Drying A Dollar Bill With A Mixture Of Ethanol 70% and Water

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Abstract:

The ethanol-water mixture is widely used as a solvent in many scientific experiments and has been used to dry glass materials in the laboratories. In this experiment, ethanol (70%)-water mixture will be used to dry wet money bills. To test this, the mass of the wet and dried bills is measured prior to, during, and after the experiment is completed. As a result, the dried bill that was soaked in the mixture and the dried money bill that was not have the same mass due to the hydrogen bonding in ethanol that reacted with water, converting it to gases.

Introduction:

The mixture of ethanol and water is a clear, colorless liquid [1]. Ethanol (CH3CH2OH) is widely used as a solvent and preservative in pharmaceutical preparations, in addition to serving as the primary ingredient in alcoholic beverages [1]. Industrially, ethanol is produced both as a petrochemical, through the hydration of ethylene, and biologically, by fermenting sugars with yeast[1]. Small amounts of ethanol are endogenously produced by gut microflora through anaerobic fermentation [1]. However, most ethanol detected in bio fluids and tissues likely comes from the consumption of alcoholic beverages [1]. Absolute ethanol or anhydrous alcohol generally refers to purified ethanol, containing no more than one percent water[1]. Generally absolute or pure ethanol is used as a solvent for lab and industrial settings where water will disrupt a desired reaction[1] ,[2].

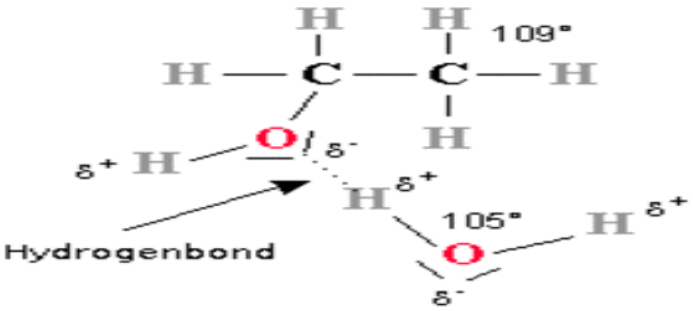
The mixture of ethanol and water is mostly used in laboratory to dry glass materials. This mixture reacts to form two types of gases as shown in the reaction below:

$$CH3CH2OH\ (liq) + 3H2O\ (liq) \xrightarrow{Heat} 2CO2\ (gas) + 6H2\ (gas)$$

This mixture doesn't behave like pure water nor like a pure alcohol [2]. A closer examination reveals that except for the oxygen atom, the ethanol molecule is symmetrical to a perpendicular

plane between the carbon atoms [2]. Only one hydrogen atom has been replaced by a hydroxyl group(-OH). In sum, the ethanol molecule is electrically neutral, but the hydroxyl group causes local differences in electronegativity, which is called dipole-dipole interaction) [2]. Normal water molecules have these dipoles, too, since they too are angled (109°) [2]. These dipoles on ethanol and water molecules cause the formation of hydrogen bonds between the molecules as shown in Fig 1[2].

Figure 1: Chemical structure of the mixture (Ethanol and Water) [2].



As a result of this experiment, we expect to find the masses of both bills (the dried one and the one that was dried after being soaked in ethanol) to be the same. Furthermore, we will see how some important physical and chemical properties change as a function of the temperature in these mixtures.

Objective

This experiment measures the mass of a bill before and after soak it in a mixture of water and ethanol 70%.

Materials

Figure 2: the materials used in this experiment

- ✓ Two graduate plastic cylinders (50 ml)
- ✓ 50 ml of CH3CH2OH (ethanol) 70%
- ✓ 50 ml of H2O (tap water)
- ✓ Two chopsticks or any other holder
- ✓ 100ml glass beaker
- ✓ Plastic pipette (10 ml)
- ✓ Small plate (plastic or glass)
- ✓ Lighter or any other fire sources
- ✓ Money bill (one dollar)
- ✓ Balance 1mg-100g
- ✓ Cooking thermometer
- ✓ A stopwatch or a phone chronometer

Experimental procedure

1- 50.0 ml of ethanol (C2H5OH) 70% (Molar mass of C2H5OH = 46.07 g/mol) was poured into the first graduate cylinder using a plastic pipette (see figure 3).

Figure 3: the measurement of ethanol 70%

2- 50 ml of tap water (H2O) (Molar mass of H2O = 18.01528 g/mol) was poured into the second graduate cylinder using a plastic pipette.

   (a) Some precautions were taken in order to minimize the systematic errors of measurements. The ethanol and water were measured many times using the same protocol, which is known as precision measurement.

