**Lab 09 Separating a Mixture using Differential Solubility**

Lab Equipment

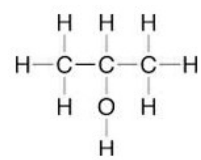
| | | |
|---|---|---|
|  Safety goggles |  Balance |  10 mL graduate cylinder |
|  100 mL and 150 mL polypropylene beaker (or two plastic cups) |  graduated pipet |  Large plastic cup for waste solution |

Student Supplied:

| | |
|---|---|
| Rubbing alcohol solution   70% by volume rubbing alcohol 2-propanol(*aq*) |  small empty jar with lid (an empty rinsed 10 oz or small food jar e.g. salsa) or clear water bottle |
|  Table salt (non-iodized) | |

**Background Information**

Rubbing alcohol or isopropyl alcohol (2-propanol) is usually sold in concentrations of 70% by volume aqueous solutions. It is used as a disinfectant and cleaning agent. Since it has a vapor pressure that is higher than water, it evaporates more quickly than water and feels cool when applied to the skin.



2-propanol has the alcohol functional group on its second carbon of the 3-carbon propyl chain[1].

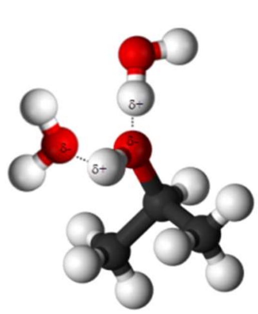
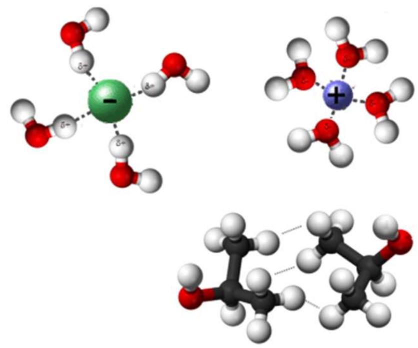
More concentrated solutions of 2-propanol, 90% solutions, require special shipping because they are more flammable than the 70% solutions. As a result, it is difficult to find 90% rubbing alcohol solutions in stores. If you have 90% rubbing alcohol, you can dilute[2] it to 70% by volume for this experiment and use it undiluted for the next experiment.

In this experiment you will make a dilute solution of 2-propanol solution and then decrease the propanol's solubility in the solution by having the water molecules separate from the 2-propnaol to form ion-dipole attractions with salt.

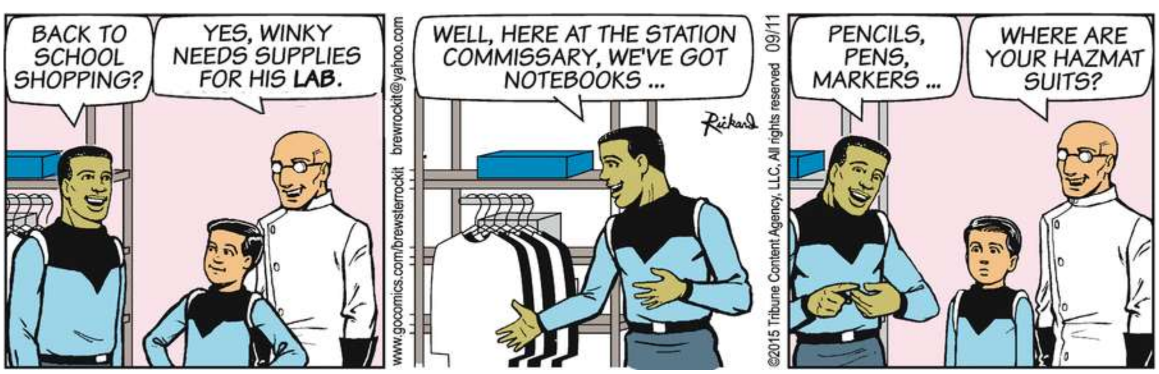
In addition to my Virtual lab you can view this experiment as done by Yeo Yong Kiat, a Chemistry teacher, at Juying Secondary School, Singapore.

