PAH and Nitro-PAH emissions from GDI vehicles

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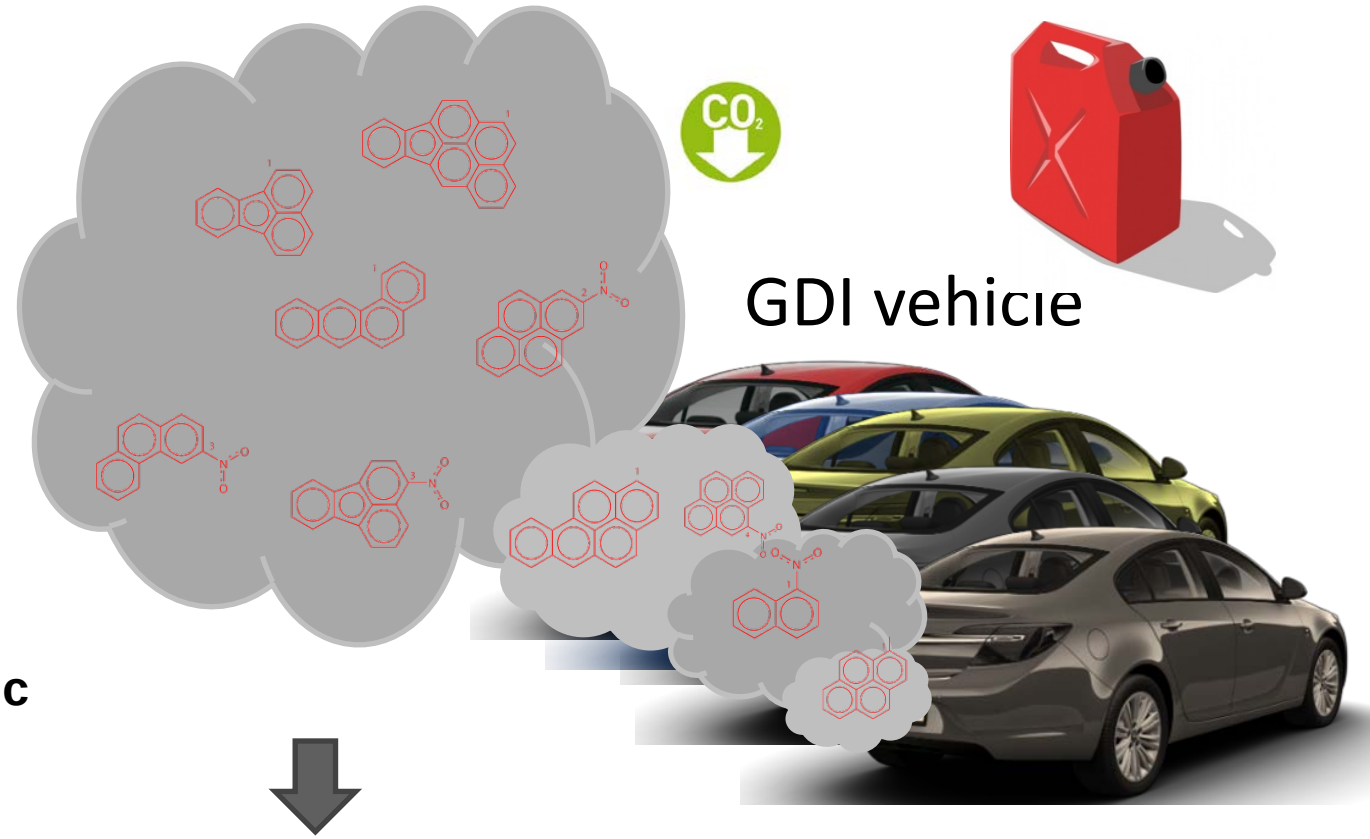


Are GDI vehicle exhausts as genotoxic as those of diesel engines?

