius)*

3 *Data*

Alcohol Type	*Temperature* (°C)	*TDS Reading* (g/L)
Methanol	20 ±0.2	96.2 ±0.5
	30 ±0.2	145.2 ±0.5
	40 ±0.2	132 ±0.5
	50 ±0.2	150.8 ±0.5
	60 ±0.2	113.2 ±0.5
Ethanol	20 ±0.2	24 ±0.5
	30 ±0.2	35 ±0.5
	40 ±0.2	145 ±0.5
	50 ±0.2	194.4 ±0.5
	60 ±0.2	164.4 ±0.5
Propanol	20 ±0.2	2.5 ±0.5
	30 ±0.2	21.4 ±0.5
	40 ±0.2	13.8 ±0.5
	50 ±0.2	32.6 ±0.5
	60 ±0.2	265.8 ±0.5
Butanol	20 ±0.2	1.2 ±0.5
	30 ±0.2	16.8 ±0.5
	40 ±0.2	38.2 ±0.5
	50 ±0.2	44.6 ±0.5
	60 ±0.2	122.4 ±0.5
Pentanol	20 ±0.2	0 ±0.5
	30 ±0.2	6.8 ±0.5
	40 ±0.2	46.4 ±0.5
	50 ±0.2	48.8 ±0.5
	60 ±0.2	134.6 ±0.5

Table 2: *Consolidated Data from the experiment*

4 *Analysis*

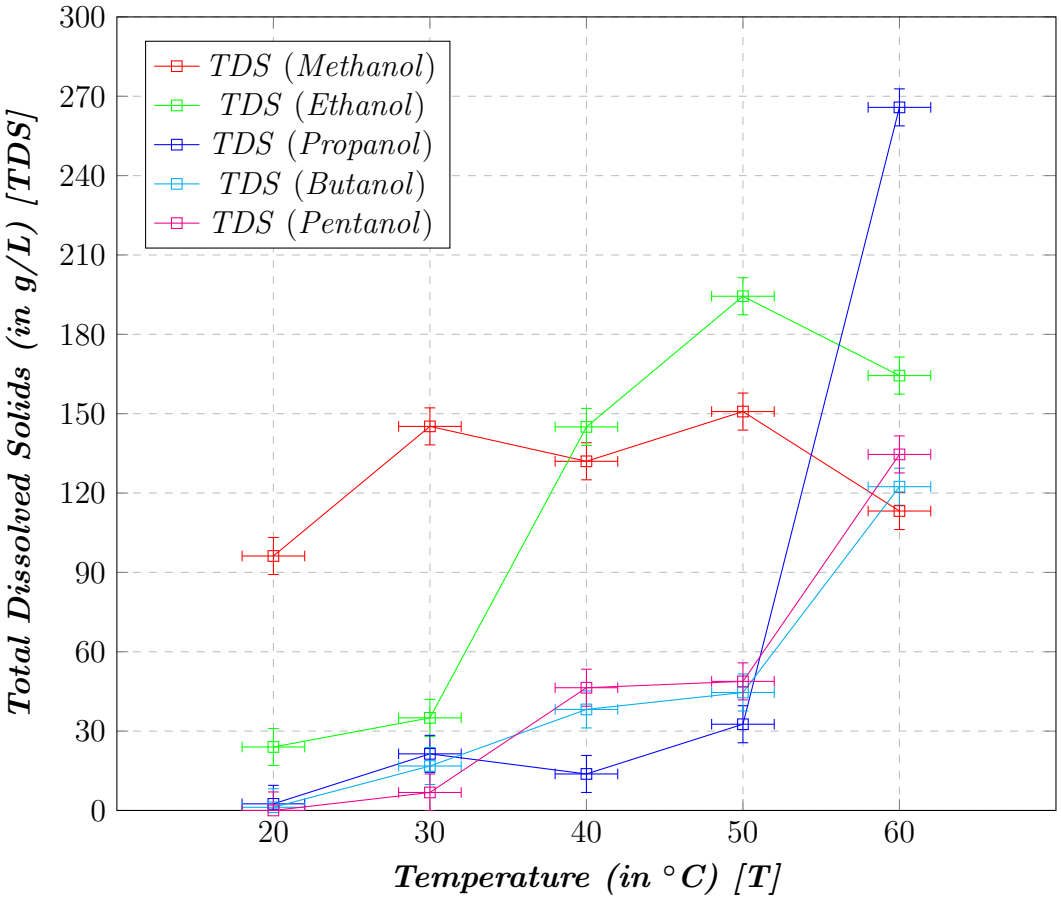

Figure 1: *Graph in relation to the* ***experimental*** *values of* ***TDS*** *versus* ***temperature***