[1] 1-propanol also called normal or n-propanol. 1-propanol is used in specialized pharmaceutical preparations.
[2] Use your volumetric flask to get 50 mL of 90% alcohol, pour the alcohol in a beaker and then add between 6-7 mL of water to it. Volumes are not perfectly additive in alcohol dilutions, but this will be accurate enough for the experiment.

$$C_1 \times V_1 = C_2 \times V_2$$
$$90.\% \times 50 \text{ mL} = C_2 \times 70\%$$

| | |
|---|---|
|  |  |
| 2-propanol readily forms hydrogen bonds with water molecules. The drawing shows the two polar Hδ⊕ of water molecules attracted to the alcohol's oxygen atom's negative dipole, Oδ-.<br><br>Likewise, the Hδ⊕ of the alcohol's -OH group is attracted to the negative dipole of the water molecules.<br><br>Because of the hydrogen bonding of the water to the OH functional group 2-propanol, 2-propanol is miscible with water. | If a soluble ionic compound is put in a 2-propanol water mixture, the ions of the ions of the ionic compound will compete for the water molecules that have formed hydrogen bonds with the 2-propanol.<br><br>Water molecules will preferentially surround each ion because the polar water molecules are attracted to the ion charges. This type of intermolecular attraction is classified as dipole-ion.<br>100 g of water can dissolve 36 grams of sodium chloride using dipole-ion attractions.<br><br>The 2-propanol because of the London dispersion forces will not be as attracted to NaCl's ions.<br>100 g of 2-propanol can only dissolve 0.003 g of NaCl.<br><br>With the water molecules attracted to the charges of the ions in solution, the 2-propanol's London dispersion forces will be left to form intermolecular attractions with one another. The 2-propanol will "precipitate" from the solution. |

**Hazards**
2-propanol is flammable. Read the cautions on the bottle. Don't perform this experiment in a kitchen with an open flame source such as a gas range.



**Procedure:**

1. Measure out about 75 mL of the 70% by volume rubbing alcohol solution into the 150-mL plastic beaker using the approximate volume graduations on the side of the beaker. Add water to produce approximately 125 mL of solution. Mix by stirring with the gradated pipette. Note that the isopropyl alcohol is miscible with water as the two solutions readily mix to make a homogeneous solution.

2. Using your balance, 10-mL graduate cylinder, and pipette to find the mass of 10.0 mL of this diluted solution. Calculate the density and using the density table at the end of the instructions, determine the % by volume of the 2-propanol in this mixture.

3. Pour the diluted rubbing alcohol solution into the glass jar and put the lid on securely. I used a water bottle, but any empty, cleaned small glass jar or bottle that can be sealed will work.

4. Tare a dry 100-mL plastic beaker (or light plastic up) on the balance. Remove the beaker from the balance and pour about three tablespoons or about 50 mL of finely granulated table salt into the beaker. Don’t use coarse salt since you want a larger surface area so that the salt will dissolve quickly. Reweigh. Adjust the amount of salt to between 50-60 g of salt.

5. Open the lid of the jar with the diluted 2-propanol and pour the salt into a glass jar. Seal the jar and keeping the jar away from your face, shake to mix the diluted rubbing alcohol solution with the salt.

6. Put down the jar and let the mixture settle for at least 5 minutes. As the mixture settles you will see two liquid layers. There will be a clear top layer and a second cloudy layer under the clear layer with undissolved salt crystals in it. You will see wavelike oscillation between the two layers when you gently tip the jar back and forth.

7. Unscrew the lid. Slowly decant most of the top layer into the 150-mL plastic beaker leaving behind the bottom layer of salt solution and undissolved salt. Decanting a solution is typically done using a glass rod. The liquid adheres to the clear glass, controlling the stream of decanted liquid. However, since you don’t have a glass rod you can just carefully pour.

8. Find the density of this new 2-propanol solution as you did in step 2.

9. Use the density table to find the new propanol concentration. Empty the 2-propanol in the graduate back into the 2-propanol in the 150-mL plastic beaker.

10. Empty the remaining salt-water solution into waste plastic cup. Rinse and dry the glass jar as best you can and pour the now more concentrated 2-propanol solution back into the jar and seal the lid. Put a label on the jar as 2-propanol and its % by volume. It will be used in the next experiment.

