COSMOS Cluster 3
Summer 2013

Clouds in Rootbeer

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References: *Atmospheric Chemistry and Physics*
J.H. Seinfeld and S.N. Pandis, 1997
Clouds in a Glass of Beer: Simple Experiments in Atmospheric Physics
C.F. Bohren, 1987

Objectives:

As part of this demonstration, the student will be able:

1. to observe the difference in carbonation of water and root beer to form clouds in root beer
2. to form clouds in root beer using different particles
3. to understand the concepts of super saturation, heterogeneous nucleation and cloud condensation particles
4. to begin to think about how simple controlled demonstrations can represent real world processes, and compare and contrast physical systems that we encounter on a daily basis

Introduction:

We have all seen bubbles grow inside soda. We call these 'carbonated beverages' because the gas carbon dioxide (CO_2) is purposely supersaturated in the liquid. Super saturation means the liquid has more CO_2 than it would have if it were in equilibrium. Nature, as we will see in this class, likes to maintain equilibrium, or balance. To make the CO_2 balance between the liquid and the atmosphere bubbles form to release the excess CO_2.

You may notice that this does not occur all at once, but rather through the creation of many small bubbles that rise to the top. The process known as 'heterogeneous nucleation' is required to form bubbles on preexisting particles. Literally, this means making or generating ('-geneous') a 'nucleus' out of different ('hetero-') substances. It is this small nucleus that attracts more CO_2 around it until it becomes large enough to be a bubble that can float to the top. Make enough of these bubbles, and one will have a cloud inside a glass of root beer!

Today we will demonstrate how adding particles in a glass of root beer allow for heterogeneous nucleation of CO_2 to make clouds in the liquid.

Experiment

Each group of 4-6 students should have:

2 empty beakers
1 can of root beer
1 bag of sand
1 bag of sea salt
1 baking sheet

All tests should be performed with the bottles on the baking sheet to avoid spilling.

Fill 1 water bottle half way with water. This will be our control bottle.

SLOWLY empty the root beer into the second water bottle. Try not to make too much foam on the top.

SLOWLY drop a few grains of salt into the water bottle. *Does anything happen?* Try the same for a few grains of sand.

Now slowly and carefully drop a FEW grains of salt at a time into the root beer. Be careful not to overflow the foam - but be prepared with the baking sheet in case it does. *Observe what happens in this different super saturated environment.*

You may wonder, is this a chemical reaction? Test the sand the same way you tested the salt. *Does anything different happen?*

Afterthoughts

You should have observed the following:

1) no bubbles or clouds formed in the water with sand OR salt
2) clouds formed in root beer with BOTH sand and salt

Try to generalize the concepts we introduced with your observations…
You should come to the conclusion that water does not contain any supersaturated CO2. *Why can we say this?*

You should come to the conclusion that root beer is indeed carbonated with supersaturated CO2. *How do we know this?*
You should also convince yourself that the process is more a physical transformation of phase change (liquid to gas) and less dependent on chemistry. *What about the testing of salt versus sand makes this claim valid?*

As with any experiment, the most important part of the scientific method is to apply the isolated test case to real world examples. *Can you think of any other situations where clouds form from heterogeneous nucleation? Can you think of any other liquids or gases that may be supersaturated in our environment? Can you think of any other types of cloud condensation nucleus particles? What roles might these play in the weather and climate?*