GENOTOXIC EMISSIONS **?**

GasOMeP

Chemical characterization

OVERVIEW

Introduction

- Energy data and diesel case
- Polycyclic aromatic hydrocarbons
- Genotoxicity

Sampling and Laboratory analysis

- Detailed HRGC-HRMS analysis

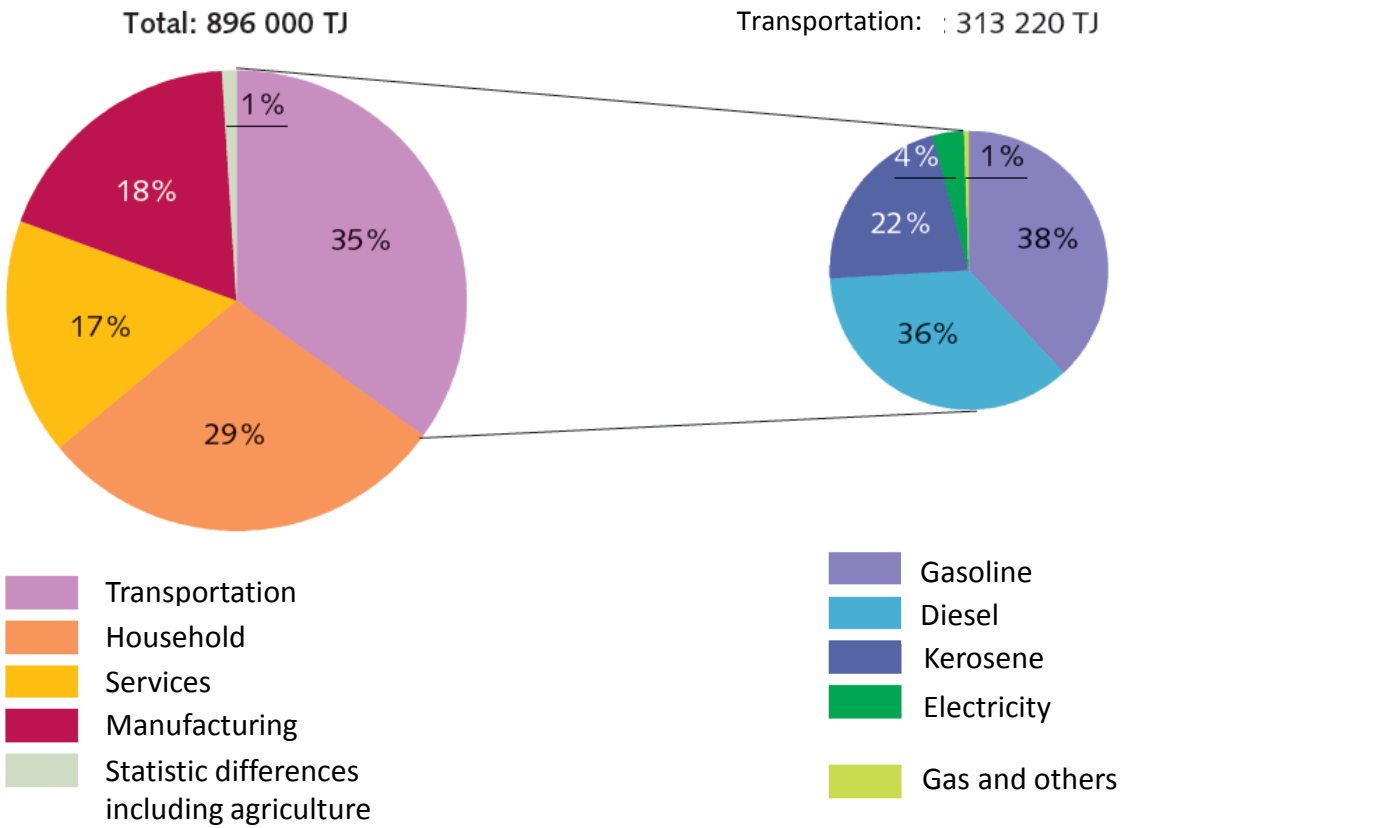
Results

Conclusions

Swiss energy consumption

Energy consumption traffic (313.220 TJ, 35% in 2013)