The above graph is the ***line graph*** *based on the averages of the* ***data points*** *of the* ***experimentally collected values*** *The error bars represent the error in the measurement of both* ***temperature*** *and the* ***TDS*** *readings.*

Using the data points from this data set plotted on the above graph, a cubic regression model was created an plotted to ***effectively study the trends*** *of the behavior/phenomenon of the solubility of Oxalic acid in various alcohols with change in temperature.*

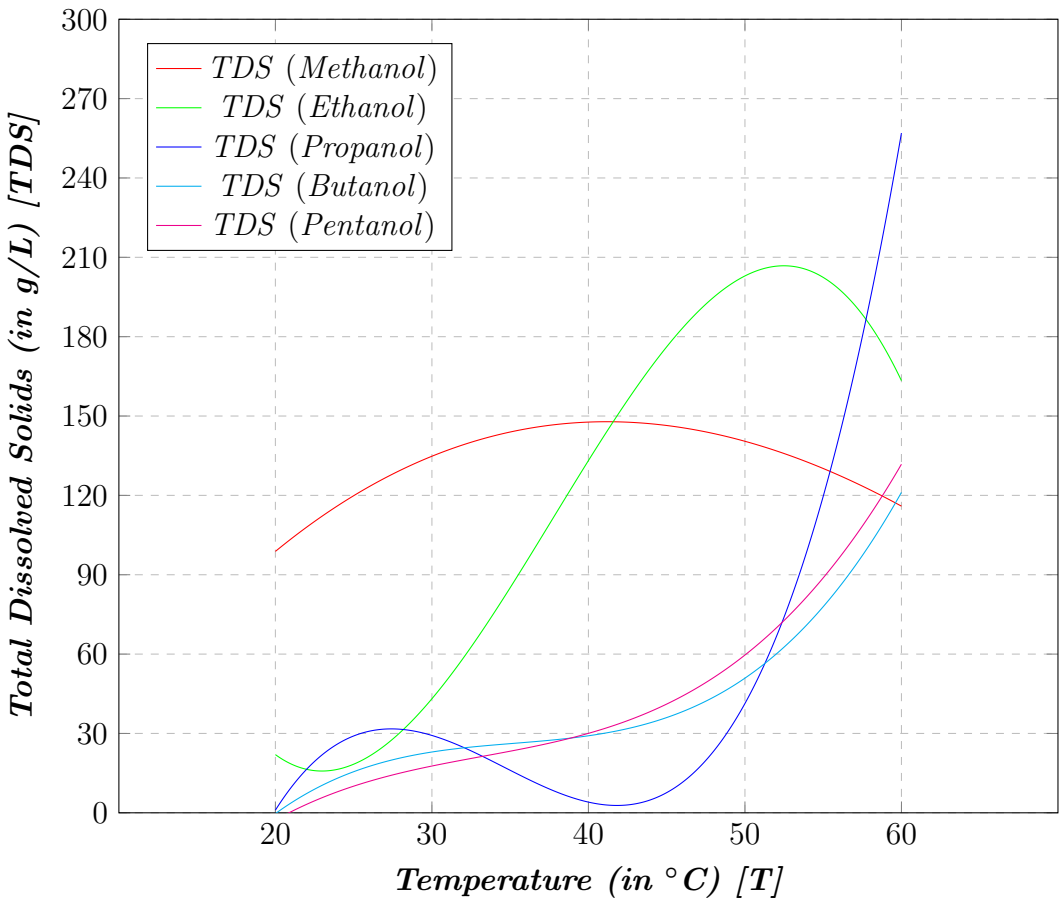

Figure 2: *Graph in relation to the* ***regression line*** *of* ***TDS*** *versus* ***temperature***

The above graph is the ***cubic regression*** *of all* ***data points*** *within the* ***data set*** *of* ***experimentally collected values****. A* ***cubic regression*** *was utilized to plot the* ***line of best fit****, because a regression creates an* ***accurate model*** *of the system according to the data points and is a* ***mathematical function of each and every data point****. This was used rather than plotting an simple line between the range of the* ***maximum and minimum*** *values of the data points, as it would be similar to guesswork.*

Note*: The* ***cubic regression*** *was plotted to only* ***study the trends*** *(gradation) of the* ***changes in the solubility of Oxalic acid in various alcohols with changes in temperature****. The cubic regression model does* ***not*** *accurately model the* ***behavior of the phenomenon*** *of the solubility in alcohol's, though it can* ***predict the trends*** *at a given* ***temperature range***

(domain of temperature in the study).

