Ultrafine Particles and its fractions

Joop van Ham, Thomas Reichert and John Murlis

EFCA, Delfgauw, The Netherlands

info@efca.net

www.efca.net

18th ETH Conference on Combustion Generated Nanoparticles,

Zürich, Switzerland, 22-25 June 2014

Content of presentation

- EFCA – Mission and Activities
- Priority topics
- Particulate matter: Fraction-by-Fraction
- Health risks by fraction
- Feasibility of Fraction-by-Fraction Approach
- Conclusions and Roadmap for progress

What is EFCA?

European Federation of National Associations

Objectives

- Furthering professional activity in Europe
- Connecting science and policy

Mission

To help to achieve policies and measures that will protect the environment, climate and human health in Europe against the effects of pollution while fostering sustainable development

Priority topics

Present drivers

- **Concern on the limitations of the policy approach on particles**: $PM_{10}/PM_{2.5}$ are „container metrics“
- **One atmosphere: need for integration of clean air and climate in science and policy**

Professional activities

- **Conference series on Non-CO_2 Greenhouse Gases**
  - VVM, Netherlands; since 1993; NCGG-7 in 2014
- **Conference series on Ultrafine particles**
  - GUS, Germany; since 2007; UFP-5 in 2015
- **Conferences on “One Atmosphere”**
  - APPA, France; 2008, 2011; Vancouver, 2010

Policy Activities

- ***Response at EU Public Consultations***
- ***Policy Initiative*** „Linking air pollution and climate change“ (PI-2, 2010)
- ***Policy Initiative*** on Black Carbon Particles as extra metric, <u>additional</u> to PM_{10}/$PM_{2.5}$ (PI-3, 2012)
- ***Publicity actions***
  - *Special sessions and presentations* at conferences (Lille, 2006 on PM; Vancouver 2010 on ‚One atmosphere‘; Istanbul 2012 on ‚Transboundary transport in the Mediterranean‘; Zurich, Sibenik, Capetown and Belgrade, 2013 on Black Carbon/PM)
  - *Publications* (Proceedings, Journals and EFCA‘s Newsletters and website)

Black Carbon Particles

Focus on Black Carbon:

- Better correlation with short-term health endpoints than PM_{10}/$PM_{2.5}$
- BC-sources are well known; emissions in ultrafine mode
- BC-policy is coherent with policies to reduce emissions of particle numbers from combustion sources
- Climate forcer: AQ-policies for BC result in less warming
- Potential co-benefits of integrated policy furthers implementation of AQ legislation in MS

However, PM is more than just Black Carbon

Composition of $PM_{10}/PM_{2.5}$

Primary

- Black Carbon
- Organic Carbon
  - ✓ Primary Organic Aerosol (POA)
- Metals
- Abrasion particles
- Natural
  - ➢ Sea salt
  - ➢ Pollen
  - ➢ Saharan dust

Secondary

- Organic Carbon
  - ✓ Secondary Organic Aerosol (SOA)
- Inorganic aerosol
  - ➢ sulphates
  - ➢ nitrates
- Natural (natural haze)
- Resuspended aerosol

Ultrafine particles

specific health risks

Primary

- **Black Carbon**
- Primary Organic Aerosol (**POA**)
- Metals (combustion, metallurgical processes)
- Abrasion particles (traffic)
- Natural (Sea salt, Saharan dust)

Secondary

- Secondary Organic Aerosol (**SOA**)
- Inorganic aerosol
  - Sulphates (ultrafine?)
  - Nitrates (ultrafine?)
- Natural (Natural haze)
- Resuspended aerosol: ultrafine?

