SBSE applied to evaluate personal protective equipment against NBC threats

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What is (the best) NBC protection ensemble?
Evaluation Swatch-to-System level

Skin protection

Respiratory protection

Swatch

Product

System

Skin protection

Respiratory protection

Product

System
How can the performance of PPE be quantified?

- Protection Factor: \( PF = \frac{C_{t_{\text{outside}}}}{C_{t_{\text{inside}}}} \)
- Local physiological protective dosage

Simulation of an operation in a contaminated field
Integral testing of NBC protection ensemble

Experimental:
• Mannequin or test person
• Specific exercise protocols
• Duration: up to 3 hrs
• Wind: < 10 m/s
• Chemical: Methyl salicylate (gas)
• Biological: Aerosolized DEHS (C_{26}H_{50}O_{4})
• Nuclear: Radionuclide (solid)
Portable gas detection systems
Passive Sampling & Analysis (1)

- Classical

- Liquid extraction and HPLC or GC-MS

Passive Sampling & Analysis (2)

• At Spiez laboratory

+ TDS / GC-MS
Calibration (gas)

PF from 1 to 50’000 (ideally!) \[ \text{PF} = \frac{C_{t\text{outside}}}{C_{t\text{inside}}} \]

For \( C_{t\text{outside}} = \) up to 10’000 mg/m\(^3\).min

the PF range corresponds to \( C_{t\text{inside}} = 0.2 \ldots 10’000\) mg/m\(^3\).min

\( t_{\text{calib}} = 5\ \text{sec} \ldots 3\ \text{days!} \)

With \( t_{\text{calib},\text{min}} = 30\ \text{sec} \)

below linear extrapolation until S/N<10

And \( t_{\text{calib},\text{max}} = 90\ \text{min} \)

(Saturation of the detector)

PF from 25 to 5’000, extrapolated up to 50’000

\[ C_{\text{calib}}: 2.5\ \text{mg/m}^3 \]
 Requirement for **Class 3:**

- **Local PF:** 120 [-]

- **Overall PF:** 76 [-]

Aerosol (1)

Classical:

• Fluorometric analysis with fluorescent-tagged silica powder

Skin deposition of aerosol simulant: UV illumination of Fluorescent tag, from RTI International, USA (left) and Naval Air, USA (right)
Aerosol (2)
Aerosol at Spiez laboratory:

- Aerosolized DEHS ($C_{26}H_{50}O_4$)

Aerosol generation

Sampling: + TDS / GC-MS
Calibration (aerosol), under development

Aerosol concentration in the 50 m$^3$ chamber = 25 mg/m$^3$
Final words

SBSE for the evaluation of personal protective equipment provides:

• Easy-to-handle, passive sampling methodology
• Highly automatized analytic system
• Unique sampling methodology for:
  – mannequin or human
  – gas or aerosol
• Large measuring range of protection factors
• Detection of high protection factors possible
Questions?

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