Ultrafine Particles and Urban Pollution – Mitigation Solution

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Particle Size Distributions of Atmospheric Aerosols

**PM$_{2.5}$ Sources and Lifetimes**

**Fine Particles**
*Combustion, gases to particles*
- Sulfates/acids
- Nitrate
- Ammonium
- Organics
- Carbon
- Metals
- Water

**Sources:**
- Coal, oil, gasoline, diesel, wood combustion
- Transformation of SO$_x$, NO$_x$, organic gases
- High-temperature industrial processes (smelters, steel mills)
- Forest fires

**Exposure/Lifetime:**
Lifetime days to weeks, regional distribution over urban scale to 1000s of km

**Inhalable Coarse Particles**
*Crushing, grinding, dust*
- Resuspended dusts (soil, street dust)
- Coal/oil fly ash
- Aluminum, silica, iron-oxides
- Tire and brake wear
- Inhalable biological materials, such as soils & plant fragments

**Sources:**
- Resuspension of dust tracked onto roads
- Suspension from disturbed soil (farms, mines, unpaved roads)
- Construction/demolition
- Industrial fugitives
- Biological sources

**Exposure/Lifetime:**
Coarse fraction (2.5-10) lifetime of hours to days, distribution up to 100s km
PM\textsubscript{2.5} Standard, U.S. EPA

- Established in 1997, PM\textsubscript{2.5} describes Particulate Matter (PM) that is 2.5 µm in diameter and smaller, $D_p < 2.5 \text{ µm}$
- 24-hour standard: 65 µg/m\textsuperscript{3}, 3 yr avg, 98th percentile concentration; reduced to 35 µg/m\textsuperscript{3} since 2006
- Annual standard: 12 µg/m\textsuperscript{3} in 2012, 3-yr average of annual mean concentration
Secondary PM$_{2.5}$ + Ozone

Gaseous emissions (VOCs, NO$_x$, NH$_3$, SO$_2$, etc)

PM emission

Sunlight
Harvard Six City Study

- Six small cities that differed greatly in PM levels
  - Harriman, TN
  - Portage, WI
  - Steubenville, OH
  - St. Louis, MO
  - Topeka, KS
  - Watertown, MA

- A Cohort study investigating 151 U.S. metropolitan areas

- PM$_{2.5}$ air pollution contributes to excess cardiopulmonary and lung cancer mortality in certain U.S. cities

Pope et al., Am J Respir Crit Care Med 1995;151:669-74
A Tale of Two Cities

Los Angeles Civic Center
January 1948
PM$_{10}$ = 600 µg/m$^3$

Beijing CCTV Building
January 2013
PM$_{2.5}$ = 700 µg/m$^3$
5 Decades of Pollution Control in LA

![Graph showing the decline of ozone levels in Los Angeles Urban Area from 1960 to 2010. The graph depicts the maximum 1-hour average and maximum 8-hour average concentrations of ozone (O₃) with data from the California Air Resources Board. The standards for ozone are also shown, indicating a significant improvement over the decades.]
PM 2.5 Haze in Shanghai, April 19, 2015: Traffic on the elevated highway with city shrouded with haze in the background.
The Freeway Community is exposed to high nanoparticle concentrations.

McConnell et al., EHP 2006
The member companies of CFR have $32 billion annual sales (est.) in filtration industry. Applications include:

- Removal of PM$_{2.5}$ pollutants
- Engine emission removal
- Cabin air filter for automobiles/airplanes
- Respirator and personal protection equip
Solar-Assisted Large-Scale Cleaning System (SALSCS) -- Disruptive Innovation

Clean Air from 8 Giant SALSCS bathing Beijing Basin

After installing 8 full-scale SALSCS next to the 6th Ring Road of the Beijing city, we can reduce the PM2.5 concentration up to 15% in average for the urban area of Beijing.

This conclusion is based on our atmospheric simulation performed by the WRF model.

Xi’an SALSCS Completed: July 22, 2016

In collaboration with:
Prof. Junji Cao, Institute of Earth Environment (IEECAS)
Prof. W.Q. Tao, Xi’an Jiaotong University (XJTU)
Photos of the three filtration systems

N-Filter A

W-Filter B

E-Filter C
Vice Minister Wang of China Environmental Protection Ministry review the SALSCS on September 25, 2017
2nd Generation SALSCS in City
Collaborator: Prof. Jing Sun,
Shanghai Institute of Ceramics, CAS
Two dozens of Newspaper articles and TV News

Nature (March 6, 2018) “China Tests Giant Air Cleaner to Combat Smog”

UK Chief Medical Officer (CMO) Annual Report (March 9, 2018)

NBC Universal and Digital Trend (March, 2018)
The SALCS technology represents an effective and low-cost way to mitigate both PM$_{2.5}$ and CO$_2$, for the health and well-being of mankind.
Section 7: Urban Particles and Urban Pollution
Thursday Plenary and Technical Sessions

• 9:30-10:00 Plenary Lecture by David Pui, “Green Technologies for Sustainable Environment,” Platine

• 10:45-12:30 Tech Session I, Chrome 1

• 14:00-15:30 Tech Session II, Platine