Petroleum Coke — Background

Presented to
Progressive Democrats of Benicia

Communities for a Better Environment (CBE)
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green coke

petroleum coke = “pet” coke

some terms:

“green” “calcined” “fines” (examples pictured here)

“market” or “catalyst” coke (see slides 4 and 5)

coke fines

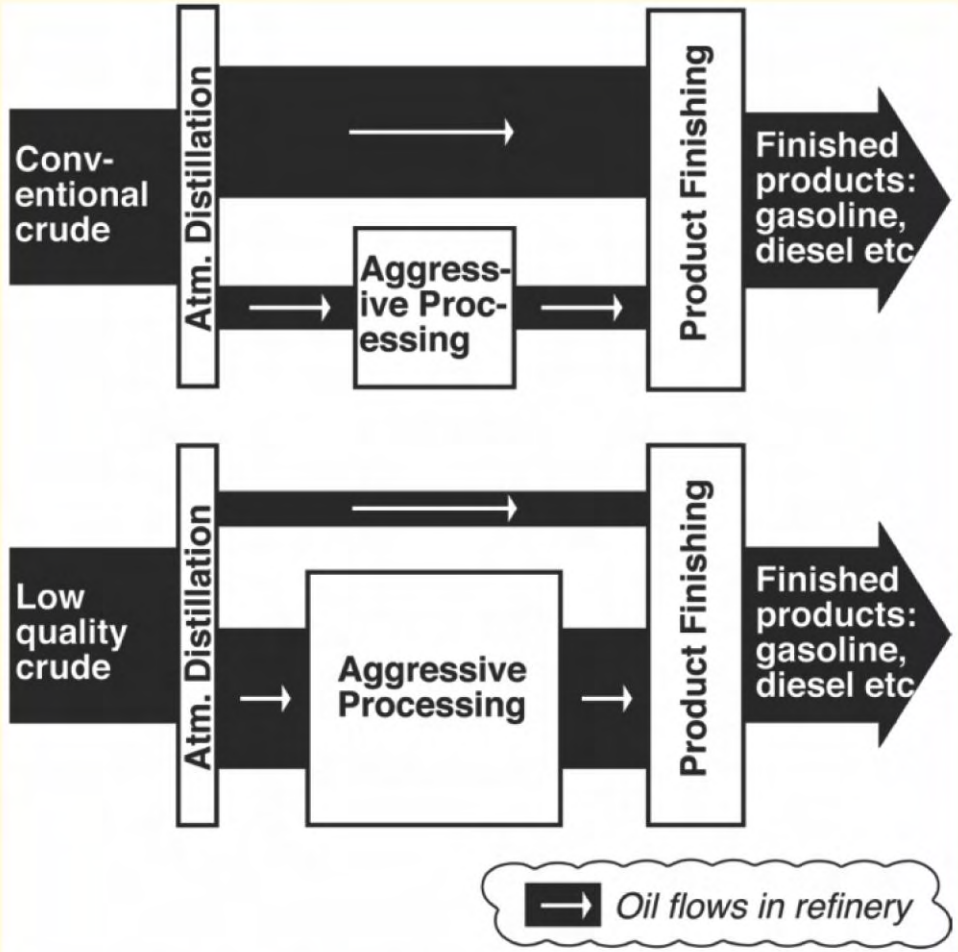
calcined coke

Pet coke is a byproduct.

To make gasoline, diesel, and jet fuel from lower-quality (heavier) crude, oil refiners use several "cracking" processes.

Two of them, catalytic cracking, and coking (severe thermal cracking) also create pet coke.

More of the crude barrel is cracked, creating more of this byproduct, from heavier crude feeds.

