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Adverse health effects of gasoline and diesel exhaust in human cell cultures

7th VERT Forum
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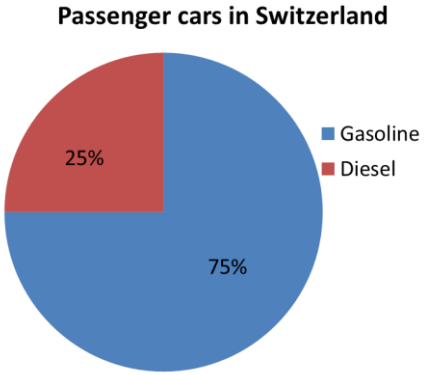
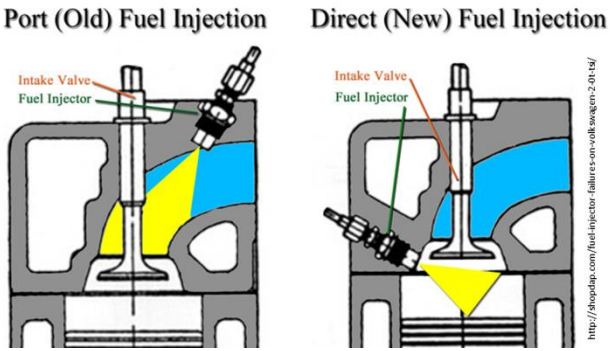
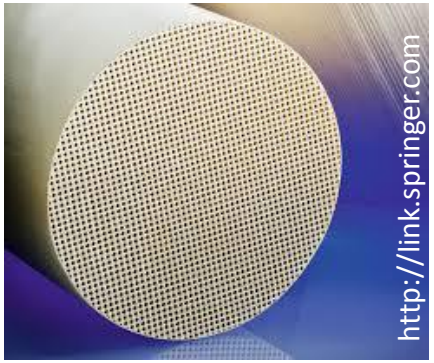
Gasoline exhaust- why do we have to worry?

- Occurence of gasoline passenger cars
- Gasoline engines- shift from Port fuel injection to direct injection (GDI)
  - Power ↑, Efficiency ↑
  - CO_2↓
  - **Particles ↑**
- Gasoline Particle Filter (GPF) on GDI?
- Adverse effects of gasoline exhaust
  - Most studies before 1990 (engines and fuel changed)
  - One recent study in animals with a 1996 GM engine, they found e.g. increased cytotoxicity and pro-inflammation in the lung

➢ **GDI/GPF → Influence on human health?**



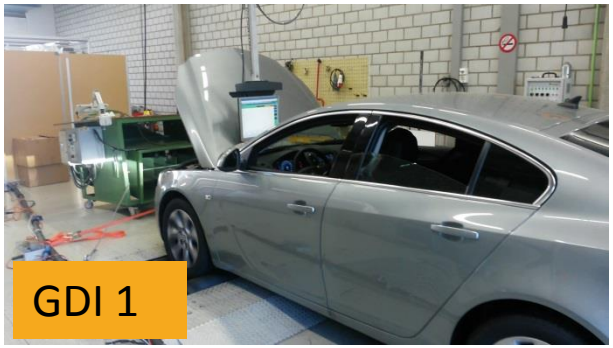




References:
Bundesamt für Statistik. «Mobilität und Verkehr 2013»
Lund et al 2006, Toxicological Sciences
McDonald et al 2007, Inhalation Toxicology
Reed et al 2008, Inhalation Toxicology
Mauderly et al 2014, Inhalation Toxicology

Methods – Exposure system

- Older diesel car
- Toxicology tests performed and published#
- Adverse effects in lung cells expected



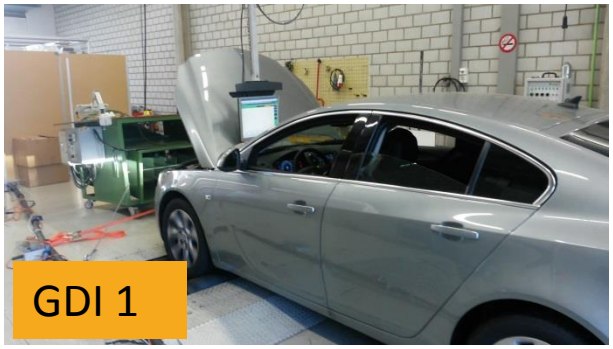
- New gasoline DI car
- Influence of a gasoline particle filter (GPF)?
- Results presented @6th VERT Forum and published*

- New gasoline DI car
- Influence of two gasoline particle filters (GPF), uncoated and coated?

