Photodynamic Airborne Cleaner (PAC)

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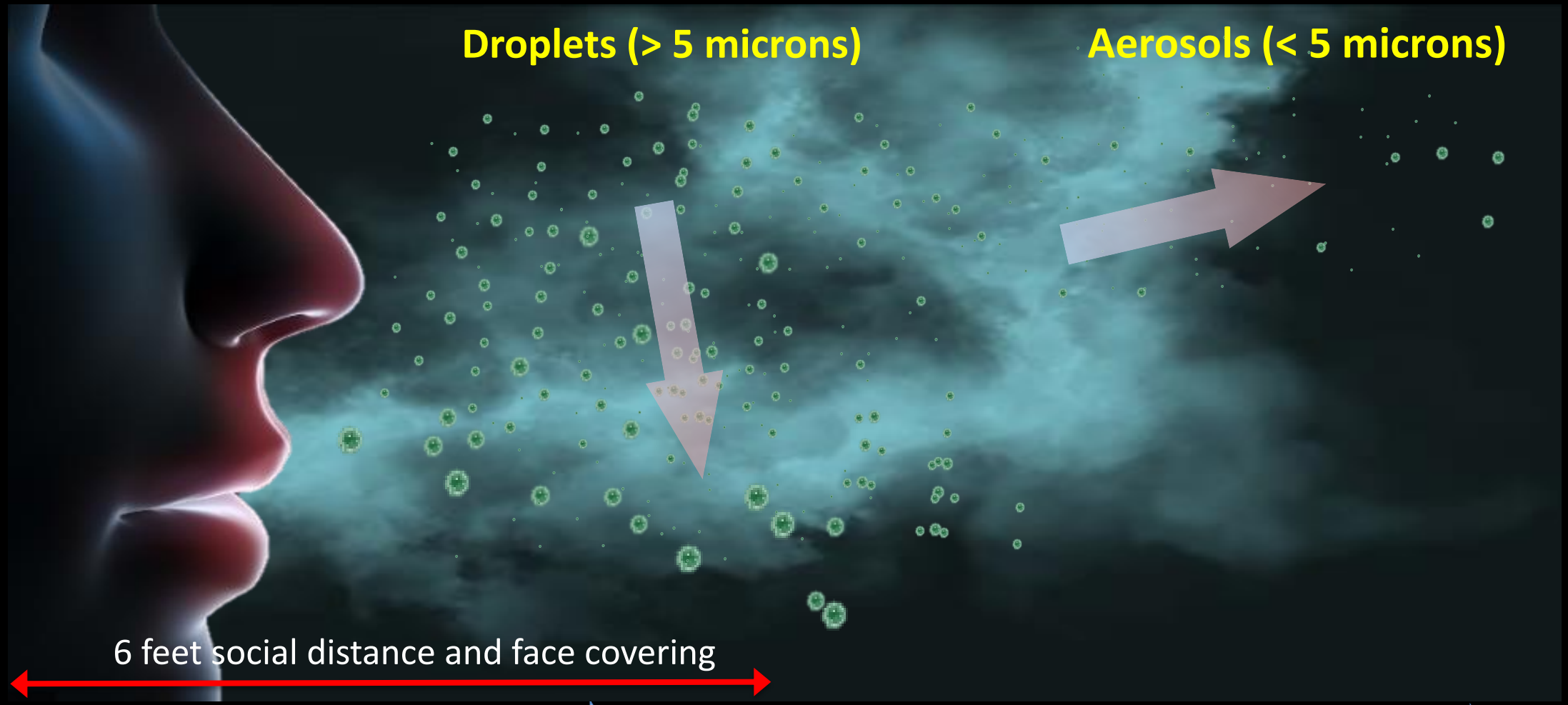
A need

Strong evidence suggests coronavirus is airborne - but no solution!

https://www.usatoday.com/in-depth/news/2020/04/03/coronavirus-protection-how-masks-might-stop-spread-through-coughs/5086553002

Transmission of COVID-19

Coughing or sneezing of an infected person produces virus-containing droplets and aerosols.