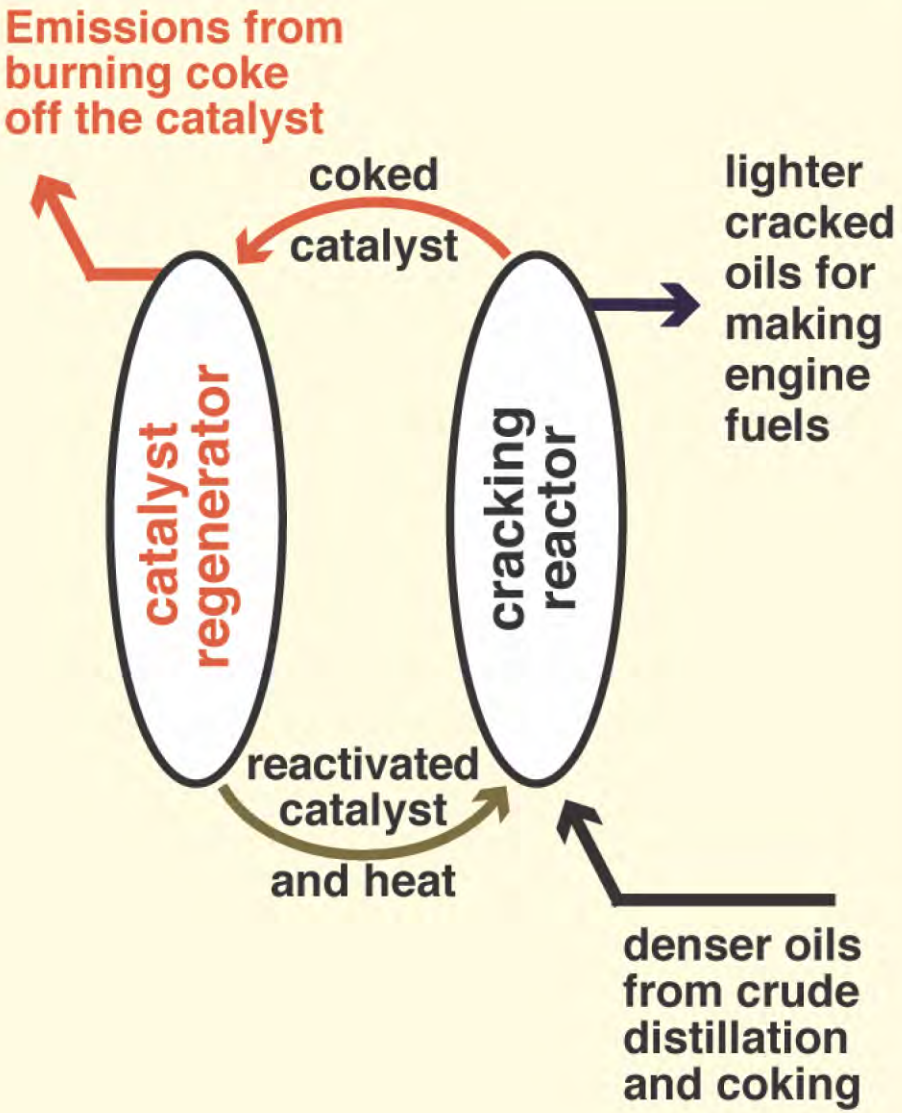


Aggressive processing (vacuum distillation, cracking, and aggressive hydroprocessing) acts on a larger portion of the total crude refined to make motor fuels from lower quality crude, requiring more fuel to be burned for energy and increasing refinery emissions.

Pet coke formed in catalytic cracking is burned off in this process to reactivate its catalyst.

It is always burned inside the refinery.

The main source of "catalyst coke."



Catalytic Cracking Unit Process Flow — Simple Diagram

Pet coke formed in coking exits this refining process.