#Steiner et al. 2013
#Steiner et al. 2014
*Bisig et al. 2015

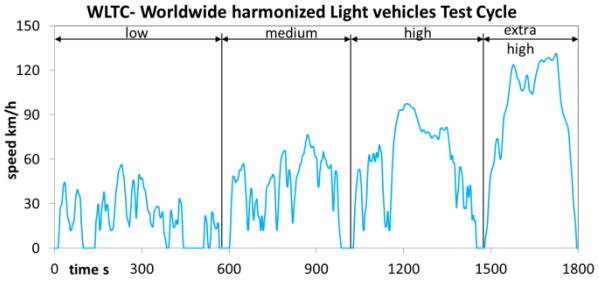
Methods – Exposure system

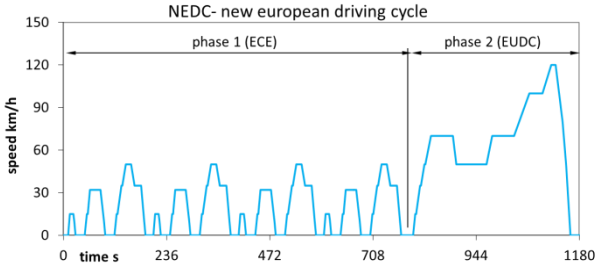
- WLTC
- Unfiltered



- **NEDC**
- Unfiltered
- Uncoated GPF

- WLTC
- Unfiltered
- Uncoated GPF
- Coated GPF

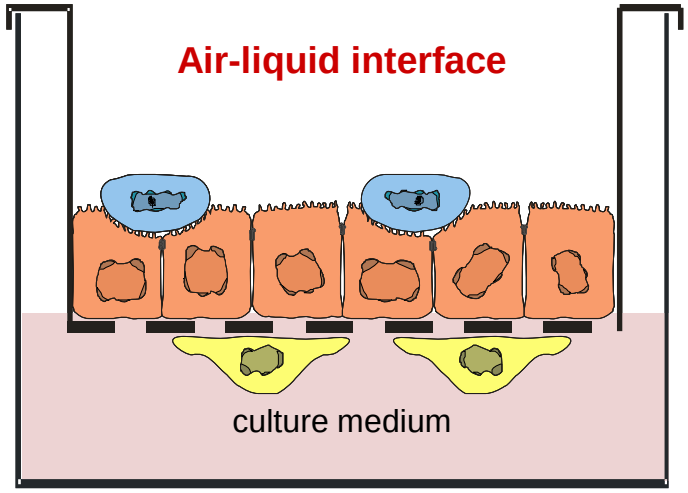




- 6 hours exposure (WLTC or NEDC)
- 1:10 dilution
- Characterization:
  - CPC
  - NOx, CO, CO_2, T.HC, NMHC

CPC= condensation particle counter
WLTC= Worldwide harmonized light vehicles test cycle
NEDC= New european driving cycle

Methods - *In vitro* human lung system

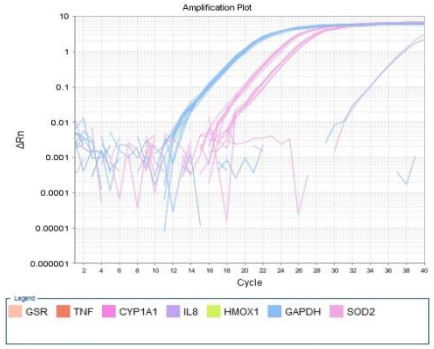


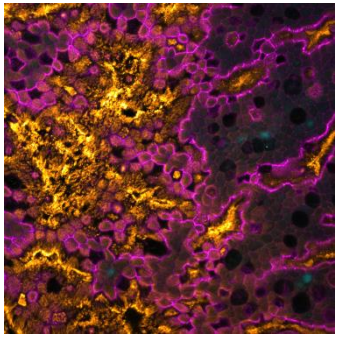
3D HUMAN model of the epithelial lung tissue barrier

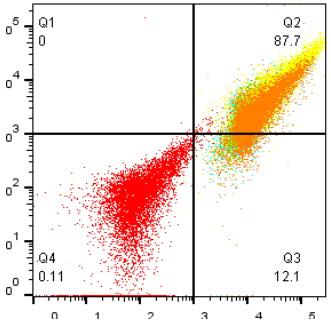
- Macrophages (from human blood)
- Bronchial epithelial cells (16HBE14o- cell line)
- Dendritic cells (from human blood)

