# Catalytic soot reduction in pool fires with applications in Oil-Spill Burning and Fire-Fighter Training

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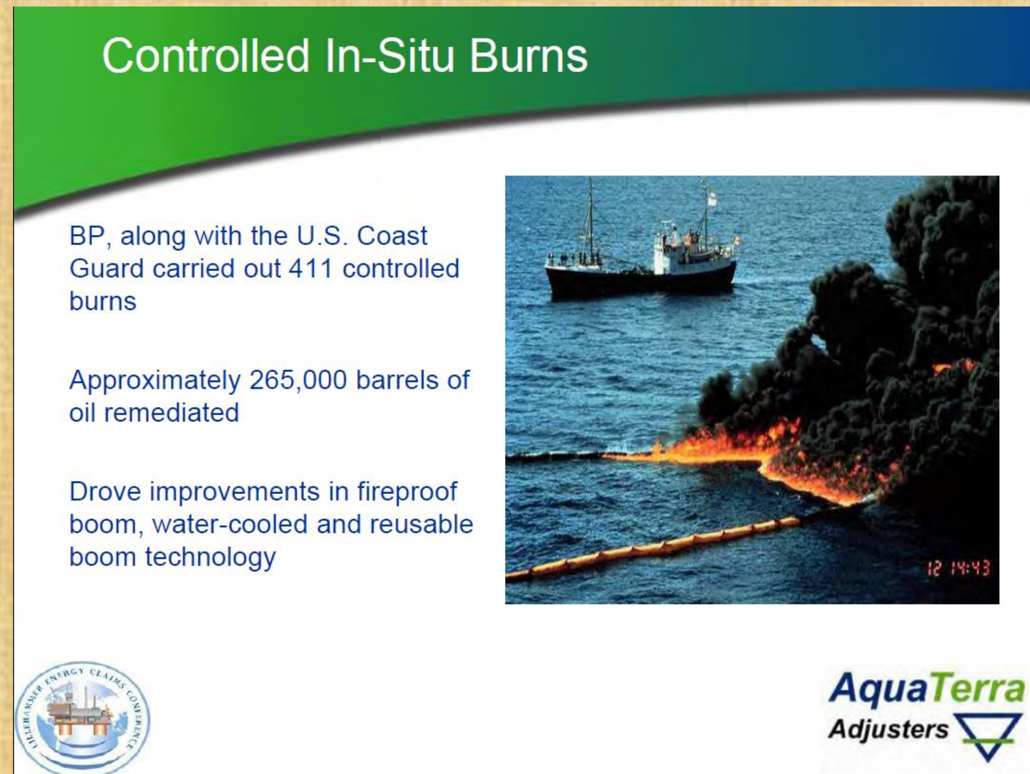
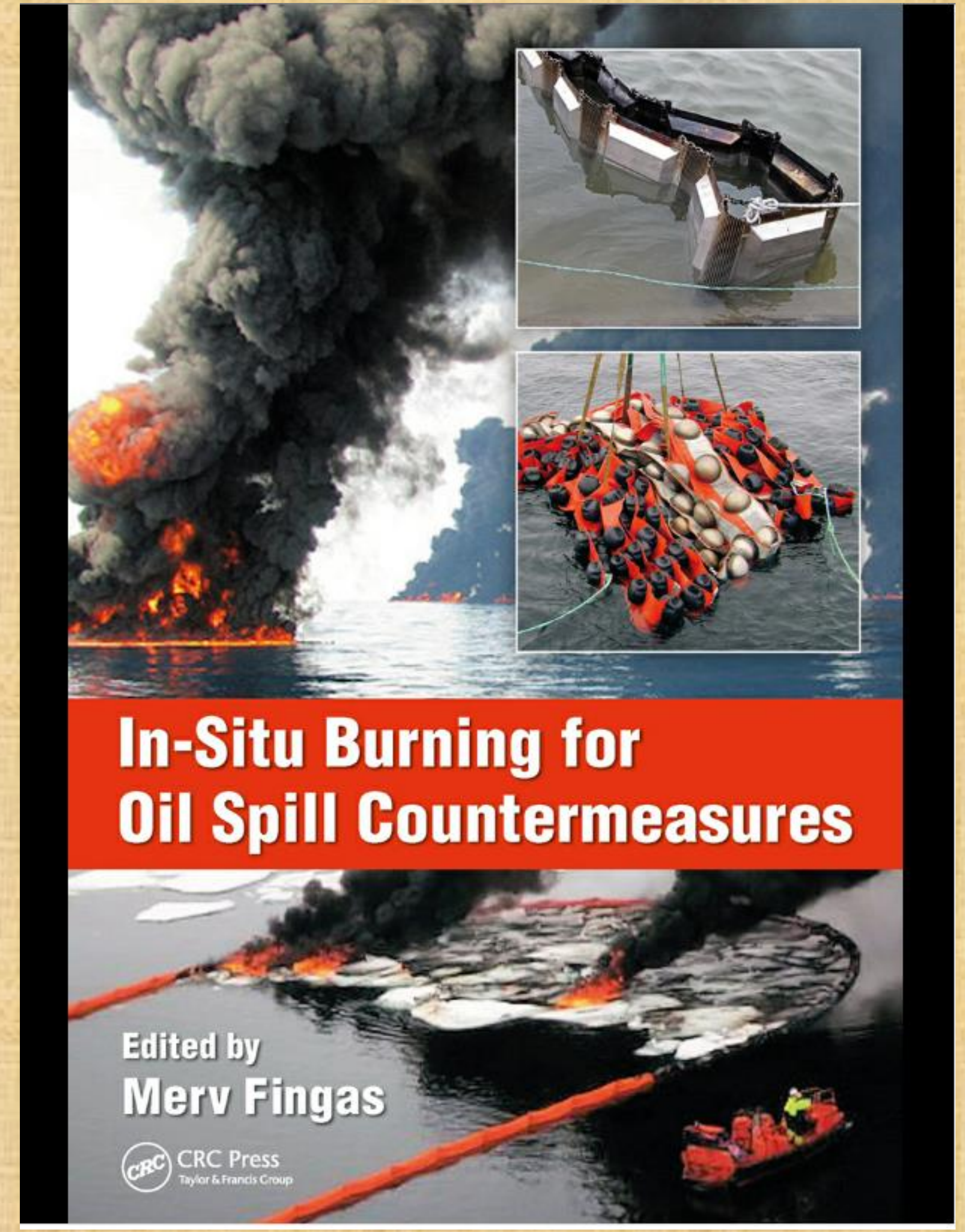
Merl-Consulting