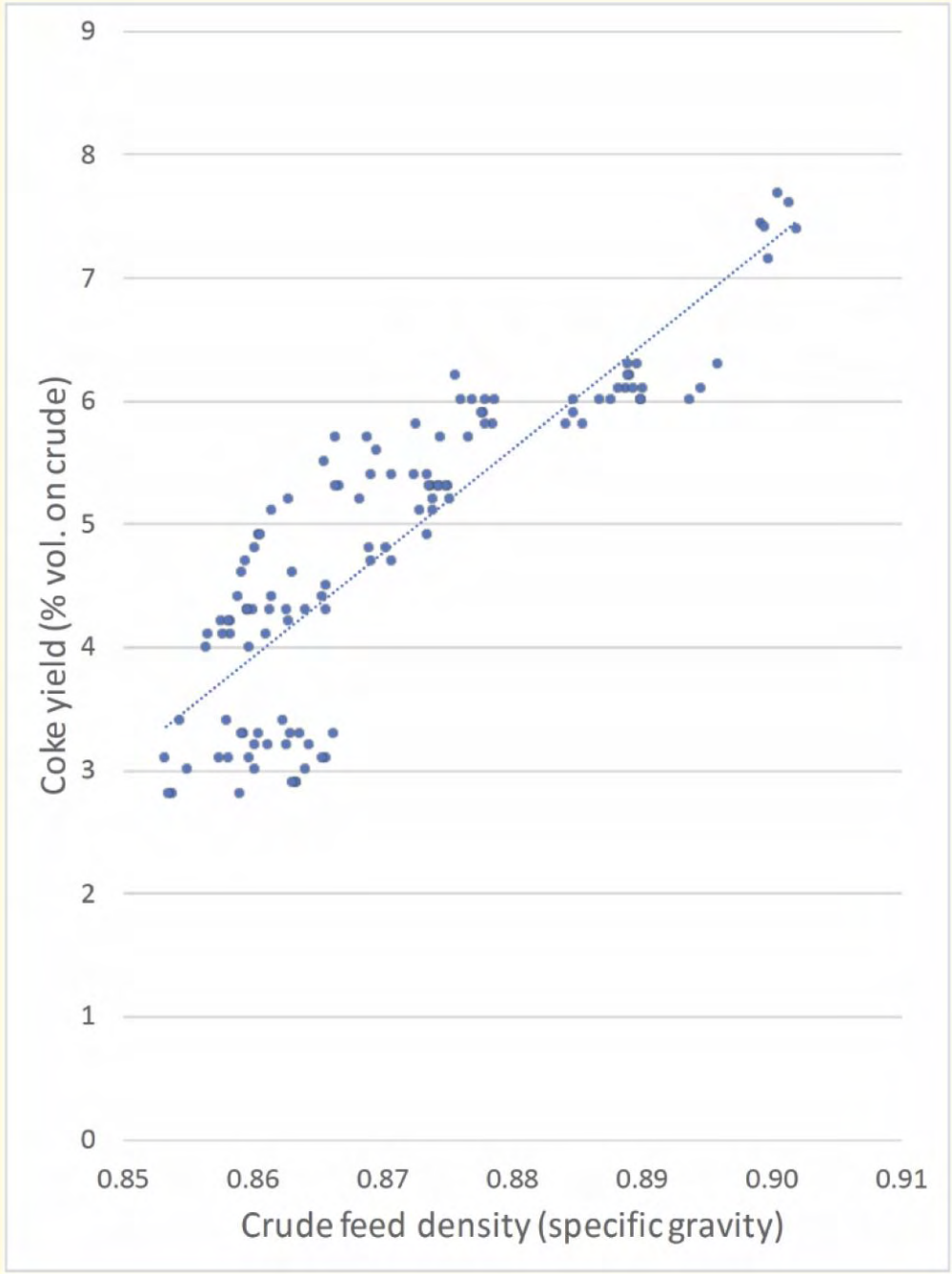
So it *may* be sold.

The main source of "marketable coke."

Delayed coker, Phillips 66, Rodeo

Crude feed quality v. refinery coke yield: nation-wide data from 1999–2017

- **Annual average from PADD 1, 2, 3, 4 or 5, U.S., or California refineries**



Petroleum coke by-production, use and export: U.S. West Coast (PADD 5) in 2017

Volumes in cubic meters/year (m^3/y)

