

Team Project 1 Report

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Flow Visualization

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Purpose:

The purpose of this project was to work with groups from class and capture an interesting and beautiful image of fluid flow. For our project we produced a fire tornado. Luckily our Professor had a personal tabletop flame tornado apparatus that she let us borrow. Initially we placed the apparatus outside but the flame produced was not big enough. We then took a fan and placed it at various spots, which circulated more oxygen into the system creating a bigger and more dramatic flame tornado. After doing some research we decided to add another element to this experiment and drop flame color crystals to produce a bluish green colored flame. The colored flame tornado was then captured with a camera and used as the final image. Chris O'Brien, Ian Macfarlane, Gamal Elbially, and myself collaboratively created this image and report.

Safety:

Since flames and combustion fluids were used to capture our images, a few safety precautions were necessary. First, the experiments were conducted outside which is a well-ventilated area, diluting any fumes that may have been inhaled or considered dangerous. We also kept a fire extinguisher nearby in case any unwanted objects were set aflame. Additionally we used oven mitts when handling any objects that may have been heated by being near the open flame. In order to achieve the desired colors of flames, different chemicals were added to the fuel. These chemicals include: Copper Sulfate, Ammonium Chloride and crystalline silica. According to the MSDS these chemicals have the possibility of irritating the nose, mouth and throat when ingested but by conducting the experiment outside we eliminated that risk. [2] Along with these chemicals a gelled fire starter was used as our main fuel. Again, this fuel was safe to burn in a ventilated area as long as it is not ingested.

Flow Apparatus:

The device used to create the flame is a Tempest Table Top Torch device. This device, which can be purchased at www.tempesttorch.com, creates a nice controlled fire tornado.



Figure 1: Tempest Table Top Torch

The image above shows the apparatus used for our experiment. The Tempest torch is 2 feet tall with 1.5 feet of that height being the glass containing the flame. As seen in the image, there are openings at the corners of the glass, which allow the device to create a tornado like flame. The Tempest Table Top Torch's website describes this phenomena as a Natural Venturi Effect.

The Venturi Effect is caused by a pressure difference. Pressure decreases as the air is forced into the small openings in the side of the glass, leading to an increase in the velocity of the air [1]. We were able to increase the amount of air being pushed into the openings with the use of a fan on the air circulating outside the apparatus. This action heightened the Venturi Effect. The Venturi Effect along with the placements of the slots in the glass create the vortex shape of the flame.

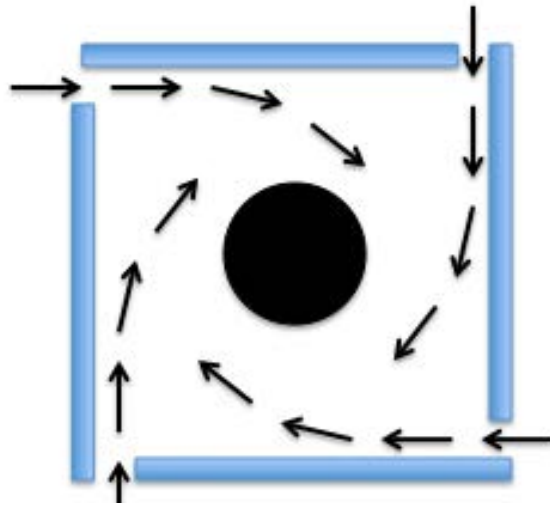


Figure 2: Diagram of wind flow

The diagram above shows how the use of the Venturi Effect and the slots in the glass come together to create a vortex. Once the wind vortex has been created and the fire is lit, the flames follow the wind pattern creating the fire tornado captured in the images.

Visualization technique:

The following materials were used for this experiment: The Tempest Table Top Torch, one BIC Multipurpose Lighter, Westpointe Table Top Fan, RUTLAND One Match Gell Fire Starter, and RUTLAND Rainbow Flame Crystals. We acquired the Tempest Table Top Torch from our professor and the other items were purchased from McGuckin's Hardware Store.

We placed the Tempest Table Top Torch apparatus outside on a second story balcony to conduct the experiment. We waited for the sun to go down at around 8:00 PM on Sunday the 18th of October in order to take away any light from the background of the image. It was partially cloudy that day so there was

little to no light from the Moon. The Schematic of the set up can be seen in figure 3.