# In-Situ Burning Deep Horizon Oil Spill



# In-Situ Burning



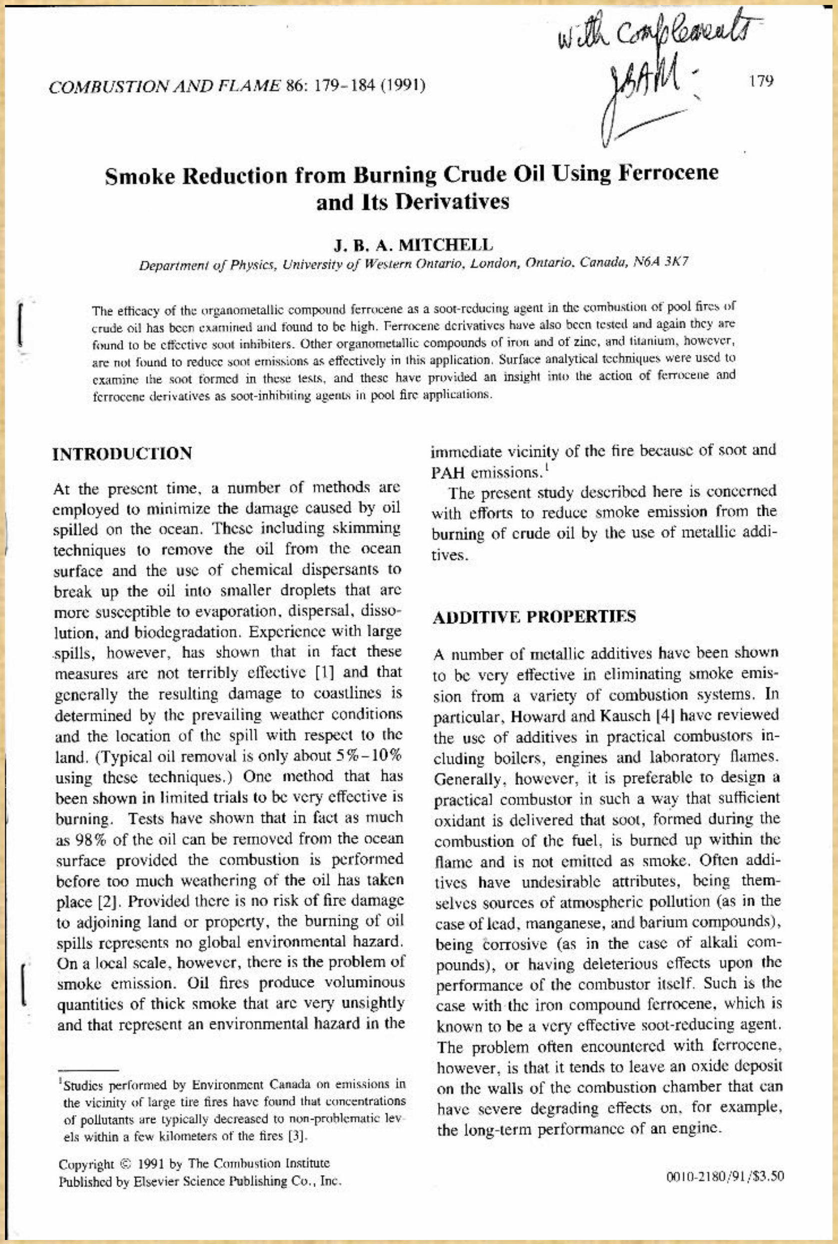
# Comparison with other methods

**TABLE 1.4**

**Approximate Comparison of On-water Countermeasures**

| | Light Crude | | Heavy Crude | | Bunker C | |
|---|---|---|---|---|---|---|
| | Hours to Clean | Tons/ Hour | Hours to Clean | Tons/ Hour | Hours to Clean | Tons/ Hour |
| Brush drum skimmer | 7.5 | 8 | 30 | 2 | 75 | 1 |
| Large weir skimmer | 1.5 | 40 | 0.9 | 71 | 18 | 4 |
| Dispersants | 0.2 | 75 | 0.2 | 47 | 0.2 | 10 |
| In-situ burning | 0.2 | 356 | 0.3 | 238 | 0.3 | 238 |

# Early Days



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with compliments JBAM



## Smoke Reduction from Burning Crude Oil Using Ferrocene and Its Derivatives

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The efficacy of the organometallic compound ferrocene as a soot-reducing agent in the combustion of pool fires of crude oil has been examined and found to be high. Ferrocene derivatives have also been tested and again they are found to be effective soot inhibiters. Other organometallic compounds of iron and of zinc, and titanium, however, are not found to reduce soot emissions as effectively in this application. Surface analytical techniques were used to examine the soot formed in these tests, and these have provided an insight into the action of ferrocene and ferrocene derivatives as soot-inhibiting agents in pool fire applications.

### INTRODUCTION

At the present time, a number of methods are employed to minimize the damage caused by oil spilled on the ocean. These including skimming techniques to remove the oil from the ocean surface and the use of chemical dispersants to break up the oil into smaller droplets that are more susceptible to evaporation, dispersal, dissolution, and biodegradation. Experience with large spills, however, has shown that in fact these measures are not terribly effective [1] and that generally the resulting damage to coastlines is determined by the prevailing weather conditions and the location of the spill with respect to the land. (Typical oil removal is only about 5%–10% using these techniques.) One method that has been