

25. Particles 3- fogs

Wednesday, November 13, 2024

YES CLICKERS TODAY

Today:

Particles - how to get/make them
 Finish air, then talk about particles in water.

A) Smoke = solid particles

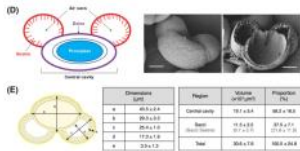
Alumina= Aluminum dioxide

Cheap, common for polishing powders, fillers
 Available in micron and submicron sizes
 Clumps with water vapor - may need drying before use

Pollen and Spores

Pine pollen

Has air sacs, is large but low density, goes far before settling



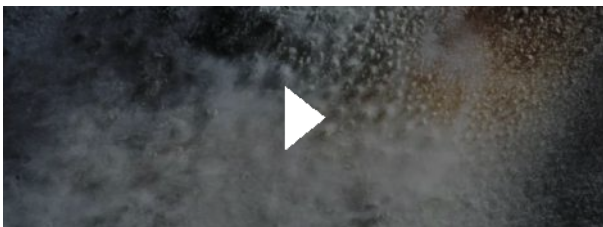
Cheng, Yong, Zhenyu Wang, Wei Quan, Chaoyi Xue, Tao Qu, Tong Wang, Qiuming Chen, et al.
 "Pine Pollen: A Review of Its Chemical Composition, Health Effects, Processing, and Food Applications." *Trends in Food Science & Technology* 138 (August 2023): 599–614.
<https://doi.org/10.1016/j.tifs.2023.07.004>.

Sold as nutritional supplement, but is ground up, destroying air sacs

Lycopodium Powder

Clubmoss spore
 Very flammable, used in magic acts as flash powder and in physics demos

Susi Sie, loudspeaker advertisement. Lycopodium powder and cymatics
[The Essence Of Sound](#)



Chladni nodes

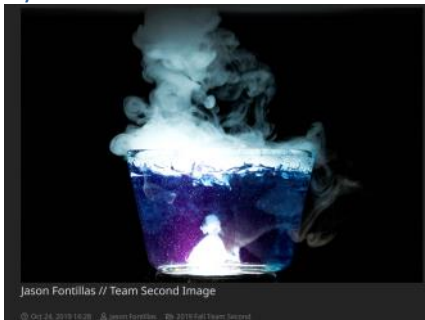
B) Fog = aerosols of liquids

Water fog: Safe, but evaporates quickly

Spray type (cool fog)

- ultrasonic humidifier
- Bernoulli jet
- medical nebulizer
- Pressurized orifice (garden or household spray bottle)

Dry Ice



Clicker: What in the fog is scattering light?

1. Water aerosol
2. Dry ice aerosol
3. Dry ice particles

	2024 vote 1	2024 Vote 2	2023	2022
1	25%	77	63	36%
2	6	8	6	10

Clicker: What in the fog is scattering light?

1. Water aerosol
2. Dry ice aerosol
3. Dry ice particles
4. Carbon dioxide droplets

	2024 vote 1	2024 Vote 2	2023	2022
1	25%	77	63	36%
2	6	8	6	10
3	6	8	6	5
4	44	8	25	47

[Slow Motion Dry Ice at 2000fps](#)



Dry Ice Vapor: Dry ice = solid CO₂

Sublimates (solid to gas) at 1 atm, -78 C (-109 F)

<http://www.dryiceinfo.com/fog.htm>

Submerge in hot water: much water fog created.

Cold stage fog:



A theater fog machine is generally a 30 to 55-gallon metal or plastic water container with a 110-volt or 220-volt water heater to keep the water hot. Dry ice is placed in a bucket with holes to allow hot water to enter. Fog production drops for water temperature < 50 F.

From <https://www.dryiceinfo.com/fog/>

\$2000 or so for a theater sized machine.