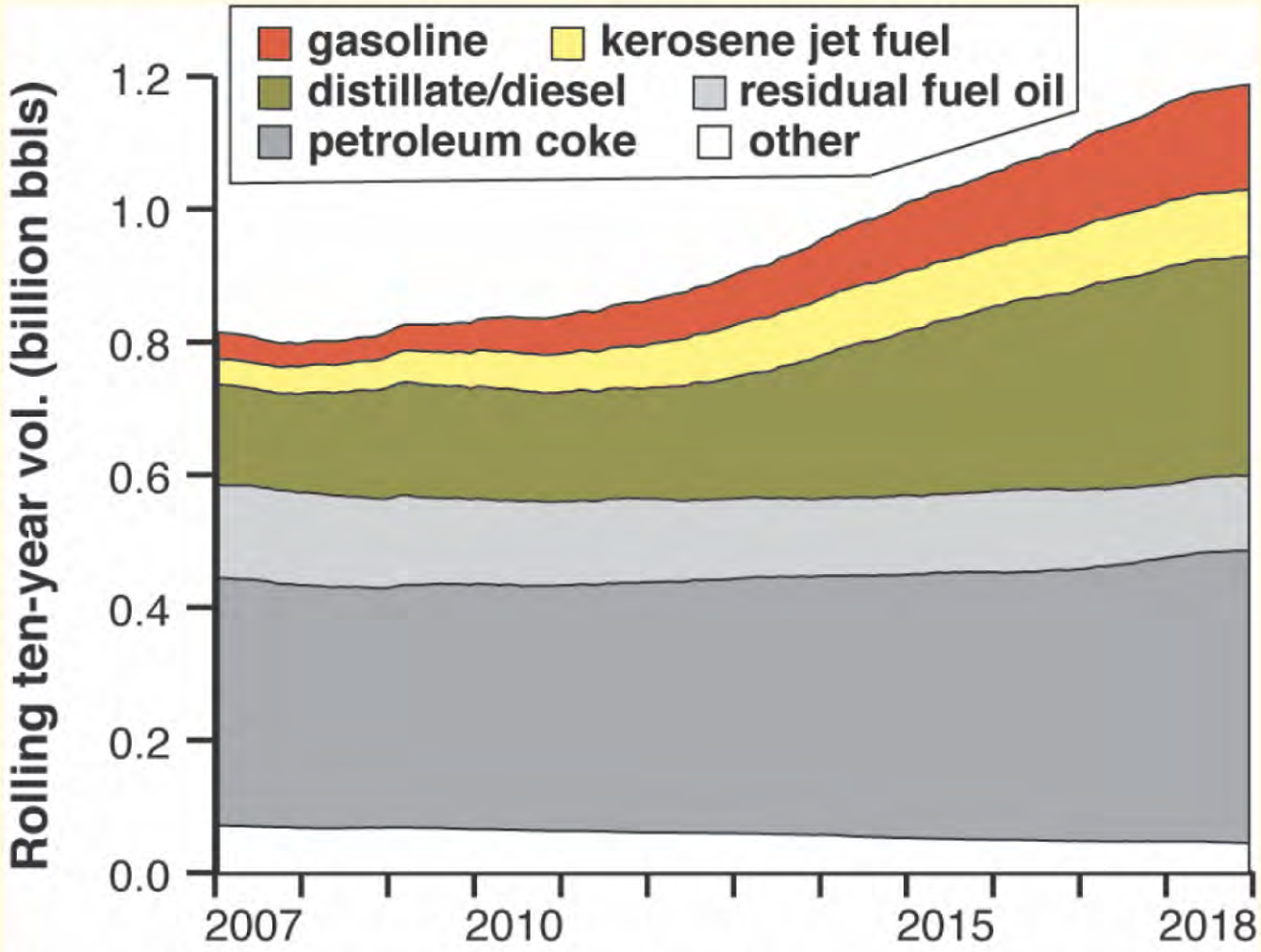
Refinery coke by-production: 52 million m^3/y

Used* on the West Coast: 18 million m^3/y

Exported* from West Coast: 34 million m^3/y

* **Pet coke use outside refineries:**
The vast majority is burned in power, cement or smelting plants while a smaller volume is calcined for graphite.

Pet coke exports are the largest share of refinery exports by volume and are increasing slightly as refiners boost production to increase gasoline, diesel and jet fuel exports.