Energy consumption 2013



Quelle: BFE – Gesamtenergiestatistik

Swiss Federal Office for Statistics

GDI vehicles on the rise

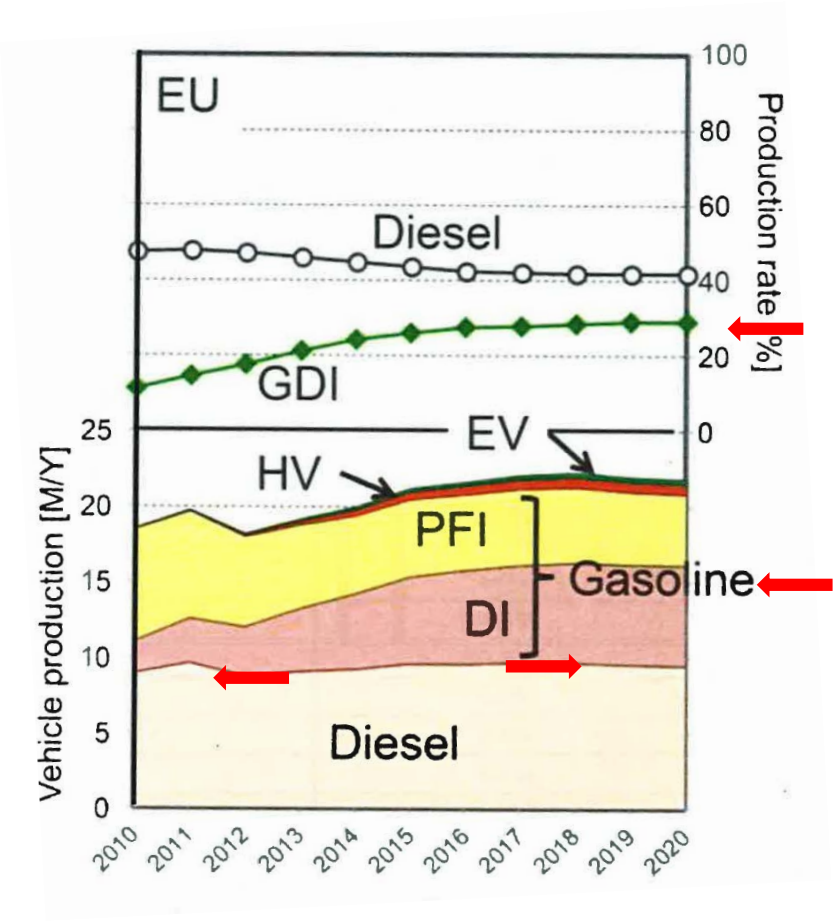
Gasoline/diesel production in EU:

- 50/50 in **2010** (18 mio vehicles/y)
- 60/40 in **2020** (22 mio vehicles/y)

  half of the gasoline vehicles are GDI

30% of EU fleet will be GDI in **2020** with

53 mio cumulated in 2010-2020



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International Agency for Research on Cancer
World Health Organization

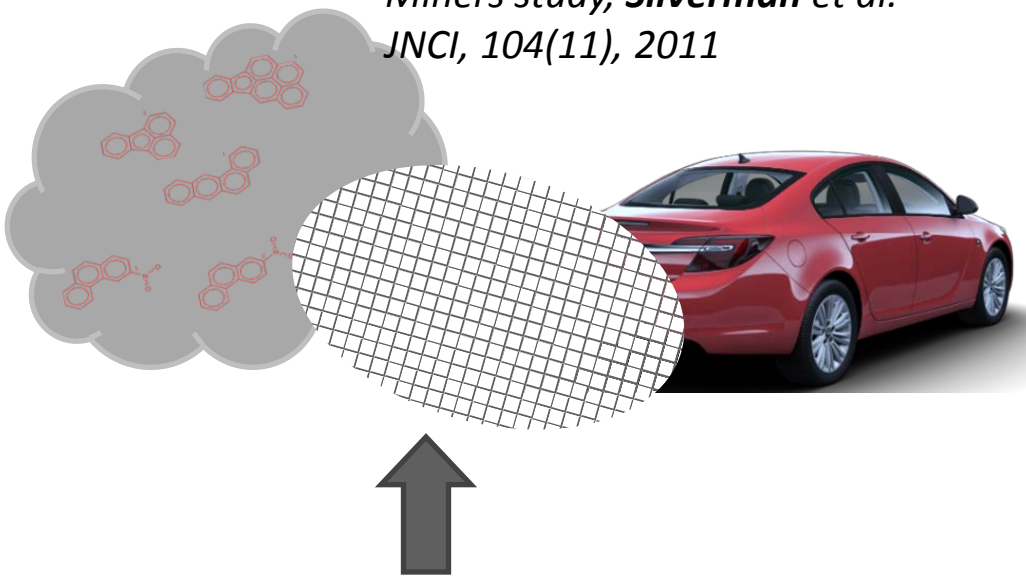
DIESEL ENGINE EXHAUST
Carcinogenic to humans (Group 1)

*Miners study, **Silverman** et al. JNCI, 104(11), 2011*

DIESEL

New pollutants

GDI



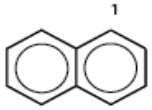
Particles exceed those of diesel with filter
(Mohr et al., Environ. Sci. Technol., 40 2375-2383, 2006)

Particle filters ?