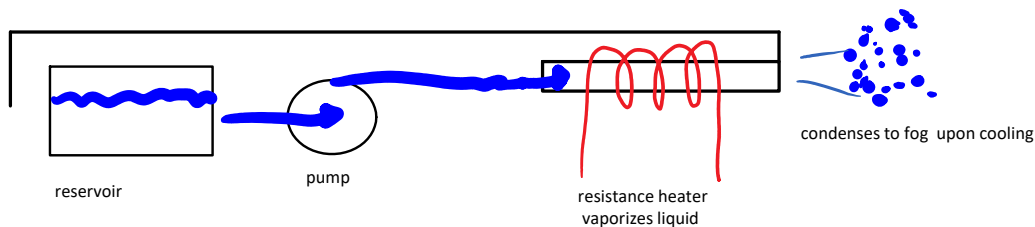
Safety: DO NOT SEAL DRY ICE IN A RIGID CONTAINER. EVER. Expands ~1000x.

60 Pounds of Dry Ice and a Swimming Pool, 2007. http://www.youtube.com/watch?v=uHX90N6igk&feature=youtu.be_data_player

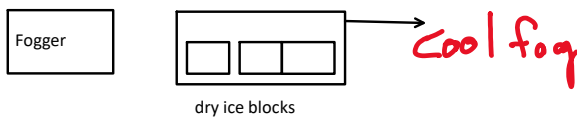
Condensation type (warm fog)

Warm Stage fog = Water + glycerin or propylene glycol. Additive slows evaporation

Club style fog machine. Physics are the same as e-cigarettes, vape



Small machines: heater too small to run continuously. \$35.

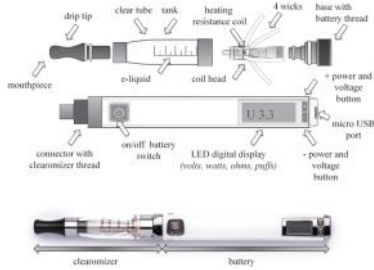


For fog-on-the-ground from a warm fog machine: Pass fog through ice chamber

Approximately 1 micron diameter droplets.

Yoshida, T., Y. Kousaka, and K. Okuyama. "A New Technique of Particle Size of Aerosols and Fine Powders Using an Ultramicroscope." *Industrial and Engineering Chemistry, Fundamentals*, Ind. Eng. Chem. Fundam. (USA), 14, no. 1 (February 1975): 47–51.

Large machines: can run continuously. For professional stage and theaters. \$1000. Mfg: Roscoe, Le Maitre. 1 gallon lasts 4 hrs, \$30.



E-cigarettes also use propylene glycol or vegetable glycerin fluid. Same physics as fog machines.

\$10?

By [Christian Giroud, Mariangela de Cesare, Aurélie Berthet, Vincent Varlet, Nicolas Concha-Lozano, and Bernard Favrat 2015](#)

Austin L was a vape artist. Builds his own custom vape device: <https://www.youtube.com/watch?v=Sycc17rd3Lk>

Anonymous clicker: Do you vape?

- a) No, never
- b) Tried a couple times
- c) Sure, weekly
- d) Daily
- e) No, but I'll try it now after seeing that video!

	2024	2023	2022
A	44	63	53%
B	38	13	24
C	6	1	-
D	0	13	12
E	13	6	12

Health effects of dilute stage fog are minimal, except to asthmatics and opera singers.

Varughese, Sunil, Kay Teschke, Michael Brauer, Yat Chow, Chris van Netten, and Susan M. Kennedy. "Effects of Theatrical Smokes and Fogs on Respiratory Health in the Entertainment Industry." *American Journal of Industrial Medicine* 47, no. 5 (2005): 411–18. doi:10.1002/ajim.20151.
Wills, J. H., F. Coulston, E. S. Harris, E. W. McChesney, J. C. Russell, and D. M. Serrone. "Inhalation of Aerosolized Ethylene Glycol by Man." *Clinical Toxicology* 7, no. 5 (January 1974): 463–76. doi:10.3109/15563657408988020.