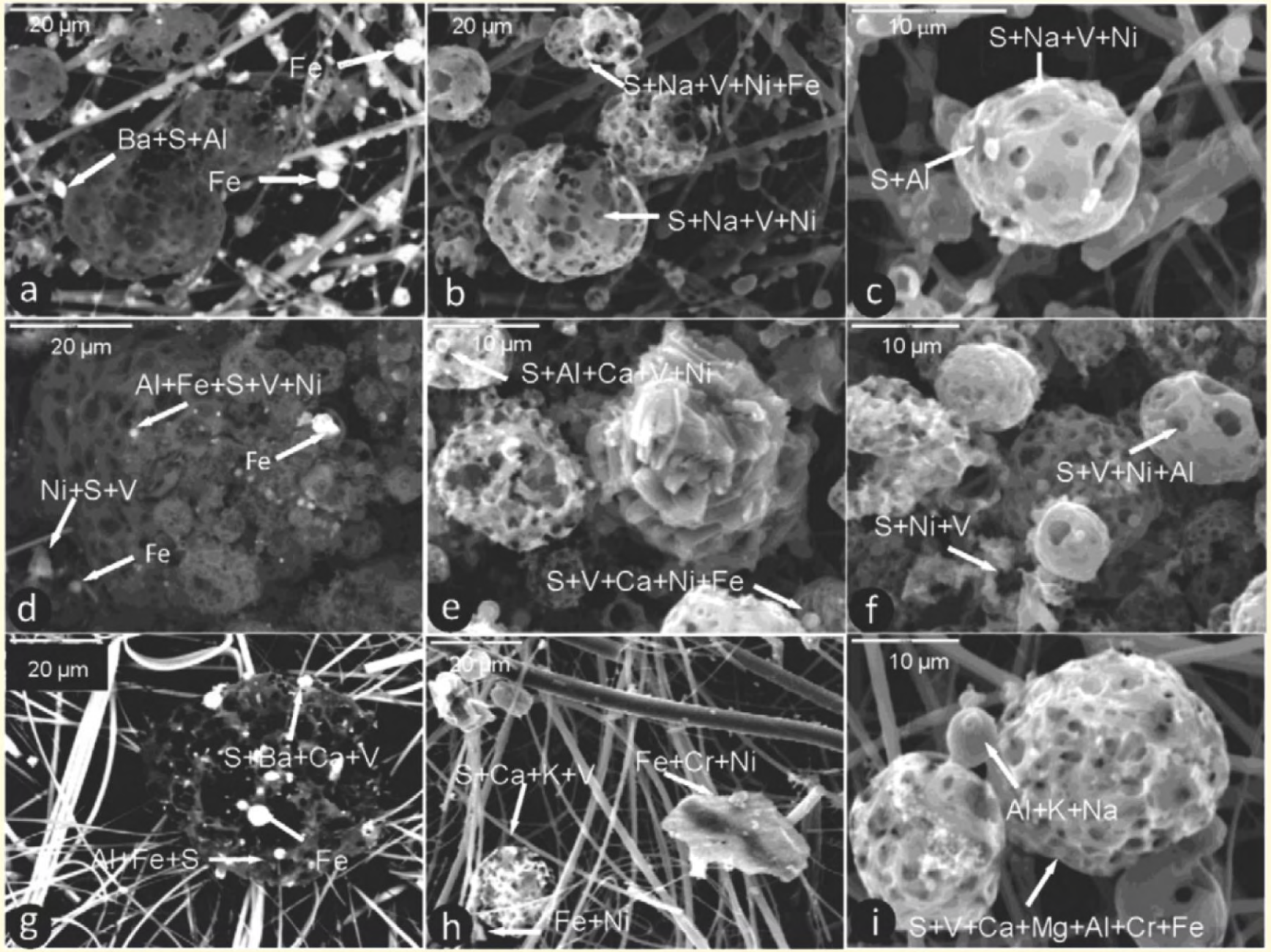


West Coast exports of finished petroleum products

Burned *and* unburned pet coke emissions include particulate matter (PM).

Factors in the toxicity of a given PM exposure:

- **particle size (PM_{10}? $PM_{2.5}$? Ultra-fine PM?)**
- **chemical composition**



Secondary and back-scattered electron images of representative particles in oil refinery stack emissions (Sánchez de la Campa et al., 2011)

Some toxic chemicals catalytic cracking and coking emit

Acenaphthalene
Acenapthene
Acrylonitrile
Ammonia
Anthracene
Antimony
Arsenic
Benzo(a)anthracene
Benzo(a)pyrene
Benzo(b)fluoranthene
Benzo(e)pyrene
Benzo(ghi)perylene
Benzo(k)fluoranthene
Beryllium
Biphenyl
Cadmium
Carbon disulfide
Cesium
Chlorobenzene
Chromium
Chrysene
Cobalt
Cresols
Cumene
Dibenzo(a,e)pyrene
Dibenzo(a,h,)anthracene
Dibenzofurans
Dioxins
Fluoranthene
Fluorene
Hexavalent chromium
Hydrogen cyanide
Hydrogen fluoride
Hydrogen sulfide
Indeno(1,2,3–cd)pyrene
Lanthenum
Lead
m&p–Xylenes
Manganese
Mercury
Methyl iso-Butyl Ketone
MTBE
Naphthalene
Nickel
o–Toluidine
o–Xylene
PCBs
Phenanthrene
Perylene
p-Xylene
Pyrene
Selenium
Styrene
Sulfur dioxide
Toluene
Vanadium