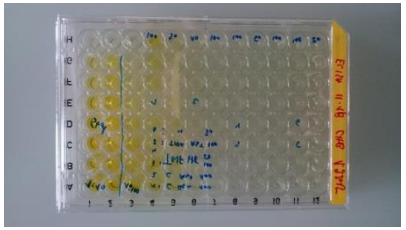
- Identical cells exposed to
  - Filtered air
  - Exhaust

In vitro testing strategy:



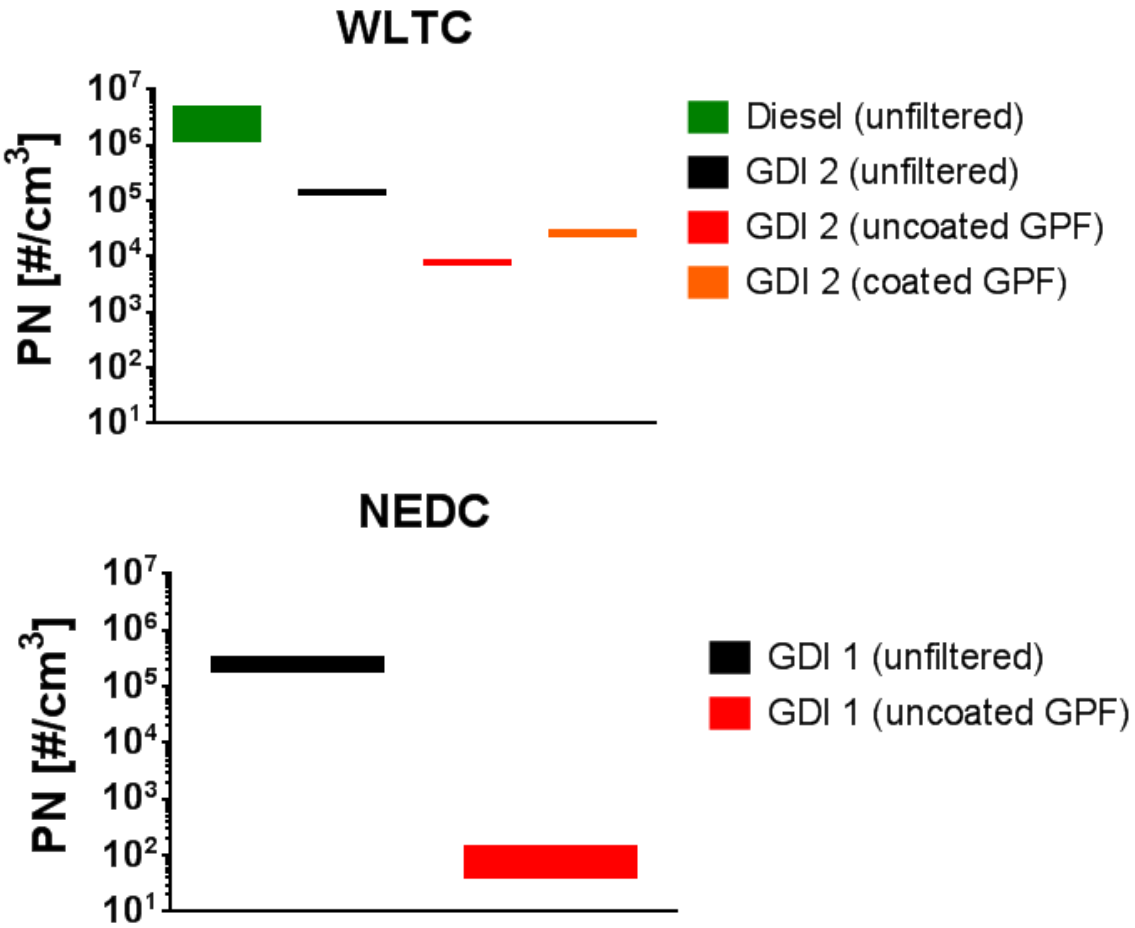






- Proteins, mRNA (gene expression)
  - Cytotoxicity, cell death, pro-inflammation, oxidative stress, mutagenicity,…