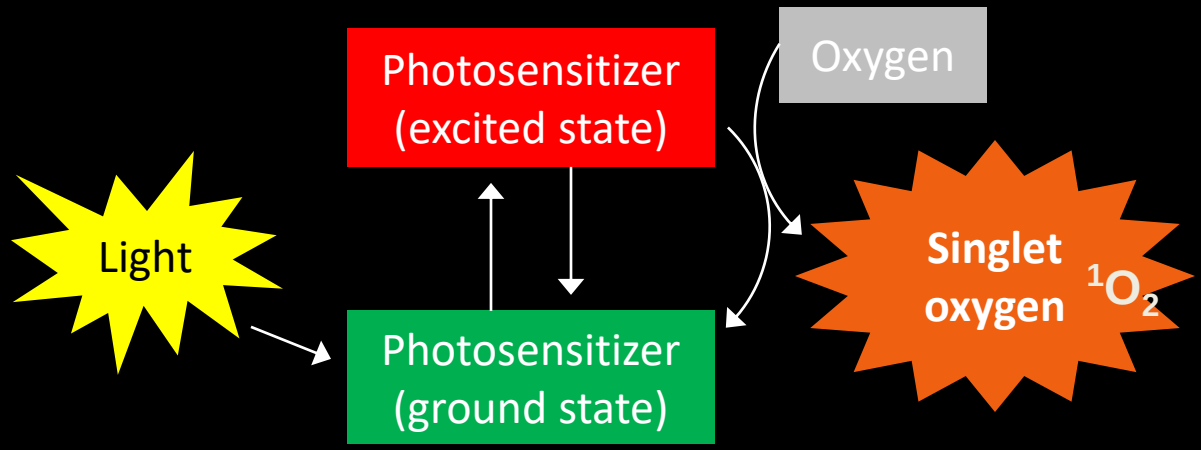
Contact precautions

Airborne precautions

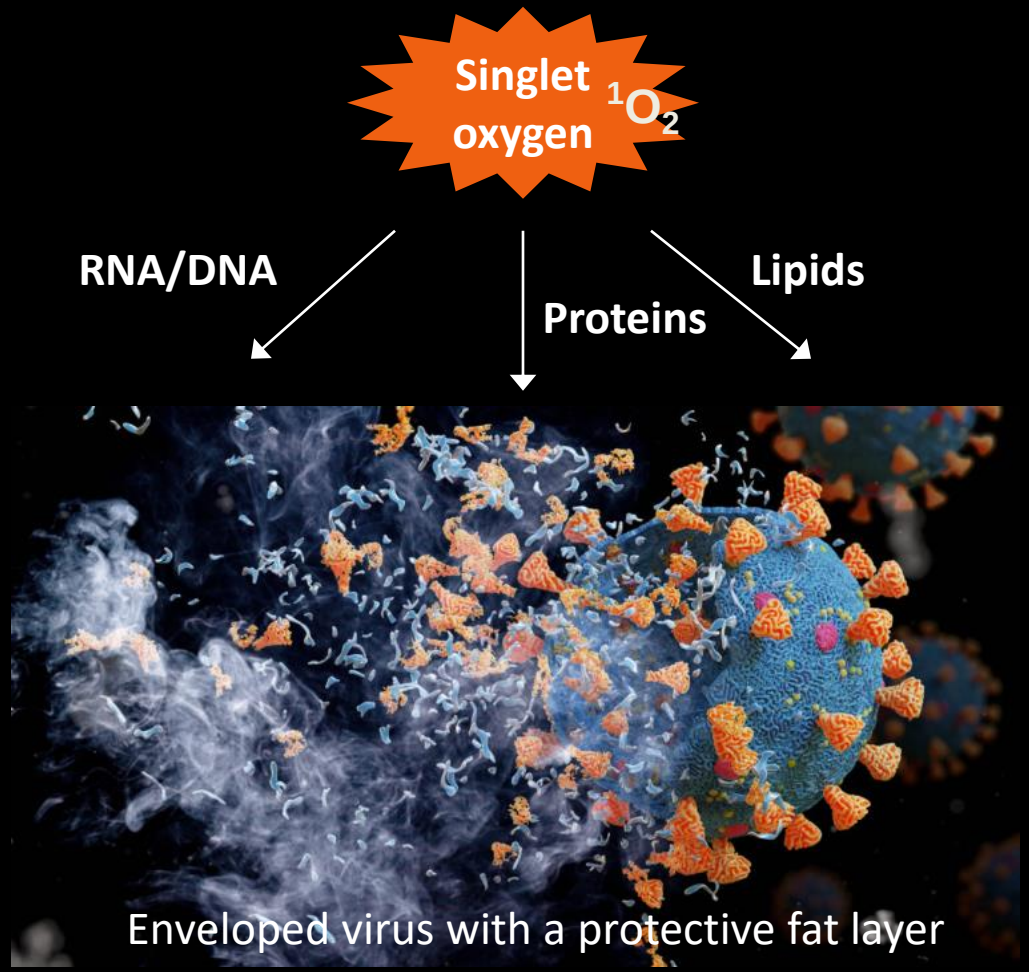
Our technology

Photodynamic Airborne Cleaner (PAC)