1000x more than other gasoline vehicles

10x more than new diesel vehicles

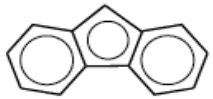
PAHs (Polycyclic Aromatic Hydrocarbons)



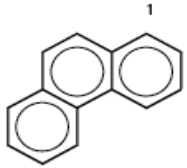
1) naphthalene

2) acenaphthylene

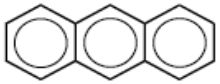
3) acenaphthene



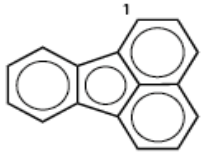
4) fluorene



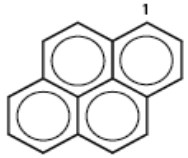
5) phenanthrene



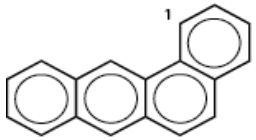
6) anthracene



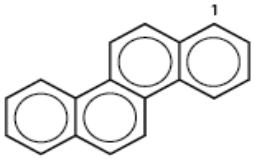
7) fluoranthene



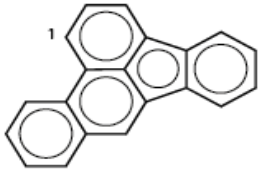
8) pyrene



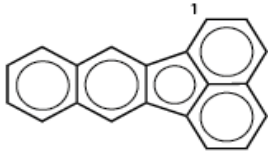
9) benzo(a)anthracene



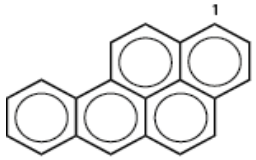
10) chrysene



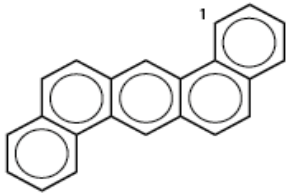
11) benzo[b]fluoranthene



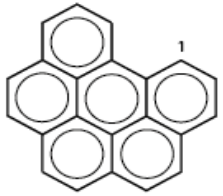