Health effects of vaping: Depends on the additives -

E-liquid concoctions usually include some mix of flavorings, aromatic additives and nicotine or THC (the chemical in marijuana that causes psychological effects), dissolved in an oily liquid base. "We think that some of the vaporized elements of the oil are getting deep down into the lungs and causing an inflammatory response," explains Broderick.

From <<https://www.hopkinsmedicine.org/health/wellness-and-prevention/what-does-vaping-do-to-your-lungs>>

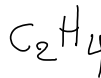
<https://www.zamplebox.com/community/what-is-a-cloud-booster> Vegetable glycerin, for vape dilution, more fog. Glycerin = glycerine=glycerol. Non-toxic, water soluble, derived from soy or palm.

C) Oil aerosols

Won't evaporate unless burned. Oil has low vapor pressure. Use medical or Bernoulli atomizer/nebulizer

Can be used to mark flame fronts. Illuminate fog with a laser sheet = "laser tomography" in 1980s.

Not same as CT scan. Computed Tomography uses multiple X ray beams/images, which are then assembled into a 3D image.



→ Danger! Oil aerosol will coat lungs = pneumonia = death

"Guidance-for-Aerosol-Applications-of-Silicone-Based-Materials.pdf." Accessed November 11, 2015. <http://sehsc.americanchemistry.com/Research-Science-Health-and-Safety/Guidance-for-Aerosol-Applications-of-Silicone-Based-Materials.pdf>.

Discusses oil aerosol effects in general.

JEAN R. HERTZBERG, MEHDI NAMAZIAN, and LAWRENCE TALBOT. "A Laser Tomographic Study of a Laminar Flame in a Karman Vortex Street." *Combustion Science and Technology* 38 (1984): 205–216.

BRIGHT REGION

Developed

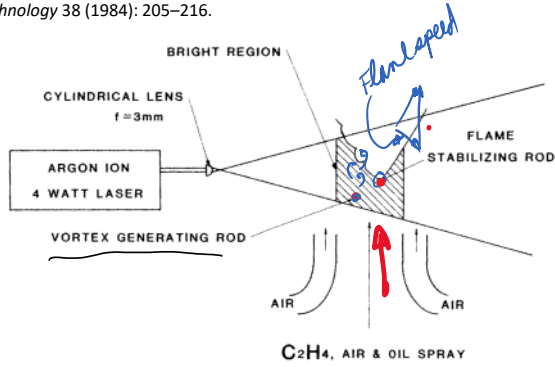


FIGURE 1 Experimental apparatus. The bright region is a cloud of oil droplets illuminated by the laser.

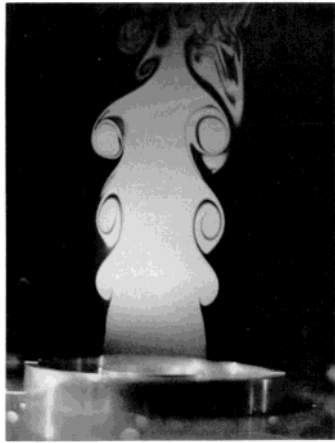


FIGURE 4 Example of tomography. Free jet, 1.2 m/s, issuing into stagnant environment.

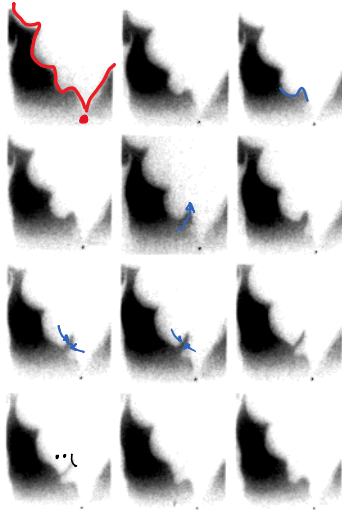


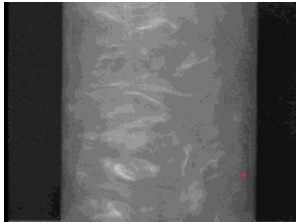
FIGURE 6 Example of tomography with combustion; from high-speed 16 mm film. The flame appears as the boundary of the dark V-shaped region. One complete cycle of interaction with vortex street is shown.