- **Photodynamic therapy (PDT)** is well known as a treatment of certain cancerous and pre-cancerous lesions.
- Two non-toxic components bring together to cause harmful effects → reactive oxygen species (ROS): singlet oxygen.



- Singlet oxygen is well established to inactivate viruses by damaging viral functions.



Enveloped virus with a protective fat layer

Our technology

Photodynamic Airborne Cleaner (PAC)

Medical PDT photosensitizers

- Porphyrins
- Chlorins
- Chlorophylls

- No cost-effectiveness
- Poor water solubility

FDA approved food coloring

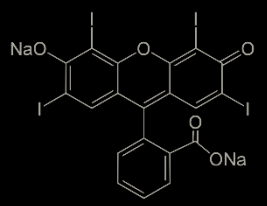
Low cost: > 100 times cheaper

PDT material	Type	Quantum yield of $^1O_2$ (max = 1)	Price per 1 g (Sigma-Aldrich)
ZnTPP	Porphyrin	0.84-0.88	$270.00
TMPyP	Porphyrin	0.74	$624.00
TPPS4	Porphyrin	0.62	$235.00
MPPa	Chlorin	0.61	$1,372.00
RED #105	Dye	0.75	$45.50
RED #3	Dye	0.63	$8.82
Fluorescein	Dye	0.06	$0.33

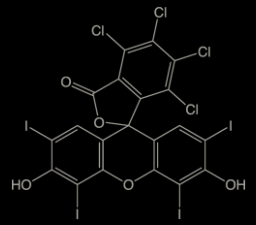
Our technology

Photodynamic Airborne Cleaner (PAC)

- **FDA approved food coloring**

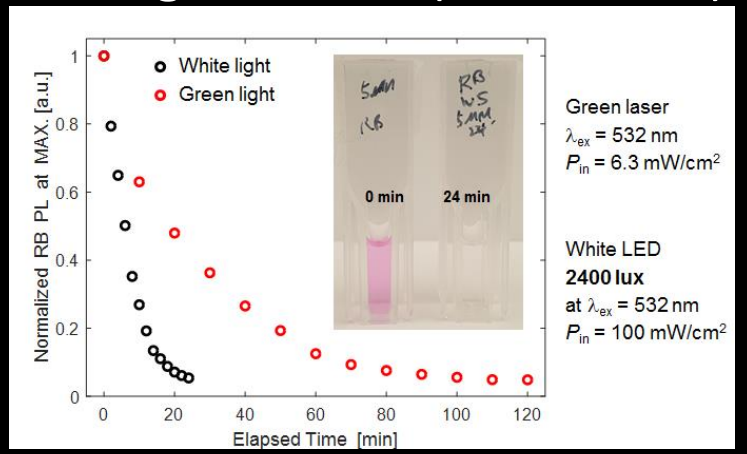


FD&C RED #3 (Erythrosine)

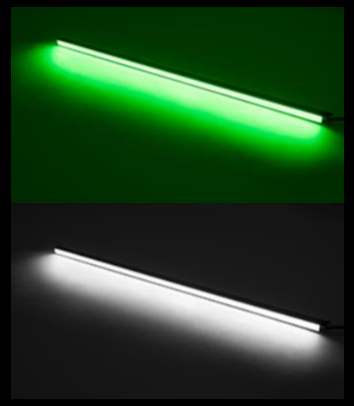


FD&C RED #105 (Rose Bengal)