12) benzo[k]fluoranthene



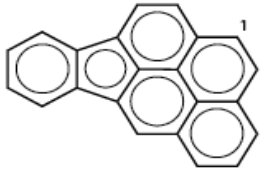
13) benzo[a]pyrene



14) dibenz[ah]anthracene



15) benz[ghi]perylene



16) indeno(1,2,cd)pyrene

International Agency for Research on Cancer

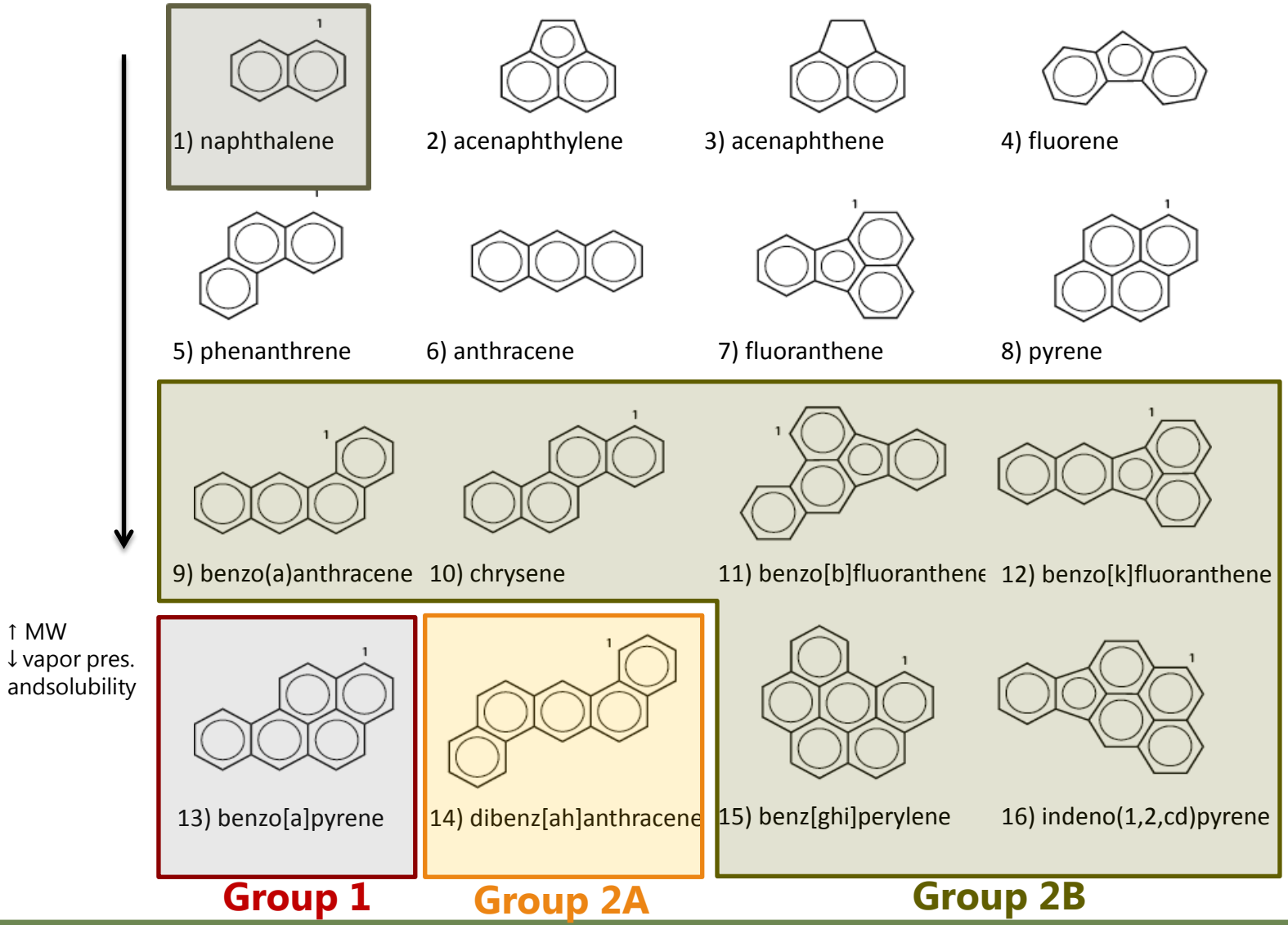
World Health Organization

AGENTS CLASSIFIED BY THE *IARC MONOGRAPHS*, VOLUMES 1–112

Group 1	*Carcinogenic to humans*	116 agents
Group 2A	*Probably carcinogenic to humans*	73
Group 2B	*Possibly carcinogenic to humans*	287
Group 3	*Not classifiable as to its carcinogenicity to humans*	503
Group 4	*Probably not carcinogenic to humans*	1

Last update: 3 June 2015

PAHs (Polycyclic Aromatic Hydrocarbons)



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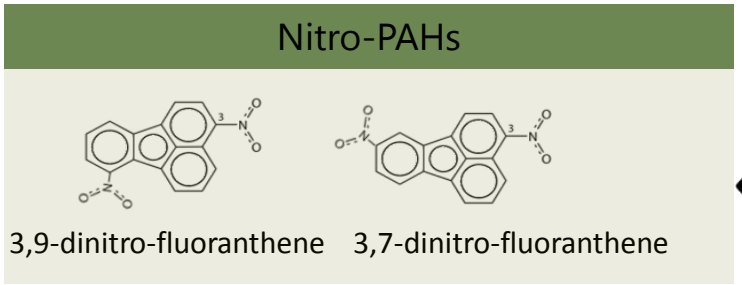
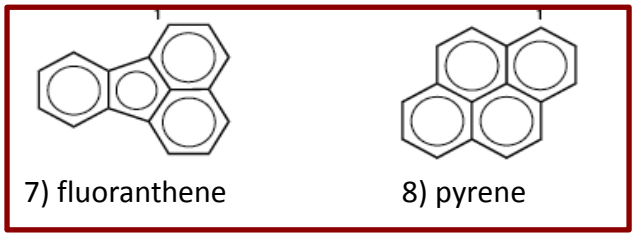
Nitro- and alkyl- PAHs