Fraction-by-Fraction policy

size - chemical composition

- Evidence that size (ultrafine fraction, 30-170 nm) is a crucial factor for cardiovascular and olfactory induced effects

PM_{10}/$PM_{2.5}$ -policy may be effective for respiratory effects, but not necessarily for cardiovascular and olfactory effects

- Black Carbon: meta-analysis of published studies (Janssen et al, 2011; WHO, 2012)
- POA: semi-volatile PolyCyclic Aromatics (PCAs) are co-emitted with BC, and subsequently are deposited at particle surfaces (POA); several PCA's are carcinogenic
- SOA: under summersmog conditions POA are oxidised in part and converted into ‚*reactive oxidative species*'; body of knowledge limited

Health risks - Black Carbon

- BCP is associated with health effects, that are not captured quantitatively in the same way by PM mass concentration
- For cohort studies, pooled estimates for all cause mortality per 1 µg/m^3 5 to 14 times higher for BCP than for PM_{10}
  - Simulation: 50% less urban traffic emissions would then save 3-4 months of lost life expectancy when referred to BCP; this is just 21 days in terms of $PM_{2.5}$ (1 µg/m^3 $PM_{2.5}$ ~ 0.6 µg/m^3 BCP)
- BCP represents one of the more health relevant components of PM, especially for cardiovascular effects

(Janssen, 2011)

Health risks – Organic Aerosols

- Semi-volatile Polycyclic Aromatics (PCAs) are co-emitted with BC from combustion sources, primarily as gases; their deposition at ambient temperatures on particles results in Primary Organic Aerosols (POA); various sources, wood stoves for heating is a risk in winter
- Under summer smog conditions PCAs at the POA surface are partly oxidised; chemical assay shows that the resulting '*aged smog*' or SOA has a higher oxidative capacity (metric for '*reactive oxidative species*') than POA; bioassay shows it is more reactive in genotoxic tests (Sioutas, 2011; Riskovski, 2013; Delfino 2014)
- Concern on Biofuels: simulation experiments in smog chambers show that their diluted exhaust gases produce much more '*reactive oxidative species*' than those from common diesel or petrol (Stevanovic, 2013)

In summary: much concern, but quantitative data are scarce.

Health risks – (Heavy) Metals

- (Heavy) metals in PM samples has a long history of monitoring and study;
- Policies throughout Europe target health risks in areas around specific industrial sources; the Heavy Metals Protocol under the CLRTAP and EU's Industrial Emissions Directive further a harmonised control in Europe
- Likely to benefit from generic PM-emissions reductions
- Considering them separately within a fraction-by-fraction PM policy may not have priority

Particle Numbers and Health Risks

- Consensus that the nano/ultrafine (30-170 nm) fractions constitute specific cardiovascular and olfactory risks; no certainty, however, that such risks are independent from chemical composition
- A PNC-approach is a perfect step in source-oriented policies; monitoring PNC is relevant, therefore
- However, PNC is a *„container metric“*, like PM_{10}/$PM_{2.5}$; less suitable in quality-oriented policy
- Fraction-by-Fraction (FbF) approach, addressing both, particle size and chemical composition, is required to assess the effectiveness of PM policy

FbF - Gaps in knowledge

Assessment modelling input

- **Sources**: FbF approach requires an emission inventory for each primary aerosol fraction and parameters for conversion into secondary fractions
- **Air quality**: FbF approach requires standardized measuring methods per fraction for reliable monitoring data
- **Health risks**: Long-term epidemiology (mortality) data; this requires time series of monitoring data on FbF basis

Feasibility of FbF approach
(educated guess)

	BC	POA	SOA	HM
Standardized Monitoring method	2015 (EC + OC)	available	2020?	available
Applied in national monitoring networks	2017	partly available	2025?	available
Epidemiological data	2025 - 2035	?	~2035	available

Conclusions

1. PM policy requires a Fraction-by-Fraction approach for adequate monitoring of its effectiveness and so furthering its cost-effectiveness; updating present policy tools is urgent
2. Controlling the PM problem probably requires addressing sources of primary PM-fractions as well as sources of precursors for photochemical oxidants (NOx, VOC)
3. More research and thorough assessment of the impacts of biofuels for transport on human health is required

Roadmap for progress

- CEN-standards for measuring BC, PNC, POA and SOA in ambient air
- Legislation which stepwise requires their monitoring in networks (AQ Directive)
- Encouragement of health effect research based on standardised monitoring data of PM-fractions
- Advanced DPF-technology, targeting POA, in addition to PN/BC emissions, should also be made available for petrol-vehicles and for other combustion sources as far as technically/economically feasible

Thank you!