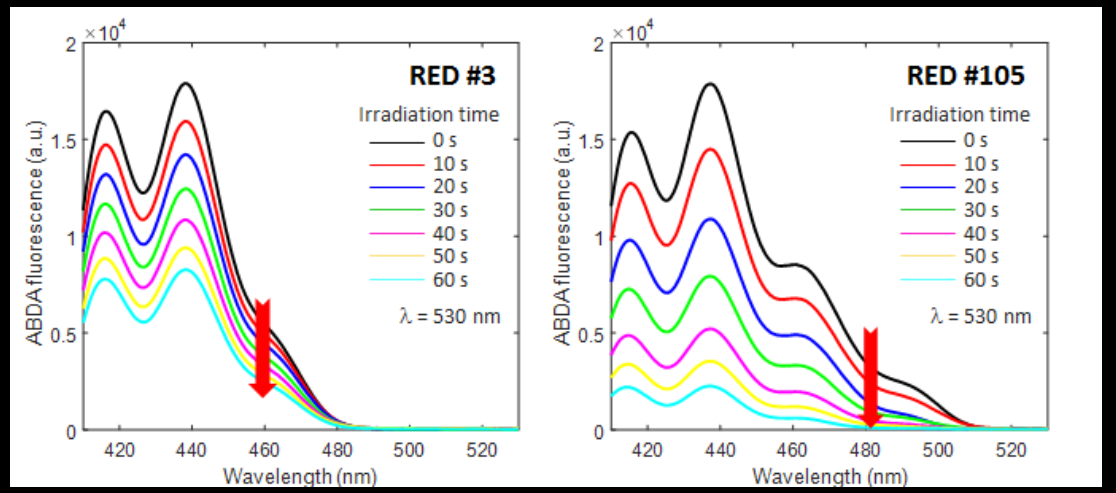
- Long Last time (3 – 5 hours)



- Green or white-light activation



- Confirmation of singlet oxygen



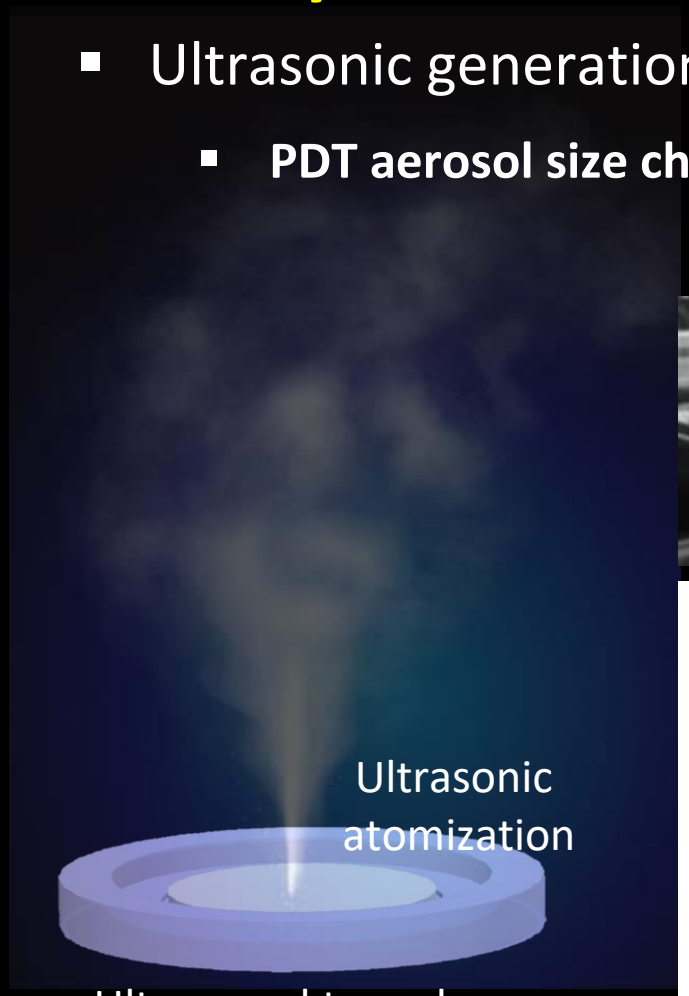
Tablet version of RED #105

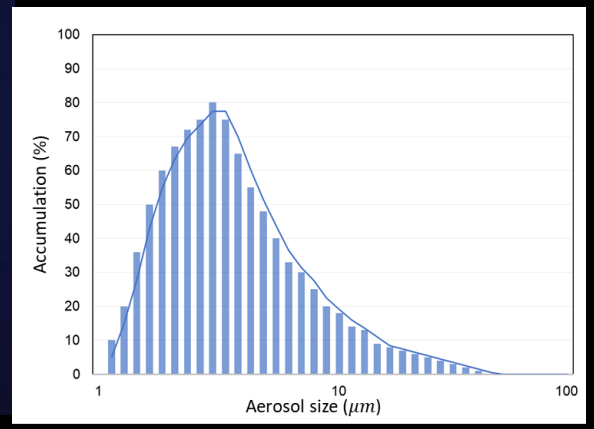
https://web.ics.purdue.edu/~kim50/PAC tablet.mp4