shown in limited trials to be very effective is burning. Tests have shown that in fact as much as 98% of the oil can be removed from the ocean surface provided the combustion is performed before too much weathering of the oil has taken place [2]. Provided there is no risk of fire damage to adjoining land or property, the burning of oil spills represents no global environmental hazard. On a local scale, however, there is the problem of smoke emission. Oil fires produce voluminous quantities of thick smoke that are very unsightly and that represent an environmental hazard in the immediate vicinity of the fire because of soot and PAH emissions.[1]

The present study described here is concerned with efforts to reduce smoke emission from the burning of crude oil by the use of metallic additives.

### ADDITIVE PROPERTIES

A number of metallic additives have been shown to be very effective in eliminating smoke emission from a variety of combustion systems. In particular, Howard and Kausch [4] have reviewed the use of additives in practical combustors including boilers, engines and laboratory flames. Generally, however, it is preferable to design a practical combustor in such a way that sufficient oxidant is delivered that soot, formed during the combustion of the fuel, is burned up within the flame and is not emitted as smoke. Often additives have undesirable attributes, being themselves sources of atmospheric pollution (as in the case of lead, manganese, and barium compounds), being corrosive (as in the case of alkali compounds), or having deleterious effects upon the performance of the combustor itself. Such is the case with the iron compound ferrocene, which is known to be a very effective soot-reducing agent. The problem often encountered with ferrocene, however, is that it tends to leave an oxide deposit on the walls of the combustion chamber that can have severe degrading effects on, for example, the long-term performance of an engine.

[1] Studies performed by Environment Canada on emissions in the vicinity of large tire fires have found that concentrations of pollutants are typically decreased to non-problematic levels within a few kilometers of the fires [3].