***Note**: Due to constraints of resources, a **cubic regression model** was utilized instead of a **quintic** or a **higher order regression model**, but the part of the model that we are to analyze exhibits **accurately similar behavior** over temperature to a higher order regression model when restricted in the domain from 20 ° C to 60 ° C.*

On effectively studying and analyzing the above graph (regression graph) with scrutiny, we observe that,

- *The soluility of all alcohols generally **increases** with **increase in temperature**, till a cutoff point which is the point at which the **trend of the model reverses***
- *The cutoff point generally increases with increase in temperature over the hierarchy of the homologous series of alcohols, ie. **The cutoff point in alcohols generally increases with respect to temperature as the length of the hydrocarbon chain increases***
- *Alcohols that are **odd** in the hierarchy of the homologous series of alcohols, first tend to **increase** and then **decrease** (this pattern may sequentially continue), this pattern can be evident by studying the trends of **Methanol**, **Propanol** and **Pentanol***
- *Alcohols that are **even** in the hierarchy of the homologous series of alcohols, first tend to **decrease** and then **increase** (this pattern may sequentially continue), this pattern can be evident by studying the trends of **Ethanol** and **Butanol***
- *The solubility of Oxalic acid in various alcohols (in the order of the hierarchy of the homologous series of alcohols), generally **decreases**, ie. **The solubility in alcohols generally decreases as the length of the hydrocarbon chain increases***
- *The solubility of Oxalic acid in a particular alcohol, generally **increases** with increase in temperature*
- *The solubility of Oxalic acid in various alcohols (in the order of the hierarchy of the homologous series of alcohols), generally **decreases** with increase in temperature, ie. **The solubility in alcohols generally decreases with respect to temperature as the length of the hydrocarbon chain increases***

5 *Limitations of Study*

There are various limitations in this study/investigation as we have placed forth, certain strict conditions that make this system so constrained and disables us to expand our researching capability of this chaotic phenomenon. Conditions such as,

- *Restricting the value of temperature domain from* $20°$ *Celsius to* $60°$ *Celsius*
- *Restricting the study to only incorporate the first five alcohols from the homologous series of alcohols*
- *Using an cubic regression model instead of an higher order regression model*

6 *Safety Measures*

The Safety Measures that were taken during the experimentation as as follows:

- *Proper Laboratory equipment was utilized to conduct and collect data*
- *All Laboratory equipment was used in the presence of Lab instructors and Lab personnel*
- *The experiment was performed at a distance from the observer so as to, limit or eliminate the chances of any possible physical harm to the observer*
- *Any and all lab equipment was thoroughly examined for any defects that could potentially lead to safety hazards, before initiating experimentation*
- *It was made sure the experiment shall not be performed to highly flammable materials that would result in combustion from the frictional force onto the alcohols*

7 *Sources of Error*

There are various ways through which errors might have crept into our raw and ordered data, some of the possible sources of errors are:

1. *Raw experimental data presented here in the investigation report is collected through lab experimentation, and there are chances that the data collected may have slight discrepancy in it*

2. *Insignificant random human errors by the observer, ie. parallax errors*
3. *Uncertainties that cannot be minimized due to lack of highly sophisticated equipment and materials used in the experiments in this investigation*
4. *Assumptions and certain conditions put forth on the the system to model its chaotic behavior*

8 *Conclusion*

In this paper, I have shown the effects of changes in the ***temperature*** *on the* ***solubility*** *of Oxalic acid on various* ***alcohol solutions*** *by collecting raw data relating to the above parameters, under certain controlled conditions as so to completely study the* ***temperature dependence of solubility of Oxalic acid in various Alcohols with respect to a gradation on the homologous series****.*

References

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