Our technology

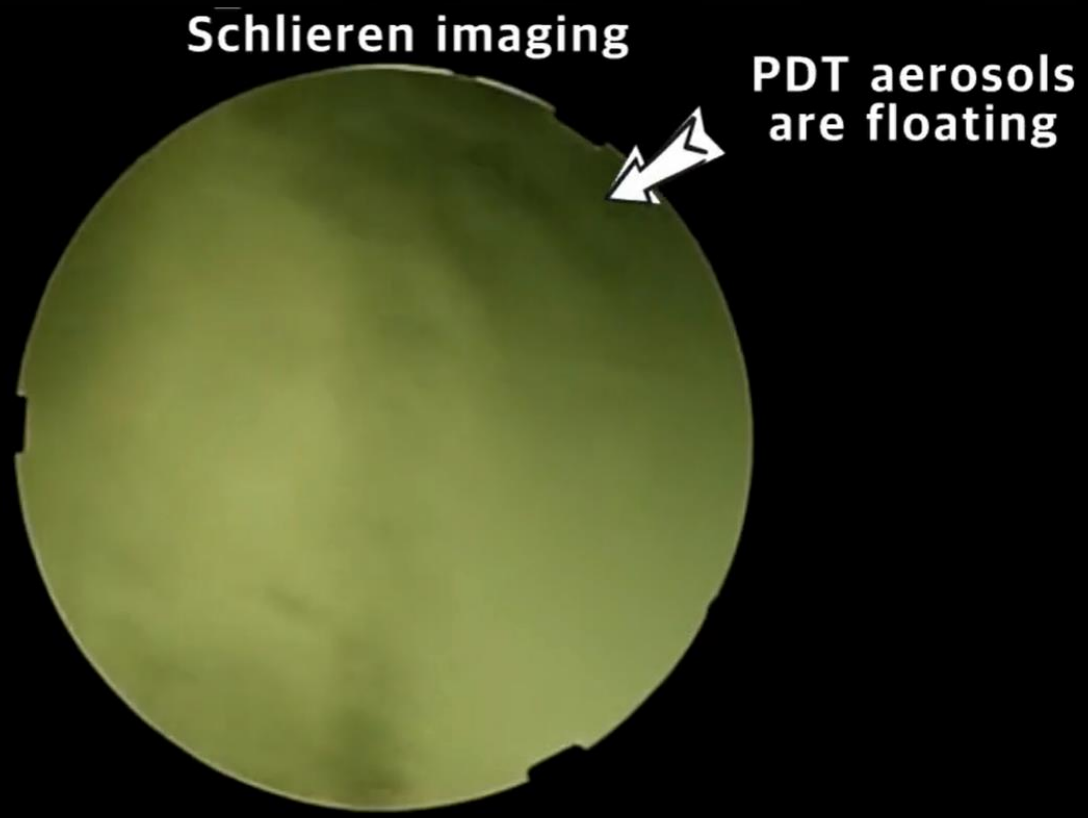
Photodynamic Airborne Cleaner (PAC)

- Ultrasonic generation of PDT aerosols (5 < microns) to be airborne
  - **PDT aerosol size characterization**