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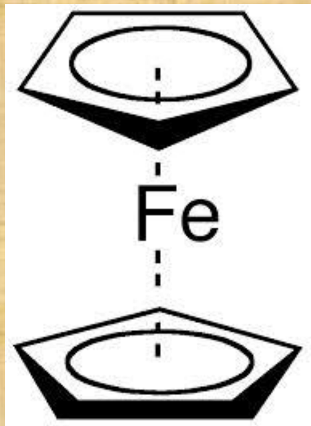
# Ferrocene
# Di-cyclopentadienyl Iron

- Non-toxic
- Stable to 450°C
- Sublimes at 100°C
- Boiling point 249°C

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Mechanism of action:

$FeO + C \rightarrow Fe + CO$

# US Air Force Initiative Development of a New Fire Training Fuel

- Chuck Risinger -USAF
- Michael Moir –Imperial Oil
- Bruce Irwin –Exxon Chemical
- AJ Misiti – Exxon Chemical
- Doug Raithby - MERL
- Ron Goodman – Imperial Oil

# Kirila Fire Training

**Diesel**

**Tekflame**

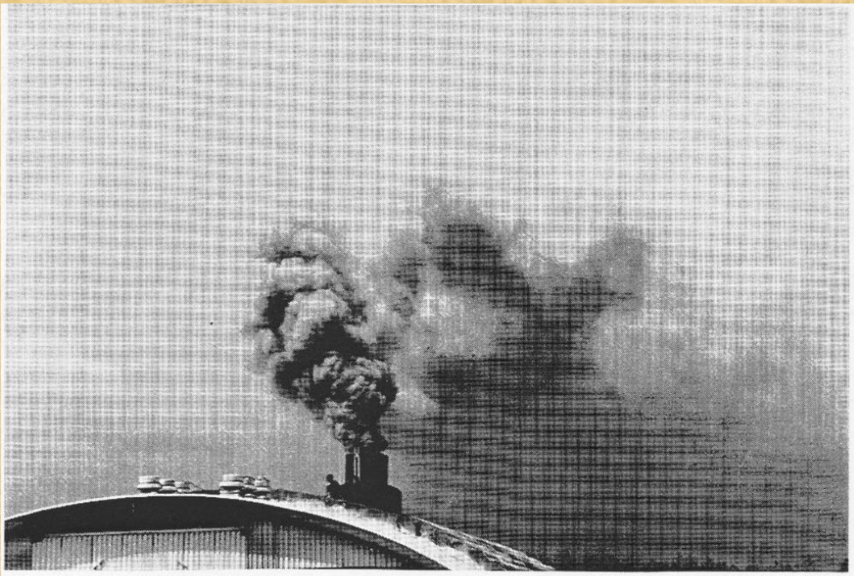


Figure 66. View of smoke emitted during dry chemical application to a JP4 fire.

Figure 67. View of smoke emitted during dry chemical application to a fire of CD2022 + 0.5% additive.

# US Air Force –Fire Training Fuel Tests
# Tyndall Air Force Base

# HALON !!!

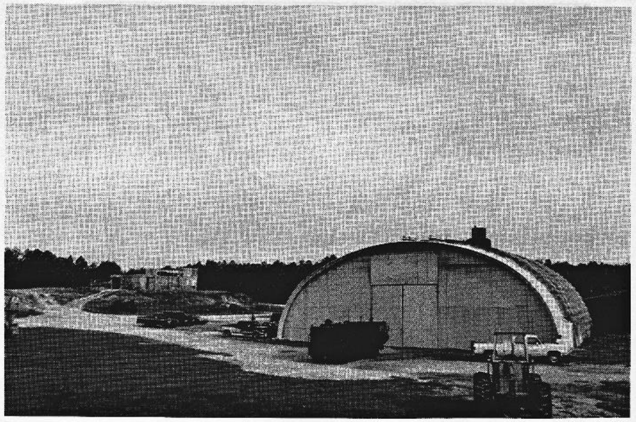


Figure 85. View of smoke stack during a fire of CD2022 + 0.5% additive prior to injection of halon.

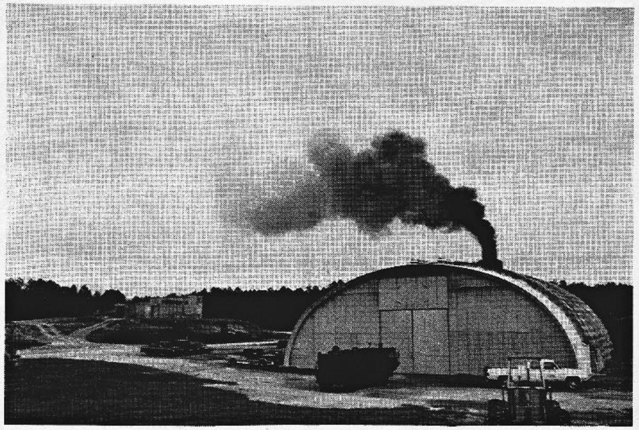


Figure 86. View of smoke emitted during application of halon to a fire of CD2022 + 0.5% additive.