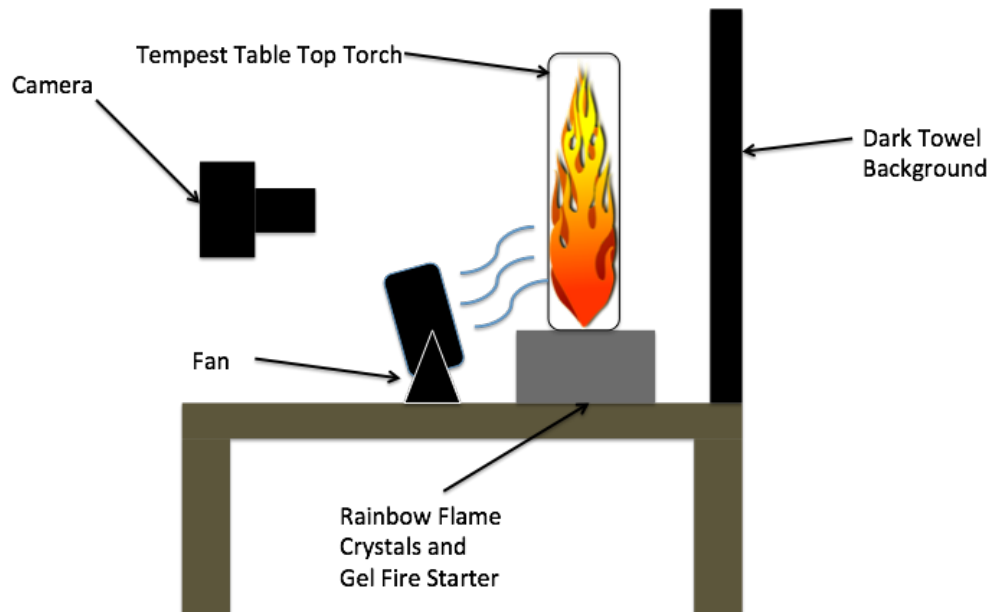


Figure3: Set up of Experiment

Next, the flame was started. Once the flame stabilized, the crystals were added. The crystals contain metal compounds, each of which give off different colors as they heat up. The heat causes electrons within these crystals to gain energy and jump up in energy levels. This excitation is not stable, and therefore as the electrons fall back to their ground state, energy is released in the form of light. Each crystal emits a different color; this is because the size of the gaps between the different energy levels is not the same in all of them. Small energy gaps result in low energy light, while large energy gaps result in high energy light [3].

Photographic technique:

The following camera settings were used when taking this photo:

- Field of View: about 15x3 inches
- Exposure Time: 1/125 sec.
- Aperture: f/5.6
- Focal Length: 28 mm
- ISOS: 3200
- Distance from lens to object: 1.5 feet
- Original image dimensions: 4608x3072 pixels

After the picture was taken I used Photoshop to do the post processing. I first tried to make the background completely dark by using clone stamp. You could see some of the fibers of the dark towel background in the image so I played with the program to get rid of those. I could see the metal columns of the Tempest Table Top Torch so I cloned stamped those as well. This made the fire tornado

stand out. I then played with the curves option on photo shop. I couldn't decide what I liked the best and ended up choosing the auto options which changed the image's colors. I liked this setting best because it brought out the colors of the flame and contrasted well with the black background. You can see the original and final images in figure 4 and figure 5 below.



Figure 4: Original Image



Figure 5: Final Image

Conclusion:

The final image reveals the beauty of flame and how you can form the shape of the fire. I accomplished the goal of our experiment by capturing the tubular tornado flame in the image. Not only did I capture the flame twisting in a circular motion, I can also see the flame tornado spinning up the glass column. There are a couple things I wish I could have done better. One would be taking a high-speed camera and capturing the motion of the flame tornado instead of simply an image. Capturing the motion would show more of the flame physics. Another way I could improve the image is in post processing. I wanted to get rid of the circular opening on the bottom of the flame but could not achieve this.

Sources:

[1] <http://www.tech-faq.com/venturi-effect.html>

[2] http://www.wildwoodovens.com/wp-content/uploads/Rainbow_Stick_msds.pdf

[3] <http://www.chemicalconnection.org.uk/chemistry/topics/view.php?topic=3&headingno=5>

Appendix:

Material Safety Data Sheet

May be used to comply with OSHA's Hazard Communication Standard, 29 CFR 1910.1200 Standard must be consulted for specific requirements.

U.S. DEPARTMENT of Labor

Occupational Safety and Health Administration
(Non-Mandatory Form)
Form Approved
OMB No. 1218-0072

IDENTITY (As Used on Label and List)

Code 715, 715S
Rainbow Flame Crystals & Sticks

Note: Blank spaces are not permitted. If any item is not applicable, or no information is available, the space must be marked to indicate that.

Section I

Manufacturer's Name

RUTLAND PRODUCTS

Emergency Telephone Number

CHEMTREC 800-424-9300

Address (Number, Street, City, State, and Zip Code)

7 CRAB TREE ROAD
JACKSONVILLE, IL 62650

Telephone Number Information

217-245-7963

Date Prepared

July 1990

Date Revised

Sept. 04

Signature of Preparer (optional)

Section II - Hazardous Ingredients/Identity Information

Chemical Identity	CAS #	OSHA PEL	ACGIH TLV	Other Limits Recommended	% (optional)
Copper sulfate, tri-basic	07758-98-7	1mg/m ³	1mg/m ³		
Ammonium Chloride	12125-02-9	10mg/m ³	10mg/m ³		
Silica, crystalline	14808-60-7	0.1mg/m ³	0.1mg/m ³	(respirable)	

(Silica is present in low concentrations as an impurity only. See section VI for discussion of health hazards.)

