

Validating the Collection Efficiency of the Nanoparticle Respiratory Deposition Sampler

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Background

Nanoparticles are hazardous to human health.

Exposure to metallic nanoparticles, such as iron (Fe) and chromium (Cr), are common in various occupational settings such as welding operations.

The Nanoparticle Respiratory Deposition (NRD) sampler has been developed to measure personal exposures to nanoparticles (<300 nm).

Objective

To validate the collection efficiency of the NRD sampler (ZNRD001, Zefon, Ocala, FL) with an independent reference sampler, the Nano-Micro-Orifice Uniform Deposition Impactor (Nano-MOUDI; 125r, MSP, Shoreview, MN) in laboratory trials.

Methods

Stainless steel fume particles generated by spark discharge and delivered to a sampling chamber

Nano-MOUDI

- Polycarbonate substrates
- 10 L/min for 1 hour

NRD

- Nylon mesh substrates
- 2.5 L/min for 1 hour

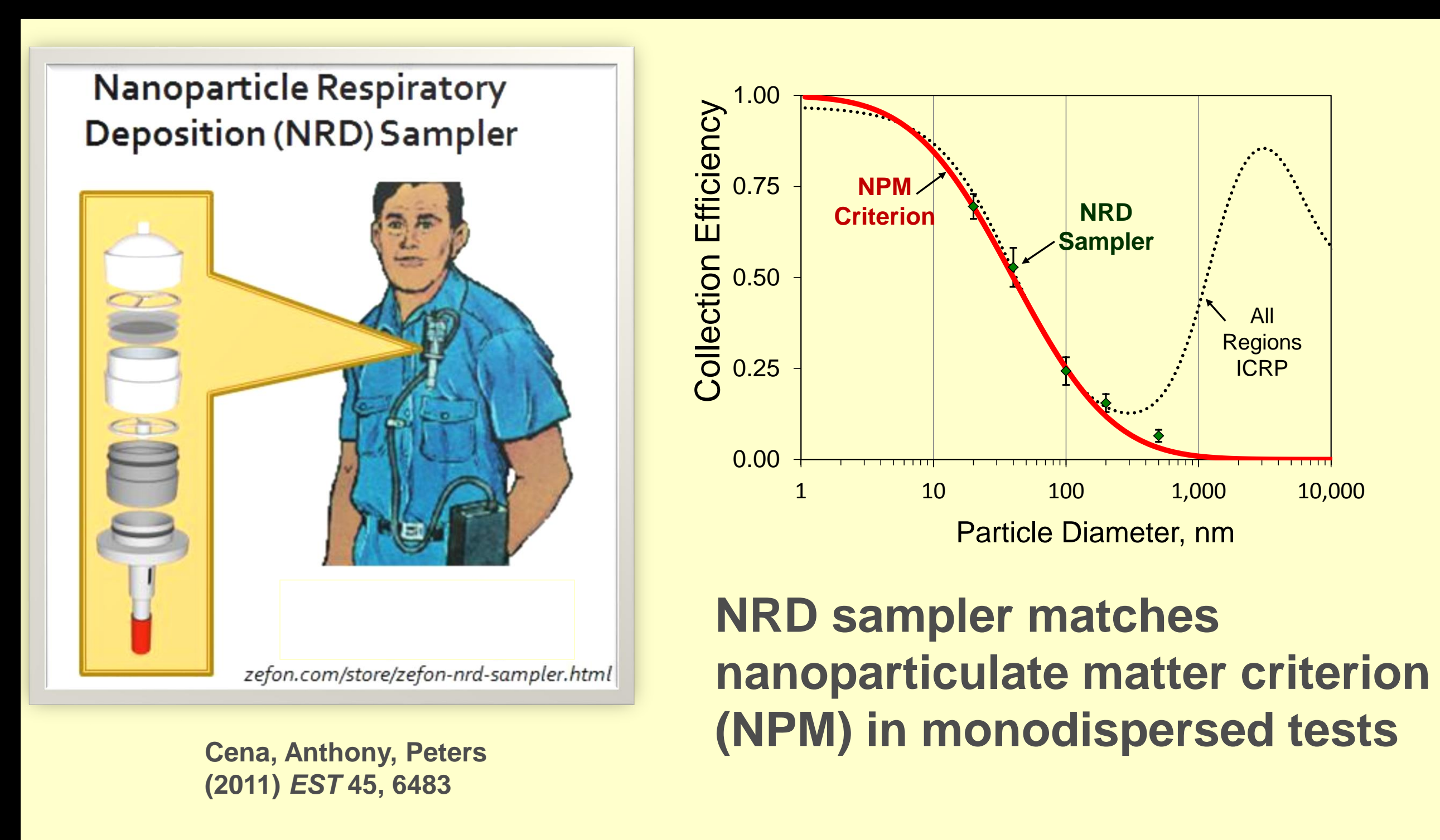
Chemical Analysis

- Microwave-assisted acid digestion
- ICP-OES measured total Fe and Cr

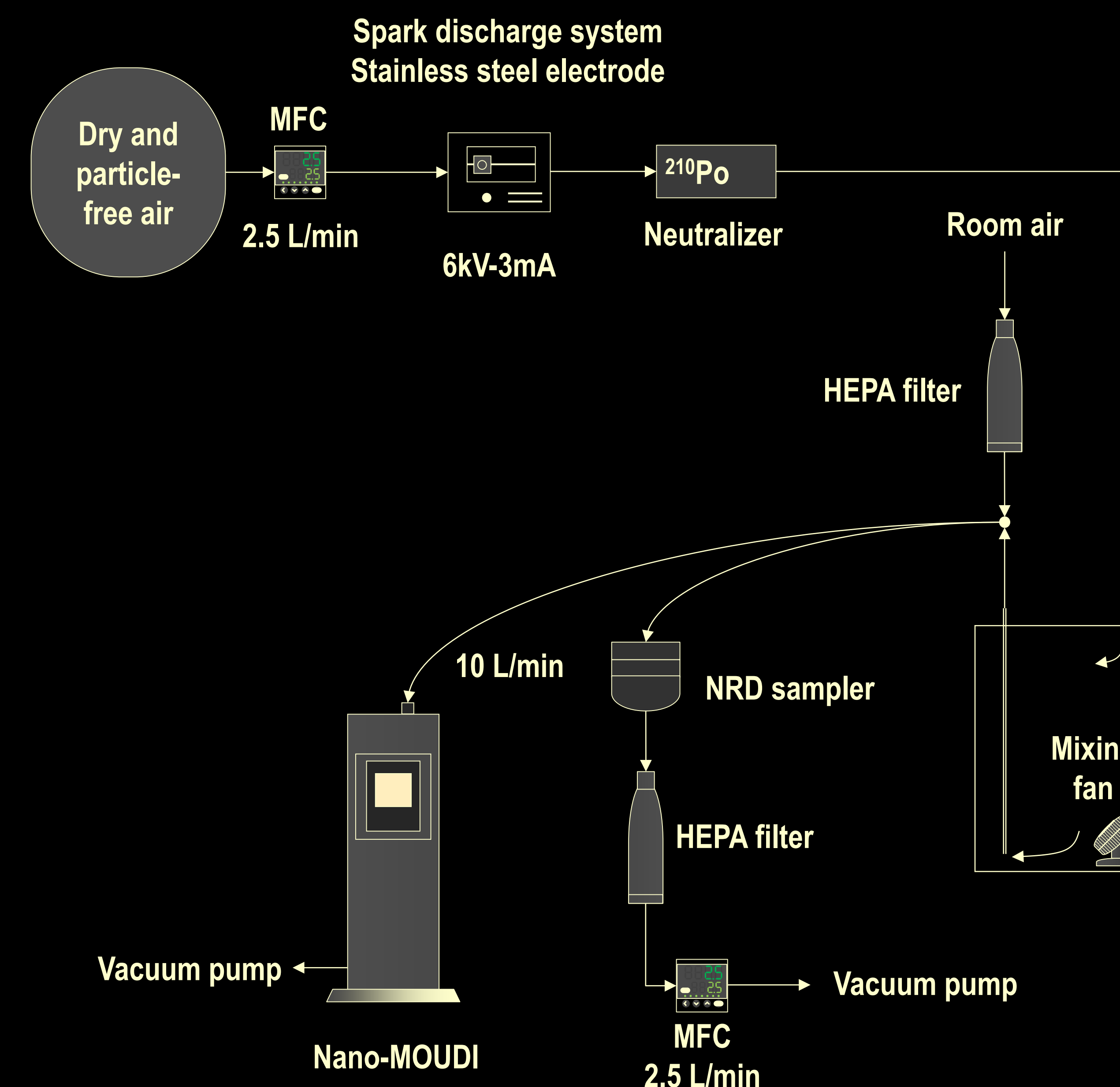
Mass results from MOUDI stages adjusted to collection efficiency curve of NRD