3- The mass of a dry bill was measured using the laboratory balance before and after the experiment, and it was noted in order to compare it.

   (a) Then the bill was soaked for three-five minutes (3-5 min) in a cup of tap water to make it wet.

   (b) The mass of the wet dollar bill was measured using a laboratory balance.

4- The two liquids, 50/50 ethanol and water, that I already measured in step 2 and 3 were mixed into a 100 ml beaker.

   (a) The temperature of the mixture (water and ethanol) was measured using the thermometer at t=0s and at t=90s

   (b) The mixture was poured in a small plastic plate

   (c) The wet dollar bill was soaked in the mixture solution for about 3-4 min (180-240s)

   (d)

Figure 4: the money bill is soaked in the mixture ethanol-water

(e) The wet dollar bill was taken out of the solution using a (holder or) chopstick

5- The magic step: Using a lighter or any other source of fire the bill was heated till it dried. No worries. It won't burn if you have the exact measurement (see fig 5).

Figure 5: Heating the money bill by a lighter.

6- After the experiment was complete, the dry bill (the bill that was soaked in the mixture) was measured again in order to compare its mass to the initial mass of the bill, before it was soaked in the mixture solution.

Experimental results

The dry bill that was soaked in the mixture was observed to have the same mass and shape as the dry bill that was measured before the experiment (see figure 6,7 and table 2).

Figure 6&7: A dollar bill after being soaked in ethanol-water and dried by a lighter.

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The observation is that the volume of the mixture ethanol-water decreased in comparison to what was expected (100 ml) to about 97.4 ml (See figure 8 and table 1).

Figure 8: the mixture solution of ethanol-water.

The temperature of the ethanol and water were measured before and after mixing both of the liquids (water and ethanol). The observations included a displayed increase in temperature compared to the initial temperature of the liquids prior to mixing them (See table 1).

The results are presented by the tables below:

Table 1: the volume and temperature of ethanol, water and the mixture

	Ethanol 70% (C_2H_5OH)	Tap Water (H2O)	Solution (ethanol 70% + water)
Average volume needed in milliliter (ml)	50.0 ml	50.0 ml	97.4 ml
Temperature in °C	21.3	13.6	24.5

Table 2: the mass of dry and wet bill

	Dry bill before the experiment	Wet bill (Soaked in water)	Dry bill after the experiment	Wet bill (Soaked in ethanol-water)
Average mass of dollar bill by grams(g)	0.987	2.035	0.987	1.670

Analysis of the results

Although it is known that a mixture of ethanol 70% and water is used to dry glass in the laboratory, it has rarely been used to dry other materials. It came to my attention that it might be used to dry paper money bills and all kind of papers that get wet. The money bills dried after being soaked in the ethanol-water solution and after getting heated by a lighter. The hydrogen

bonding (bond between oxygen and hydrogen) caused ethanol 70% to be hygroscopic to the extent that it readily would absorb water from the air [2]. The addition of even a few percent of ethanol to the water sharply reduced the surface tension of water [2]. This property partially explains the "tears of wine" phenomenon [2]. When wine is swirled in a glass, ethanol evaporates quickly from the thin film of wine on the wall of the glass [2]. As the wine's ethanol content decreases, its surface tension increases and the thin film "beads up" and runs down the glass in channels rather than as a smooth sheet, explaining why the ethanol-water volume decreased when getting mixed [2].

The temperature increase was expected because the reaction between ethanol and water is exothermic, releasing heat to the surrounding. It can be felt by touching the beaker where the reaction took place.

The mass of the dried bills after the experiment was found to be the same as the mass of the dried bills before the experiment because the mixture absorbed water from the bill after heating it. The rest of the mixture converted to CO2 and H2 gases that evaporated.

This experiment could have wide-ranging implications industrially and in our daily life, especially during rainy days when books or notebooks get wet. It is of course possible that there were things in the experiment that were not properly controlled like the cleaning of the materials before using them. However, generally the experiment was flawless, and I did not face any difficulties. If the material was not well rinsed prior to the experiment or the quality of ethanol was lower, the experiment would not have worked and the money bill would have been burnt instead of getting dried.

Acknowledgments

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Reference List

[1] "Ethanol," National Center for Biotechnology Information. PubChem Compound Database. [Online]. Available: https://pubchem.ncbi.nlm.nih.gov/compound/ethanol#section=Other-Identifiers.

[2] "Alcohol and Water," Bourbon - Grain Selection and Mixture (Mash Bill) - Whisky.com. [Online]. Available: https://www.whisky.com/information/knowledge/production/background-knowledge/alcohol-and-water.html.