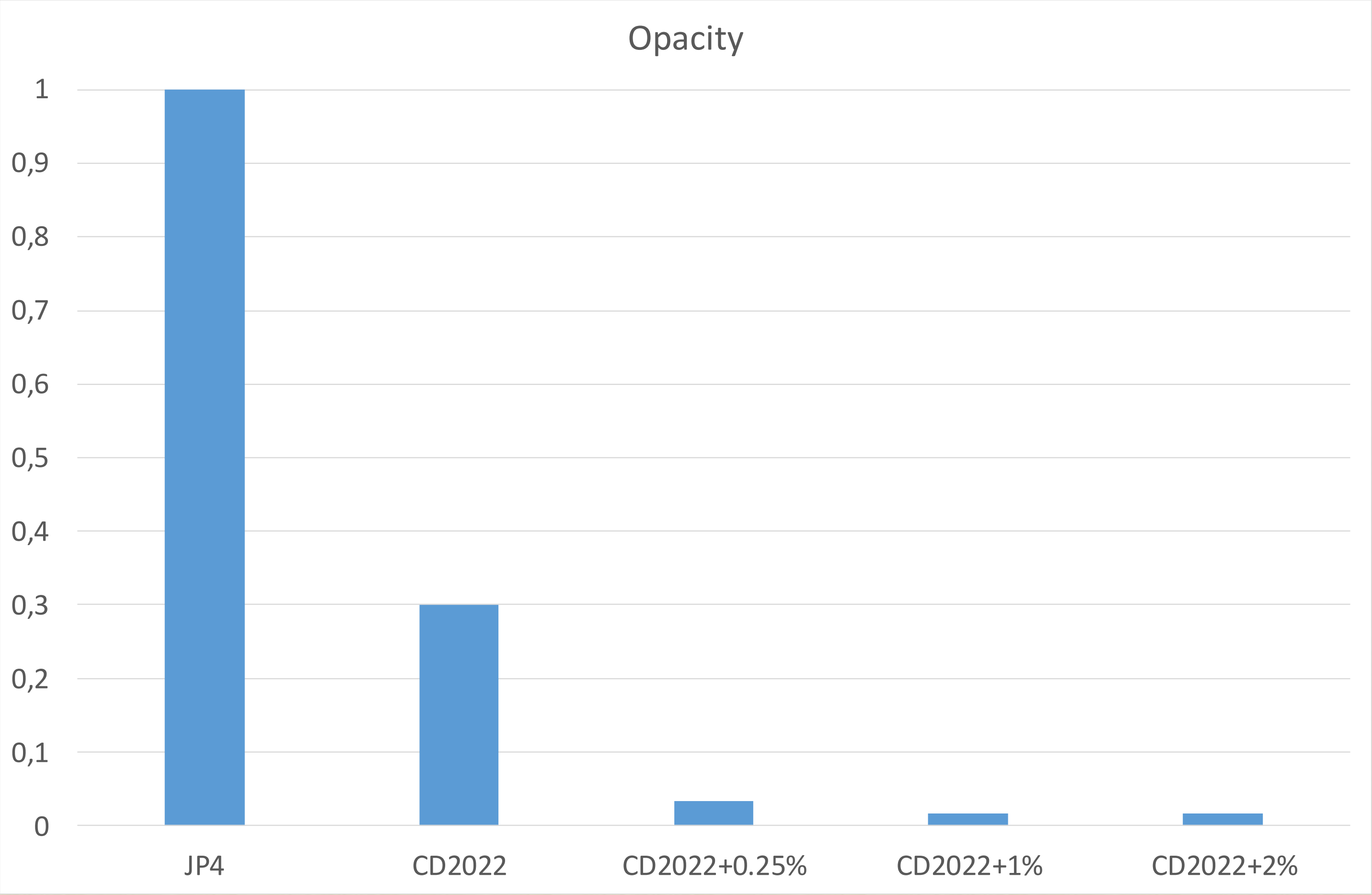
65

# FAA Tests

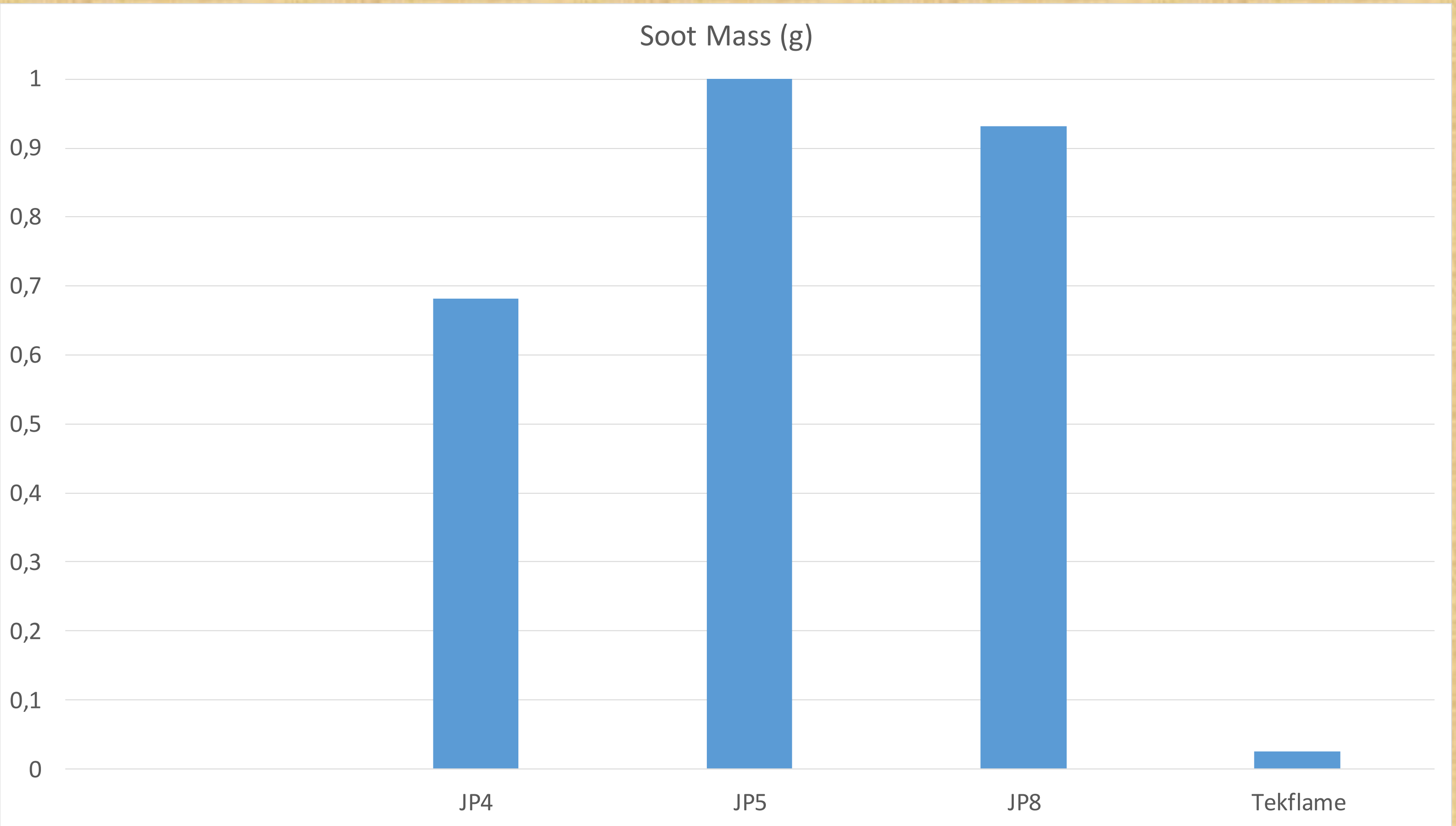