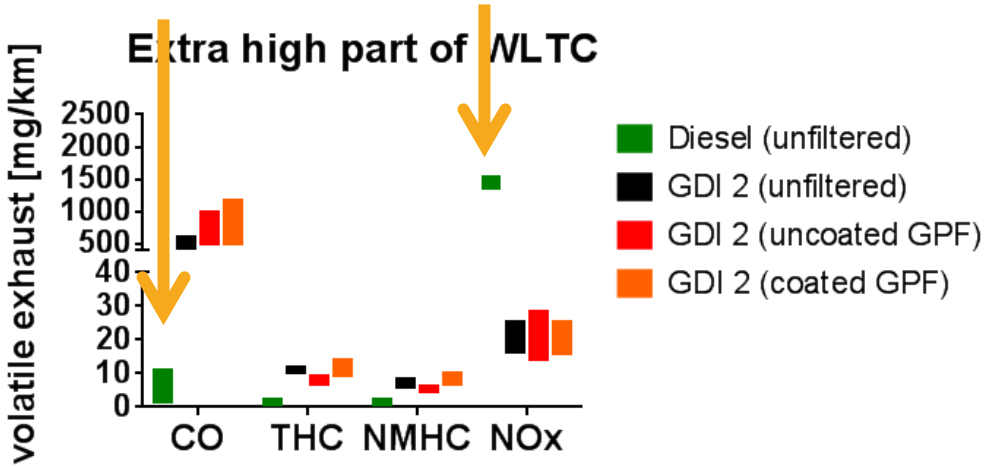
Results – Exhaust analysis

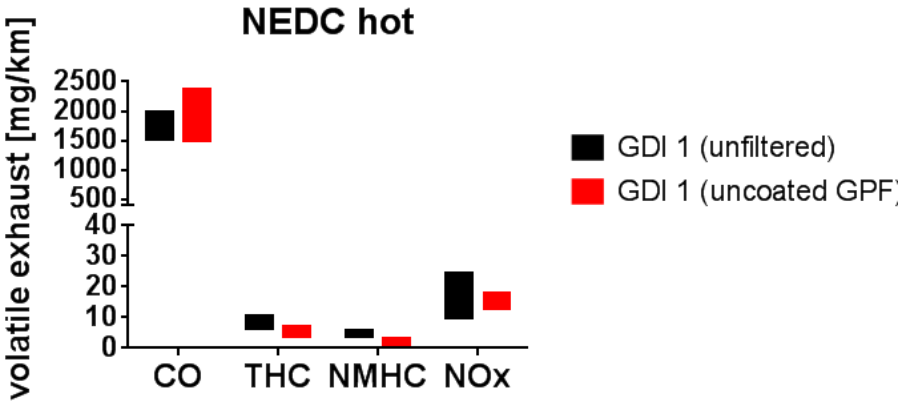


- Higher PN in Diesel exhaust
- Lower PN in filtered exhaust

SCR= Selective catalytic reduction
WLTC= Worldwide harmonized light vehicles test cycle
NEDC= New european driving cycle
PN= Particle number

Results – Exhaust analysis





- CO: Low for diesel exhaust
- NOx: Very high in diesel exhaust (no SCR)
- GDI: higher CO, low NOx
- THC/NMHC: generally very low

SCR= Selective catalytic reduction
WLTC= Worldwide harmonized light vehicles test cycle
NEDC= New european driving cycle
PN= Particle number

Summary/Outlook

Marker	Diesel unf.	GDI 1 unf.*	GDI 1 uncoat. GPF*	GDI 2 unf.	GDI 2 uncoat. GPF	GDI 2 coated GPF
Particle number (#/cm^3)	~10^6	~10^5	~10^2	~10^5	~10^4	~10^4
CO (mg/km); extra high part!	~10	~1500	~1500	~750	~750	~750
NOx (mg/km); extra high part!	~1500	~20	~20	~20	~20	~20
Cytotoxicity (LDH)	(↑)	-	-	-	-	-
Morphologie (Microscopie)	-	-	-	-	-	-
Oxidative stress	↑	↑	↑	-	-	-
Pro-inflammation	↑	-	↑	-	-	-
Mutagenicity (DNA adducts)	-	n.p.	n.p.	-	-	-
AhR-upregulation	(↑)	↑	-	-	-	-

GDI 2: NO EFFECTS

- Adverse effects influenced by vehicle
- Future test
  - Repeated/Prolonged tests
  - Create worst case, *i.e.* high lube oil, effect of GPF?

n.p.=not performed
*Bisig et al. 2015

Thank you for attention

Thank you
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