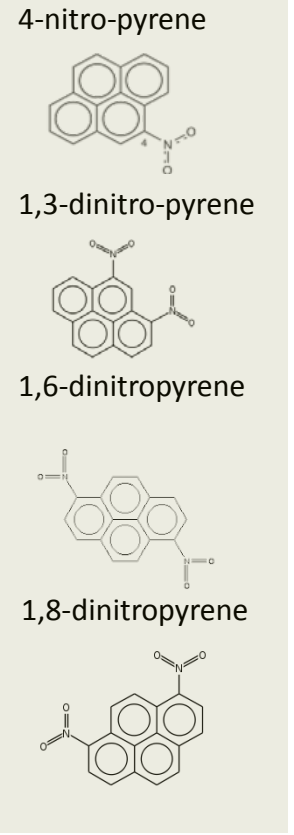
Group 2B

Nitro-PAHs

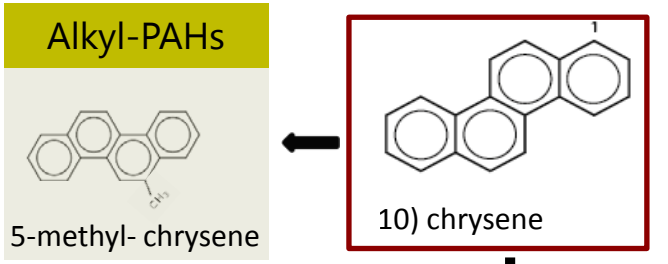




Nitro-PAHs

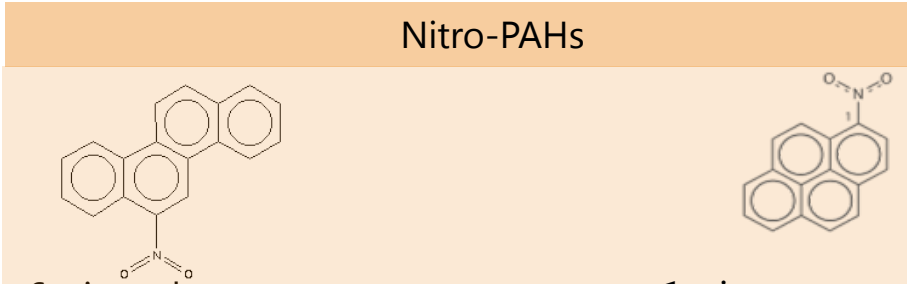


Alkyl-PAHs

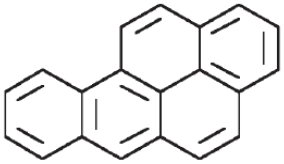
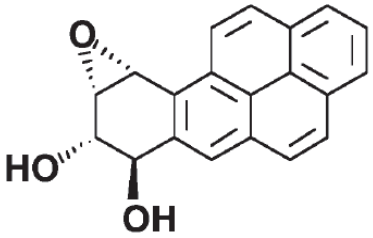


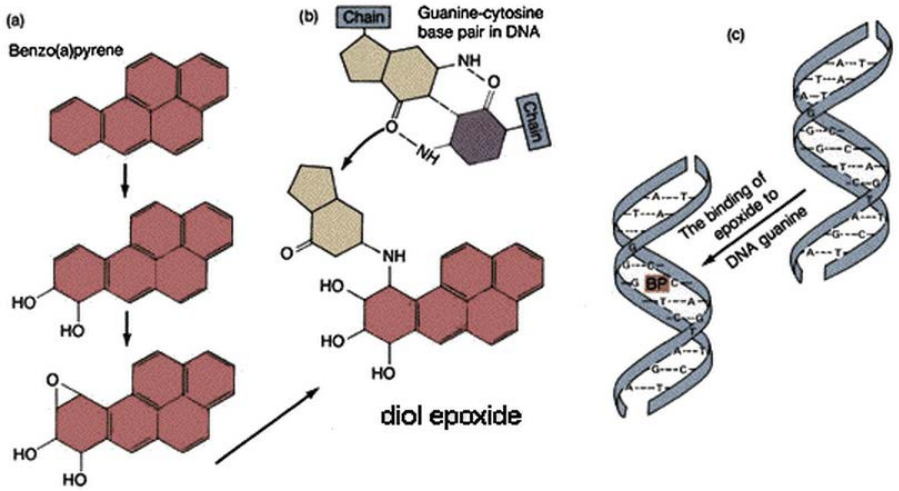
Group 2A

Nitro-PAHs



GENOTOXICITY: The Benzo[a]pyrene example

Carcinogen	Environmental source	Major active metabolite	Sites of modifi-cation	Major type of muta-tion
 Benzo[*a*]pyrene (B[*a*]P)	Tobacco smoking Combustion processes	 B[*a*]P-7,8-dihydrodiol 9,10-epoxide (BPDE)	N^2-Guanine N^6-Adenine	GC → TA