Tekflame

JP8

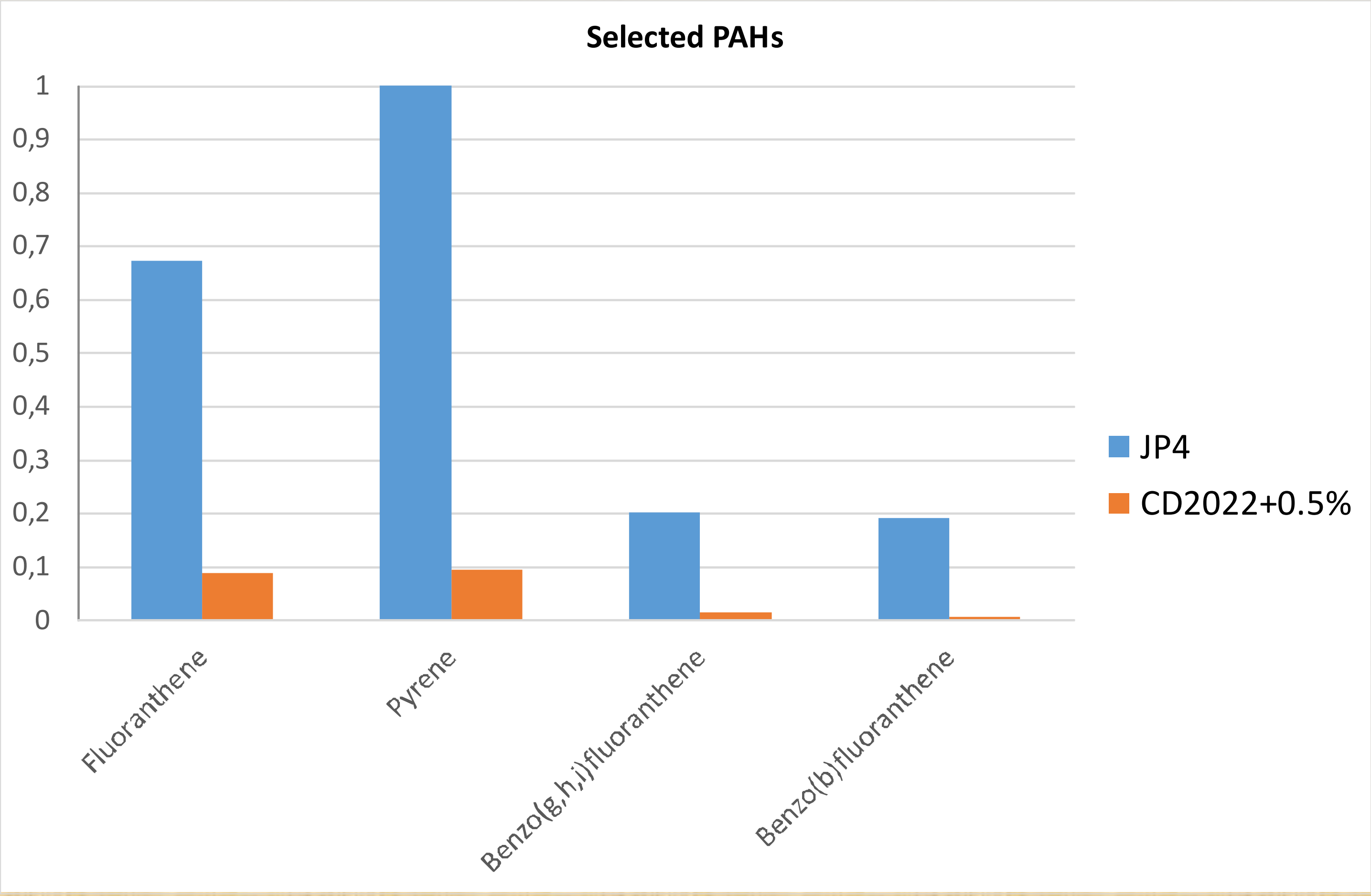
# Opacity


Opacity
1
0,9
0,8
0,7
0,6
0,5
0,4
0,3
0,2
0,1
0
JP4
CD2022
CD2022+0.25%
CD2022+1%
CD2022+2%

