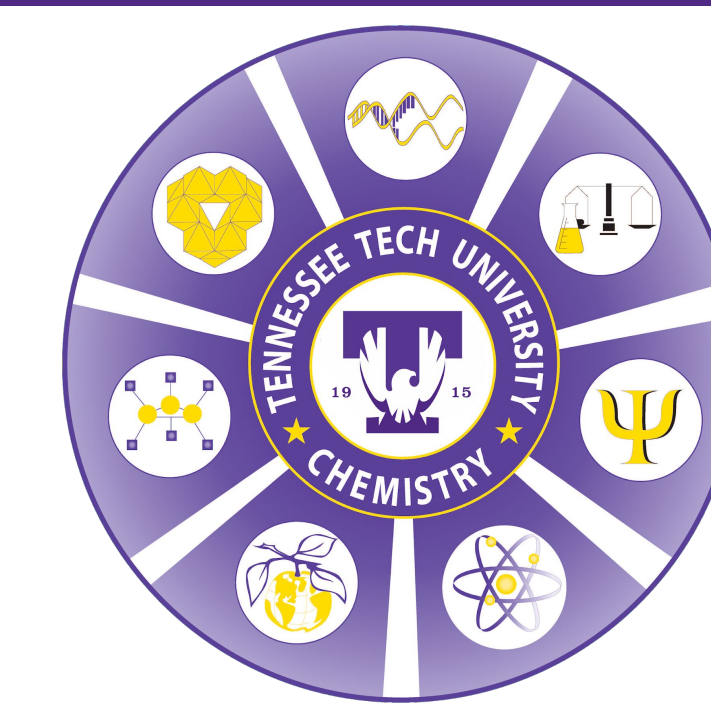




Increasing the Safety of the Rainbow Flame Test

Abigail Rossi, Amanda J. Carroll. Department of Chemistry, Tennessee Technological University, Cookeville, TN 38505, United States



Introduction

The rainbow flame test is traditionally done for students to show how emission spectra of ions are different. The test has been conducted with methanol, a highly flammable solvent, or hand sanitizer, which contains alcohol and is also flammable. In Virginia, six students were injured when their teacher performed the demonstration with methanol.¹ As a result, the ACS issued a Safety Alert, which was followed by a new procedure.² In order to improve the safety of the students, faculty, and larger community, the chosen solvent will be water. All the salts chosen are soluble in water. Another issue has been the toxicity of the salts. Barium, a highly toxic element, is normally included as it gives the color green. The ACS sanctioned method is a longer method designed to be prepared two weeks before the demonstration will be performed, while the method presented here can be prepared the night before with no long waiting period.³ The ACS method also uses barium, which this experiment includes only to see if barium or copper gives a better, more vibrant color.

Experimental

- Saturated solutions were prepared by mixing DI water with the salt until the salt no longer dissolved.
- A wooden coffee stirrer and a cotton swab were allowed to soak overnight in the solution in a screw-top test tube.
- Some of each solution was placed into spray bottle
- In a hood, set up a Bunsen burner connected to the hood's gas line.
- Using tongs, remove wooden stirrer from test tube.
- Place wooden stirrer in flame, allowing it to touch the center of the flame.
- Once finished, place wooden stirrer in a small beaker containing water.
- Remove cotton swab from test tube.
- Place swab in flame. When finished, place swab in a small beaker containing water.
- Ensure spray nozzle is aimed in correct direction and aim upward at a 45° angle to the top of the flame. Spray.
- Dispose of all materials properly according to their SDS information.