Pathway of metabolic activation and DNA adduct formation of benzo[a]pyrene

SAMPLING PROCEDURE

Several GDI vehicles:

3 different brands

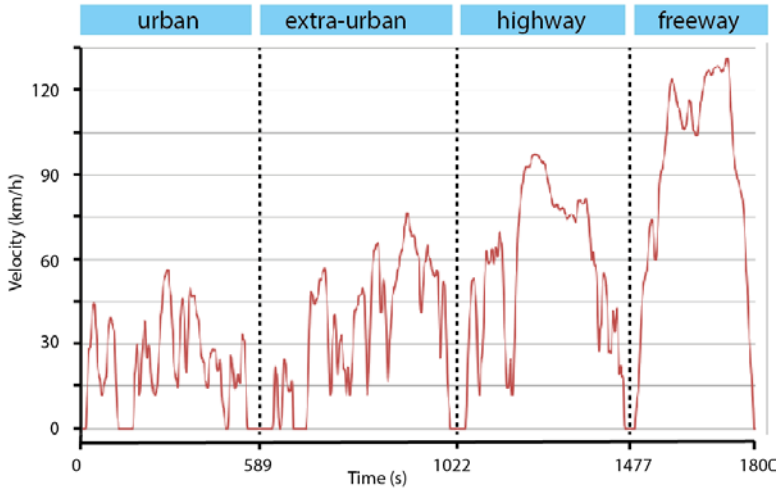
A non-catalytic filter

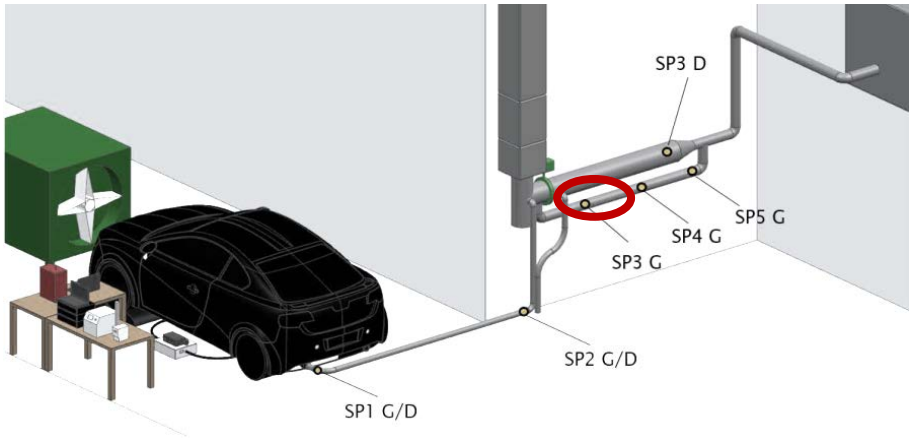
- Chassis dynamometer, UASB, **Nidau**

WLTC → **HOT start**

WLTC → **COLD start**

SSC





From J. Czerwinski Group, Berner Fachhochschule

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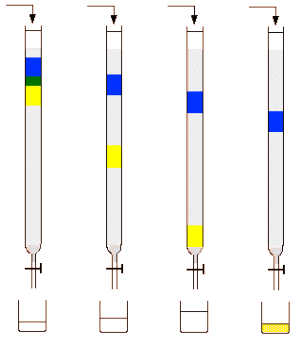
LABORATORY ANALYSIS