Particles for Water

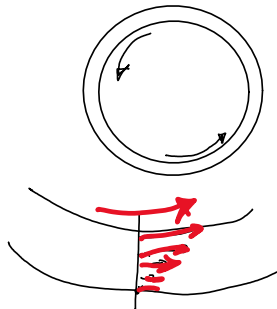
Rheoscopic fluids:

Pearl Ex (art pigment, TiO₂ coated mica).

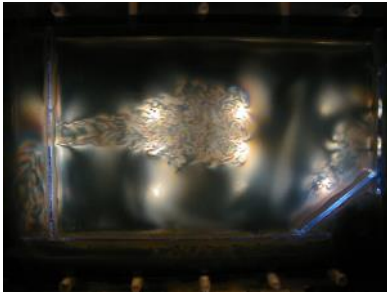
- 'Pearl Swirl' \$5/gallon from Steve Spangler Science
Shiny opaque or translucent particles, crystal flakes, ~10 μm size, aligns with shear gradient. Used in soaps, shampoos
<https://www.youtube.com/watch?v=vrTM9Q6owII>
Probably the same as:
Stearic acid crystals extracted from shaving cream,
Borrero-Echeverry, Daniel, Christopher J. Crowley, and Tyler P. Riddick. "Rheoscopic Fluids in a Post-Kalliroscope World." *Physics of Fluids* 30, no. 8 (August 1, 2018): 087103.
<https://doi.org/10.1063/1.5045053>.



Taylor Couette flow



'Blackstock' fluid, now 'KaleidoFlow Rheoscopic Fluid'



andesite clay

http://buphy.bu.edu/~duffy/thermo/4820_77.html

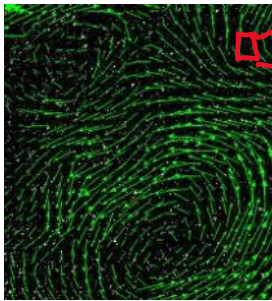
Streaming birefringence, seen when viewed between polarizing filters
 Has 2 indices of refraction
 Suspension of microscale mica flakes.

<http://www.laminarsciences.com/>
 Bob Blackstock

For individual particle images (PIV)

Individual particles are seen. Can be qualitative or quantitative (Particle Image Velocimetry, PIV).
 Two images made, close together in time

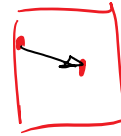
http://fiji.sc/wiki/index.php/File:Surface_wave.gif



Divide image into subwindows

Cross-correlation gives displacement vector

$$\frac{\Delta \vec{x}}{\Delta t} = \text{VELOCITY}$$



Pasted from http://www.google.com/images?q=particle+image+velocimetry&hl=en&client=firefox-a&hs=NUI&rls=org.mozilla:en-US:official&prmd=ivnsb&source=lnms&tbs=sch:1&ei=9CY3TcyNH8L7lweQ2uSMAw&sa=X&oi=mode_link&ct=mode&cd=2&ved=0CBAQAUoAQ&biw=993&bih=412

https://commons.wikimedia.org/wiki/File:Cross_Correlation_Animation.gif#/media/File:Cross_Correlation_Animation.gif

Solid Particle Sources

Neutral buoyancy

- Corn starch (diluted)
 - Glass or polystyrene microspheres. Specific size and density. \$\$
 - Latex bubbles
 - Rust (filtered)
 - Mica powder for makeup
 - Alumina, sold as polishing powder. Available in 1 to 100 micron size ranges
 - Wax beads (Pine Sol)
 - Pine pollen (floats on surface)
 - Lycopodium powder (also used as flash powder)
- <http://vimeo.com/89491724> Cymatics by Susie Sie