Figure 1: Strontium chloride flame by spray method



Figure 2: Strontium chloride flame by wooden stirrer method



Figure 3: Strontium nitrate flame by spray method



Figure 4: Bunsen burner flame with no added salts



Figure 4: Magnesium chloride flame by spray method



Figure 5: Magnesium sulfate flame by spray method



Figure 7: Copper (II) chloride flame by spray method

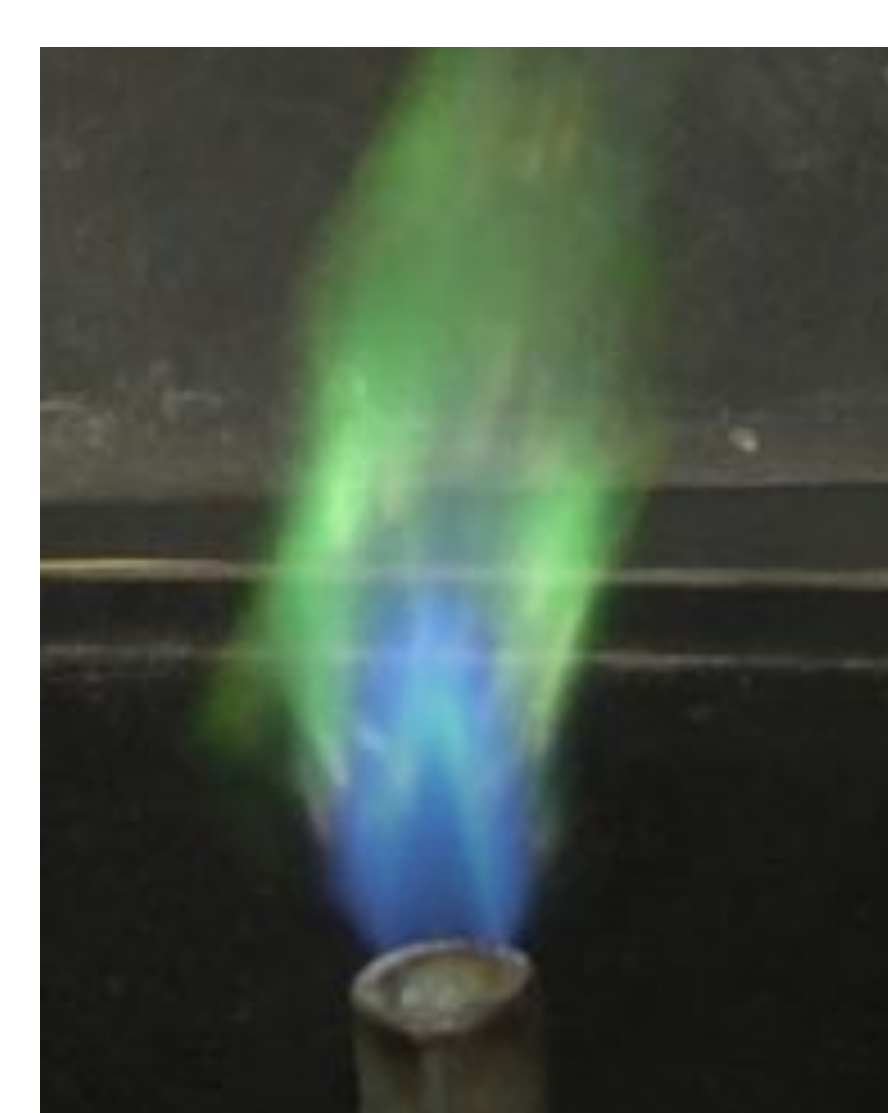


Figure 8: Copper (II) sulfate flame by spray method



Figure 9: Barium chloride flame by spray method



Figure 6: Potassium chloride flame by spray method



Figure 10: Borax solution flame by spray method



Figure 11: Sodium chloride flame by spray method



Figure 12: Calcium chloride flame by spray method



Figure 13: Calcium nitrate flame by spray method

Results

The flames were rated in a qualitative manner based on visual inspection on a zero to ten scale, where ten was a highly-colored, bright flame that was easily seen and zero was no flame change at all.

Salt	Color	Spray Bottle Intensity	Cotton Swab Intensity	Wooden Stirrer Intensity
Magnesium chloride	white	4	0	3
Magnesium sulfate	white	5	0	0
Sodium chloride	yellow	10	5	8
Borax	green	10	0	5
Copper (II) sulfate	blue	10	0	8
Copper chloride	blue	10	10	10
Barium chloride	green	7	2	0
Strontium chloride	red / orange	10	7	5
Strontium nitrate	red / orange	10	8	7
Calcium nitrate	red / orange	10	0	2
Calcium chloride	red / orange	10	0	5
Potassium chloride	light purple	8	0	6
Average Rating for Each Method		8.7	2.7	4.9

Table 1: Intensity of color based on application method

Discussion

The best delivery method was the spray bottle because it gave the brightest, most highly-colored flame followed by the wooden stirrers. The cotton swabs were the worst because the cotton had to burn so it was the solution soaked into the stirrer that gave the color change. The safest delivery method was the spray bottle, as the worst outcome for it was dousing the flame. Magnesium sulfate and magnesium chloride wouldn't be good choices for this experiment as neither gave a color.

References

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