- Diluted exhaust - CVS tunnel:
  solid + condensed + gaseous phases

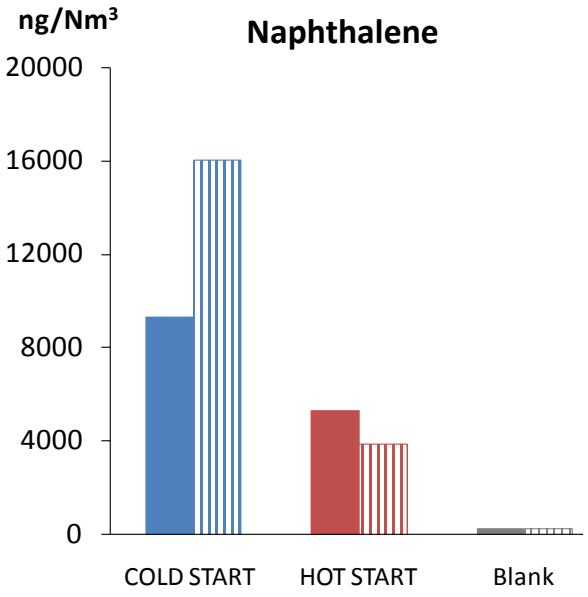
ASE/Soxhlet extraction → Concentration → Cleanup and fractionation → HRGC/HRMS analysis

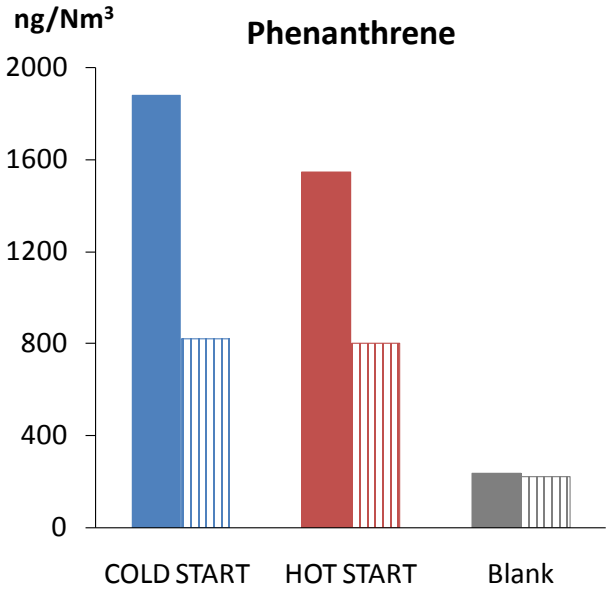


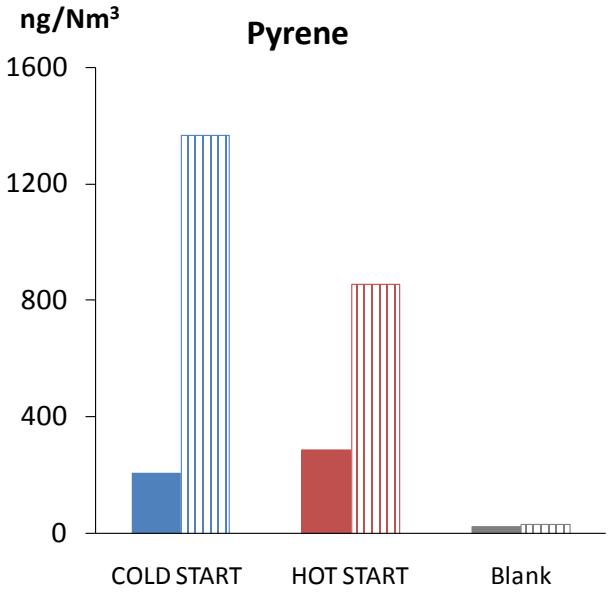
DIFFERENT VEHICLES

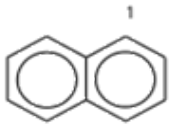
2-3 RINGS and PYRENE

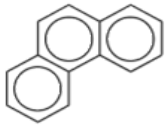
Vehicle 1
Vehicle 3

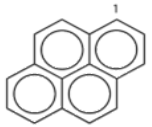












218 °C → Boiling point → 404 °C

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CONCLUSIONS

- Emissions decrease under hot start conditions (vehicles without filter)
- The higher the boiling point the better the FILTRATION EFFICIENCY

COLD start conditions

- The higher the boiling point the higher the emissions on **hot** start conditions

PAH storage/release ??
PAH formation ??

- Nitro-PAHs in ambient levels

THANK YOU VERY MUCH FOR YOUR ATTENTION

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