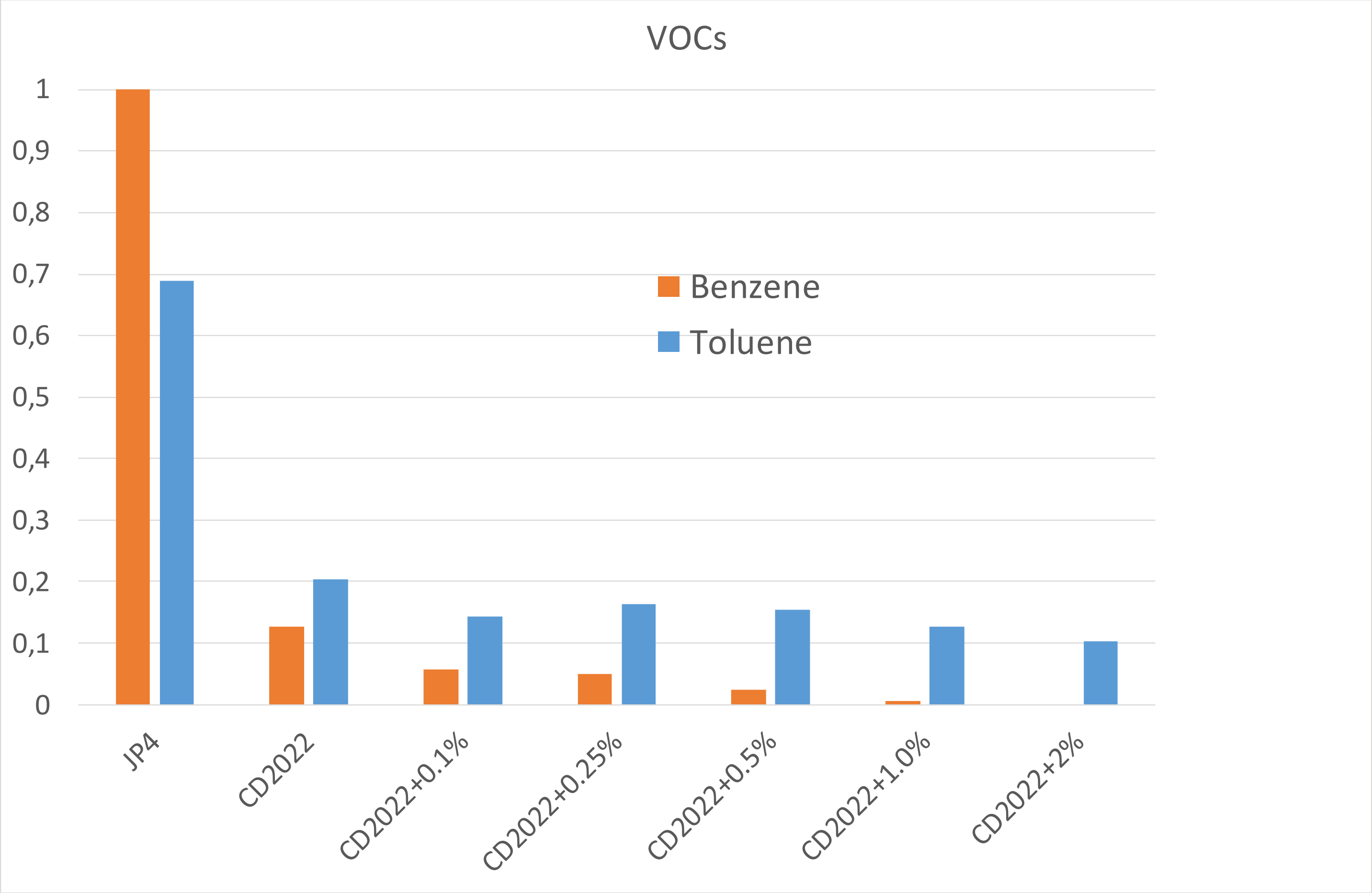
# Soot Mass



# Selected PAHs



# Volatile Organic Carbon



# Encapsulated Additive Layout

# Encapsulated catalyst
# Test at Serco IFTC, Darlington, UK
# April 2016

JET-A without Additive

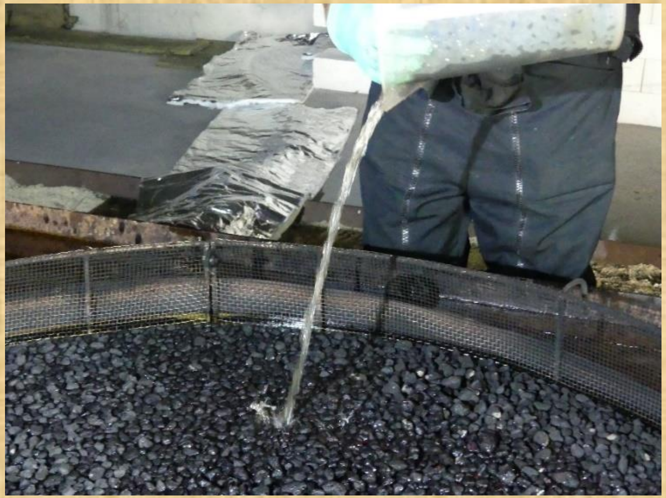
JET-A with Additive

# No CATALYST BUT UNDERLYING WATER BOILING

Residue after Arabian Crude Burn

Ecopomex Wicking Agent

After Arabian Crude Burn with Ecopomex



Water After the Burn!

# Wicking Agent Ecopomex Co.

## INERIS MAY 2018

# Final Words

- It is possible to reduce smoke emissions very substantially in an open burning pool fire
- It is possible to add the smoke reducing additive to an existing oil pool
- It is possible to add the smoke reducing additive to an existing fire
- The additive can be used on solid fuels