  - **Airborne PDT aerosols – Schlieren imaging**

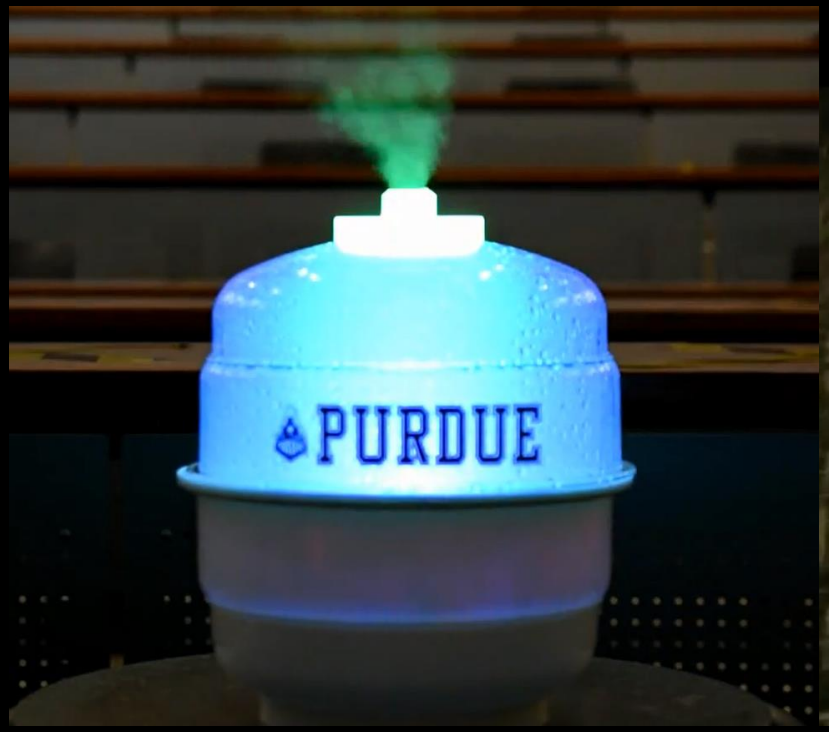


https://web.ics.purdue.edu/~kim50/PAC Schlieren imaging.mp4

Our products

Photodynamic Airborne Cleaner (PAC)

Portable PAC (pPAC), Handheld PAC (hPAC), Robot PAN (rPAC), UAV (drone) PAC (dPAC) …