ρ = density of propanol solution in g/mL

% 2-propanol by volume = $-1320.3\,\rho^2 + 1906.5\rho - 585.46$

| Density | % 2-propanol by volume |
|---|---|
| (g/mL) @20°C | mL propanol / 100 mL sol'n |
| 0.940 | 40 |
| 0.935 | 43 |
| 0.930 | 46 |
| 0.925 | 48 |
| 0.920 | 51 |
| 0.915 | 54 |
| 0.910 | 56 |
| 0.905 | 59 |
| 0.900 | 61 |
| 0.895 | 63 |
| 0.890 | 66 |
| 0.885 | 68 |
| 0.880 | 70 |
| 0.875 | 72 |
| 0.870 | 74 |
| 0.865 | 76 |
| 0.860 | 78 |
| 0.855 | 79 |
| 0.850 | 81 |
| 0.845 | 83 |
| 0.840 | 84 |
| 0.835 | 86 |
| 0.830 | 87 |
| 0.825 | 89 |
| 0.820 | 90 |
| 0.815 | 91 |
| 0.810 | 93 |
| 0.805 | 94 |
| 0.800 | 95 |
| 0.795 | 96 |

| | |
|---|---|
| | Separating a Mixture Using Differential Solubility |

*Purpose: To use different intermolecular attractions to increase the concentration of a 2-propanol solution.*

*Apparatus:*

- *Digital balance (0.01 g accuracy)*
- *150-mL beaker*
- *10-mL graduate cylinder*
- *plastic pipette*
- *sealed glass jar*
- *plastic cup for waste solution*

*Procedure:*

*Detailed instructions for this experiment can be found in my Lab Binder.*

*I diluted 75 mL of the 70% 2-propanol with water to make approximately 120 mL of solution.*

*I found the mass of the 10-mL graduate cylinder, its empty mass was 7.53 g*

*I filled the graduate to the 10.0 mL mark with the diluted rubbing alcohol mixture. The solution had a faint distinctive odor.*

*10.0 mL solution and graduate weighed 16.67 g*
*The mass of the rubbing alcohol alone was (16.67 g – 7.53 g ) = 9.14 g for 10.0 mL of rubbing alcohol.*

*The density of the rubbing alcohol was 9.14 g/ 10.0 mL = 0.914 g/mL*

*Using the table of density and concentration found in the lab instructions, the density of the 0.914 g/mL rubbing alcohol (@20°C) would indicate approximately 54% by volume, what I expected from the dilution.*

*I measured 55 g of table salt, NaCl and then added to the isopropyl alcohol solution in the jar. I sealed the jar with a screw lid and shook the mixture for 30 sec.*

*Then I let the cloudy mixture settle for 10 minutes. Much of the salt had not dissolved and it settled to the bottom of the jar. Just above the salt layer was a cloudy layer with a wavy interface between the clear layer above. Gently rocking the beaker showed interesting waves in this interface.*

*I decanted the top liquid layer into the 150-mL beaker leaving the denser, cloudy layer behind in the jar. There was about 40-mL of this liquid*

Using the pipet, I was able to extract 10.0 mL of the less dense liquid and weigh it using the previously tared graduate cylinder. The mass of the graduate and less dense liquid was 17.31 g. The mass of the liquid was (15.96 g – 7.53 g ) = 8.43 g

Calculating the density:

$$8.143\text{g} / 10.0 \text{ mL} = 0.843\text{g/mL}$$

With this lower density, the solution must have been 2-propanol that was now more concentrated than the original 2-propanol solution. Using the table, I estimated that the solution was 84% by volume 2-propanol.

There may have some dissociated sodium chloride in the solution with the remaining water in this mixture. This would increase the density of the solution. So, the concentration of alcohol might have been greater than 84% since the tables presumed a water-alcohol solution and did not include any salt in the water.

I poured the denser saltwater solution back into the waste plastic cup and then poured the less dense, more concentrated propanol solution into the glass jar, put the lid on, and labelled the solution as 84% by volume 2-propanol for the next experiment, chromatography.

Conclusion

This separation process is called salting out. The water molecules in the alcohol solution were attracted to the ions of the sodium chloride, and the water molecule dipoles surrounded the sodium and chloride ions producing the denser bottom layer of saltwater solution. This left the 2-propanol to form intermolecular bonds with one another making a lower density layer on top.

I will use this concentrated 2-propanol solution for the next experiment where I will use it as a solvent to help separate a mixture using chromatography.