HMS Rating - Health: 2 Flammability: 0 Reactivity: 0

Section III - Physical/Chemical Characteristics

Boiling Point	N/A	Specific Gravity (H ₂ O = 1)	N/A
Vapor Pressure (mm Hg)	N/A	Melting Point	N/A
Vapor Density (Air = 1)	N/A	Evaporation Rate (Butyl Acetate = 1)	N/A

Solubility in Water

Parts of mixture are soluble in water.

Appearance and Odor

Granular solids, no odor.

Section IV - Fire and Explosion Hazard Data

Flash Point (Method Used)	N/A	Flammable Limits	LEL	UEL
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Extinguishing Media

Carbon dioxide, dry chemical, foam.

Special Fire Fighting Procedures

Use self-contained breathing apparatus in confined spaces.

Unusual Fire and Explosion Hazards

None

The information presented herein is based either on data or opinion. Such data is, to the best of our knowledge, true and accurate. Such opinion is believed to be expert, and therefore generally reliable, but in some instances there are conflict in expert opinion and in these instances we have relied on the opinion which, in our best judgment, appeared the most reasonable. All information herein is presented without guarantee or warranty and Rutland Products disclaims any liability incurred from the use thereof.

Section V - Reactivity Data

Stability	Unstable	X	Conditions to Avoid
	Stable		None

Incompatibility (Materials to Avoid)

ammonium nitrate, acids, alkalis, oxidizing and reducing agents.

Bromine trifluoride, silver salts, iodine heptafluoride, potassium chlor

Hazardous Decomposition or Byproducts

Thermal or acid decomposition may release toxic and hazardous

fumes of chlorine, hydrogen chloride, ammonia and oxides of nitrogen.

Hazardous Polymerization	May Occur		Conditions to Avoid None
	Will Not Occur	X	

Section VI - Health Hazard Data

Route(s) of Entry	Inhalation?	Skin?	Ingestion?
	Yes	Yes	Yes

Health Hazards (Acute and Chronic)

Ingestion: irritation of mouth, esophagus and gastric system.

Inhalation: may irritate nose, throat and lungs.

Eyes: direct contact may irritate or burn eyes.

Skin: may cause irritation, especially under prolonged contact. May result in dermatitis.

Carcinogenicity NTP? No IARC Monographs? OSHA Regulated? No

Respirable crystalline silica from occupational sources is listed by IARC as a human carcinogen.

Signs and Symptoms of Exposure

See health hazards.

Medical Conditions Generally Aggravated by Exposure

Respiratory or skin disorders.

Emergency and First Aid Procedures

Ingestion: drink large amount of water. Call a physician.

Inhalation: move to fresh air. If breathing ceases, begin artificial respiration. Contact a physician.

Eyes: flush with water for 15 minutes. Contact an eye doctor.

Skin: flush with water. If irritation persists, contact a physician.

Section VII - Precautions for Safe Handling and Use

Steps to Be Taken in Case Material is Released or Spilled

Sweep up. Avoid breathing dust.

Waste Disposal Method

Dispose of in accordance with local, state, and federal regulations.

Precautions to Be Taken in Handling and Storing

Protect from moisture. Store tightly closed in cool dry place.

Other Precautions

Keep out of sewer or stream, may be harmful to water organisms.

Section VIII - Control Measures

Respiratory Protection (Specify Type)

NIOSH/MSHA approved respirator for dust.

Ventilation	Local Exhaust	Special
	Sufficient to keep dust below TLV	As needed.
	Mechanical (General)	Other
	Sufficient to keep dust below TLV	As needed.

Protective Gloves	Eye Protection
Rubber gloves.	Face shield, goggles.

Other Protective Clothing or Equipment

Work clothes designed to minimize skin exposure.

Work/hygiene Practices

Wash with soap and water before eating, drinking or using toilet facilities.

Rainbow Flame Crystals

NAME OF PRODUCT: Rainbow Flame Sticks

This product contains the following chemicals subject to the reporting requirements of the Comprehensive Environmental Response, Compensation and Liability Act of 1980 (CERCLA). These chemicals are also subject to reporting under Section 304 of Title III, SARA.

CAS Number	Chemical	% WT	Reportable Quantity
12125-02-9	Ammonium Chloride	15	5,000 lbs.
01344-73-6	Copper Sulfate, tri-basic	15	*****

*****No reportable quantity is assigned to the broad class of copper compounds