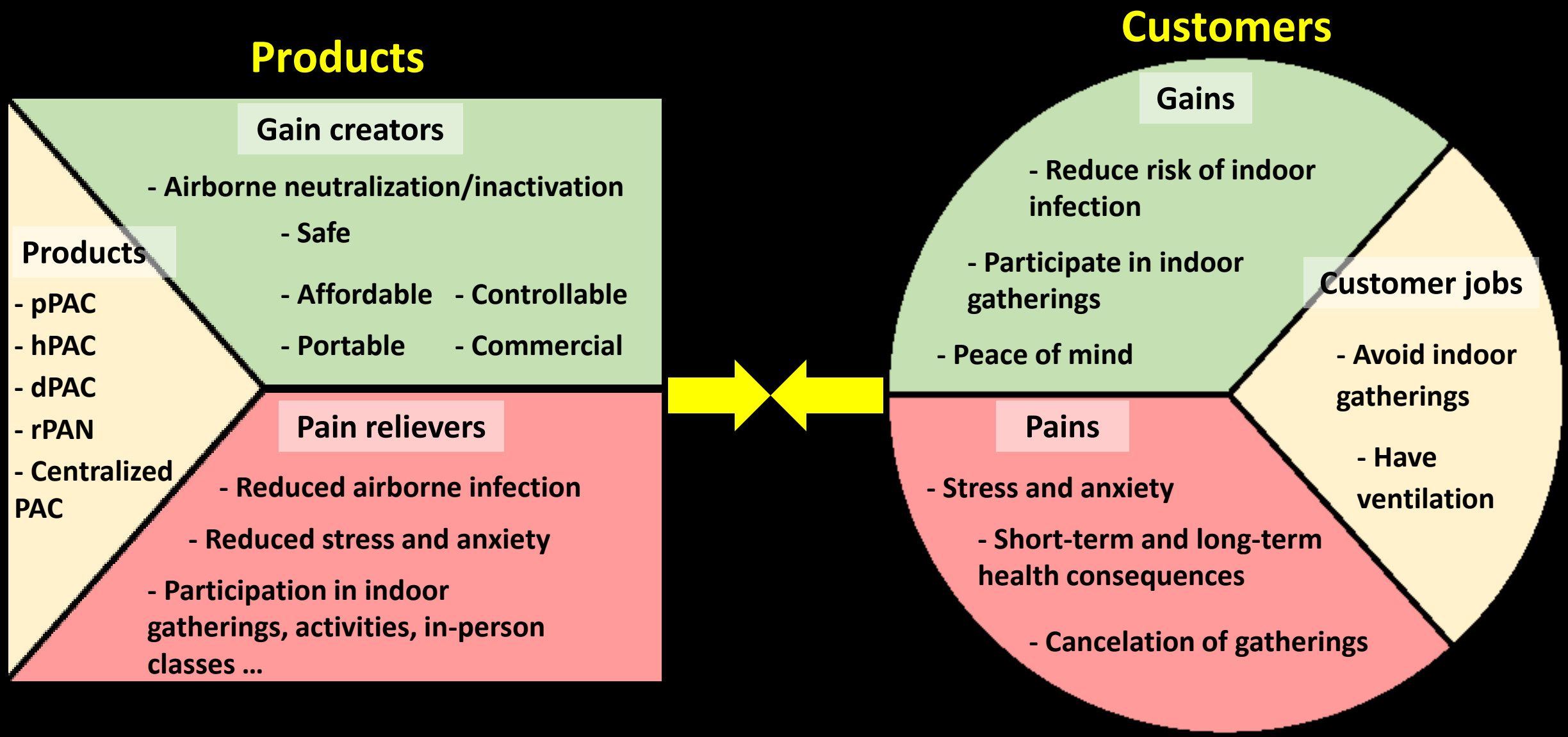


https://web.ics.purdue.edu/~kim50/PAC products.mp4

Technology comparison

Method	Disinfection target	Safety (human presence)	Lasting time	Light source	Portability	Efficacy
Photodynamic airborne cleaner (PAC)	Airborne	Yes	Controllable	Green light, white light, sunlight	Yes	Yes
UV light	Airborne surface	No	Controllable	UV-C (100 – 280 nm)	Yes	Yes
High-intensity narrow-spectrum light	Airborne Surface	Yes	Controllable	Blue light (405 nm)	Yes	No
Aerosolized hydrogen peroxide (ethanol, ozone, chlorine dioxide, etc.)	Surface	No	Short	None	Yes	Yes
Vaporous hydrogen peroxide (ethanol, ozone, chlorine dioxide, etc.)	Airborne Surface	No	Short	None	Yes	Yes
Photocatalytic disinfection	Surface	No	Controllable	UV	Yes	Yes

Value proposition



Classrooms, places of worship, performance arenas, public transportation …

Our legal landscape

- **Patent applications**

- "**Voluminous and airborne antiviral and antibacterial disinfection of photodynamic therapy using edible food dyes**", U.S. Provisional Patent Application No: 63021569, filing date: 5/7/2020, inventors: H.J. Jeon, J.W. Leem, Y. Ji, and Y.L. Kim.
- "**Antiviral and antibacterial disinfection aero-solution using edible food dyes",** U.S. Provisional Patent Application No: 63058433, filing date: 7/29/2020, inventors: H.J. Jeon, J.W. Leem, Y. Ji, and Y.L. Kim.

- **Related papers**

- "Green-light-activated photoreaction via genetic hybridization of far-red fluorescent protein and silk," Advanced Science 5:1700863, 2018.
- "Plasmonic photocatalyst-like fluorescent proteins for generating reactive oxygen species," Nano Convergence 5:8, 2018.

- **Funding**

- Purdue University

Regulatory – FDA vs. EPA

FDA	EPA
Chemical disinfectants used on critical medical devices (e.g., a disinfectant intended to reprocess anesthesia breathing circuits)	General/broad-spectrum disinfectants for residential, commercial, and institutional uses (e.g., cleaners used in households, swimming pools, and water purifiers)
Chemical disinfectants used on semicritical medical devices (e.g., a disinfectant to reprocess heart-lung oxygenator)	Hospital disinfectants and disinfectants used in the medical context (e.g., for use on hospital floors, toilet seats, and medical beds, wheelchairs, and other noncritical devices)
Sterilizers for medical devices	Sanitizers used on food-contact products (e.g., dishes and cooking utensils, equipment and utensils found in food-processing plants)
Medical air purifiers or devices used to remove particles from the air for medical purposes (i.e., recirculating air cleaner functioning by electrostatic precipitation or filtration, ultraviolet air purifier)	Sanitizers used on non-food-contact products (e.g., carpet sanitizers, air sanitizers, laundry additives, in-tank toilet bowl sanitizers)
Hand sanitizers and topical products	Sterilizers for use on surfaces other than for medical devices
	Home air filters or cleaners

https://www.alston.com/en/insights/publications/2020/04/cleaning-up-after-covid19

PAC is the first-of-a-kind of PDT aerosol generator for airborne disinfection.

Questions and suggestions?

Thank you!