# Impacts of in-duct needlepoint bipolar ionizers on indoor air quality (IAQ)

*Jialei Shen*[1], Zhenlei Liu[1], Daniel Love[2], Mary Dekold[2], Beverly Guo[1], Michael J. Birnkrant[2], Peter J. McKinney[2], and Jianshun Zhang[1]

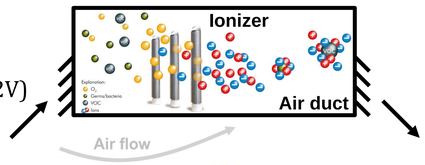
[1]Department of Mechanical & Aerospace Engineering, Syracuse University

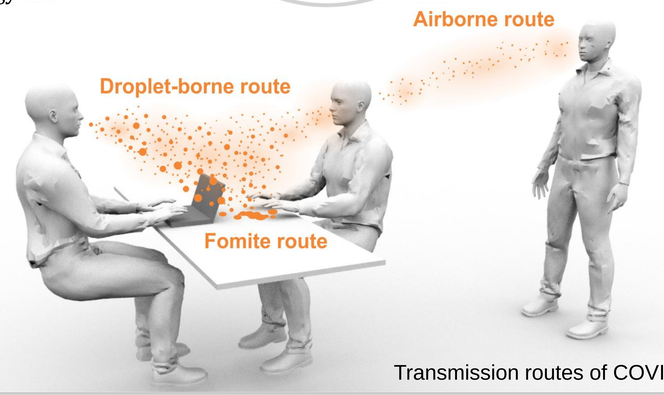
[2]Carrier Global Corporation

## Introduction

Needlepoint bipolar ionizer

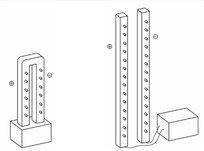
- Charging particle for removal
- Inactivating virus
- Minimizing ozone release (<12V)
- Generating (+) and (-) ions
- Low energy use



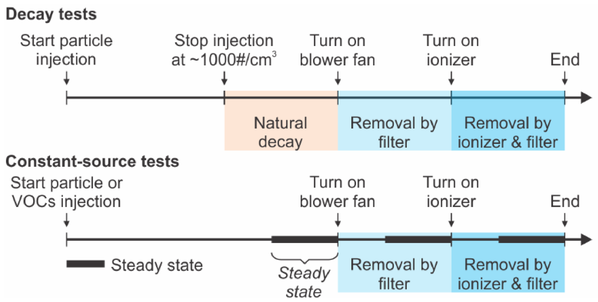




Transmission routes of COVID-19

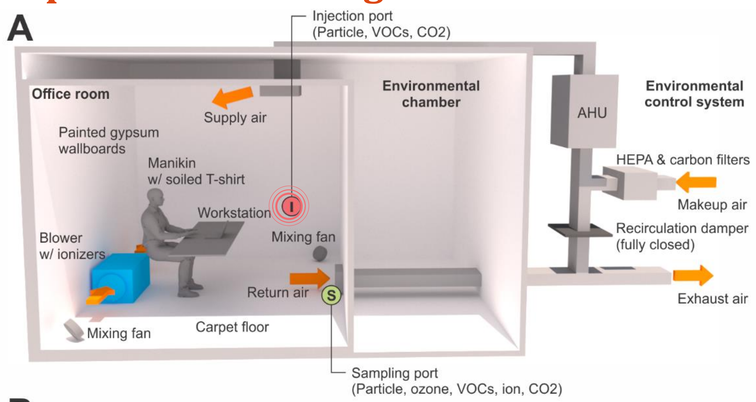
## Methodology

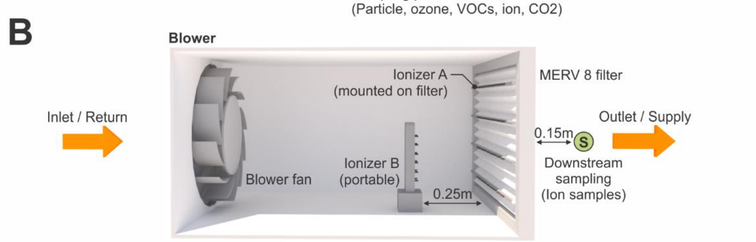


- Two configurations of in-duct ionizer were tested
- Full-scale chamber with office settings
  (carpet floor, painted gypsum wall, table, partition, heated manikin, etc.)
- A blower system to simulate recirculated air duct (with ionizers installed)
- Injection: Particles, VOCs (HCHO + Toluene) → Typical indoor levels
- Sampling: Particles, Ozone, VOCs, CO2, (-) ions
- Procedure
  - Decay test
  - Constant test




## Experimental settings





## Results

### Removal effectiveness

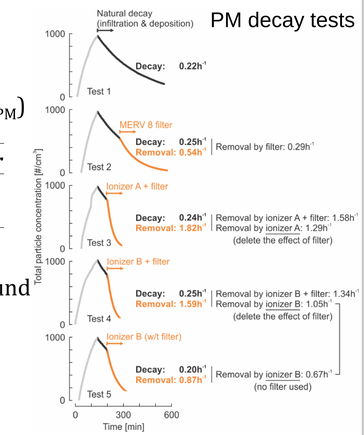
PM removal

Single pass removal efficiency ($SPRE_{PM}$)

| | *MERV 8 filter* | *Filter + ionizer* |
|---|---|---|
| ***Decay*** | ***1.7%*** | ***7.7-9.1%*** |
| ***Constant*** | ***1.0-1.6%*** | ***7.2-10.4%*** |

VOC removal

VOC variations were within background fluctuation (PTRMS data)




### Byproduct generations

Ozone generation

0.39-0.92 mg/h (no ventilation)

No emission (with typical ventilation)

VOC generation

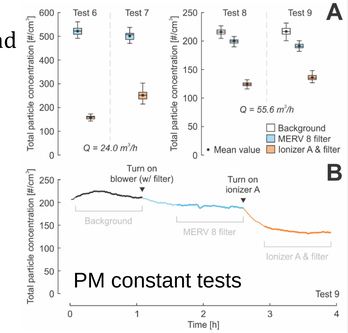
VOC variations were within background fluctuation (PTRMS data) → No emission

Ion generation

MERV 8 + ionizer:

$5.4 \times 10^{13}$ #/h → $1.3 \times 10^{12}$ #/h

(97.6% reduction across filter)




### Energy consumption

Ionizer: 0.4-1.0 W (Typical PAC: 56 W)

Power / $CADR_{PM}$ : 0.006 – 0.052 W/($m^3$/h)

## Conclusions

- MERV 8 + ionizer: 1.0-1.7% → 7.2-10.4% $SPRE_{PM}$; Not effective for VOC
- Most generated ions were captured by the filter
- No significant ozone and VOCs generation
- Moderate particle removal efficiency, but low energy use
- In-duct ionizers should work with filter to maximize their removal effectiveness and minimize the leakage of ions to indoor air