Summed mass from each stage and divided by total volume to calculate mass concentration

Paired t-test to compare mean concentrations from each sampler

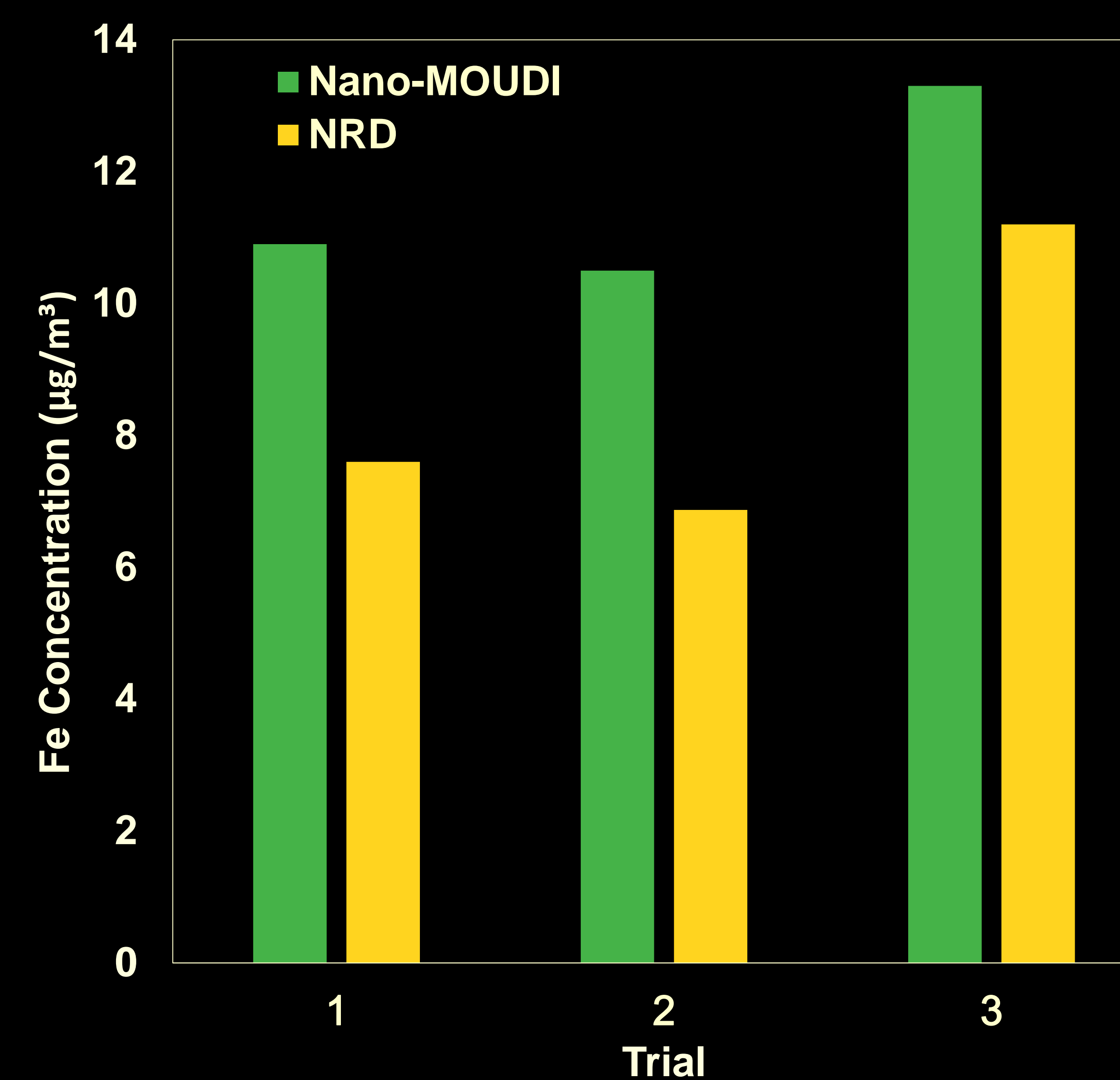


Experimental Setup



Results

Comparison of Fe Concentrations



Average NRD Fe concentration: $8.56 \mu\text{g}/\text{m}^3 \pm 2.32 \mu\text{g}/\text{m}^3$

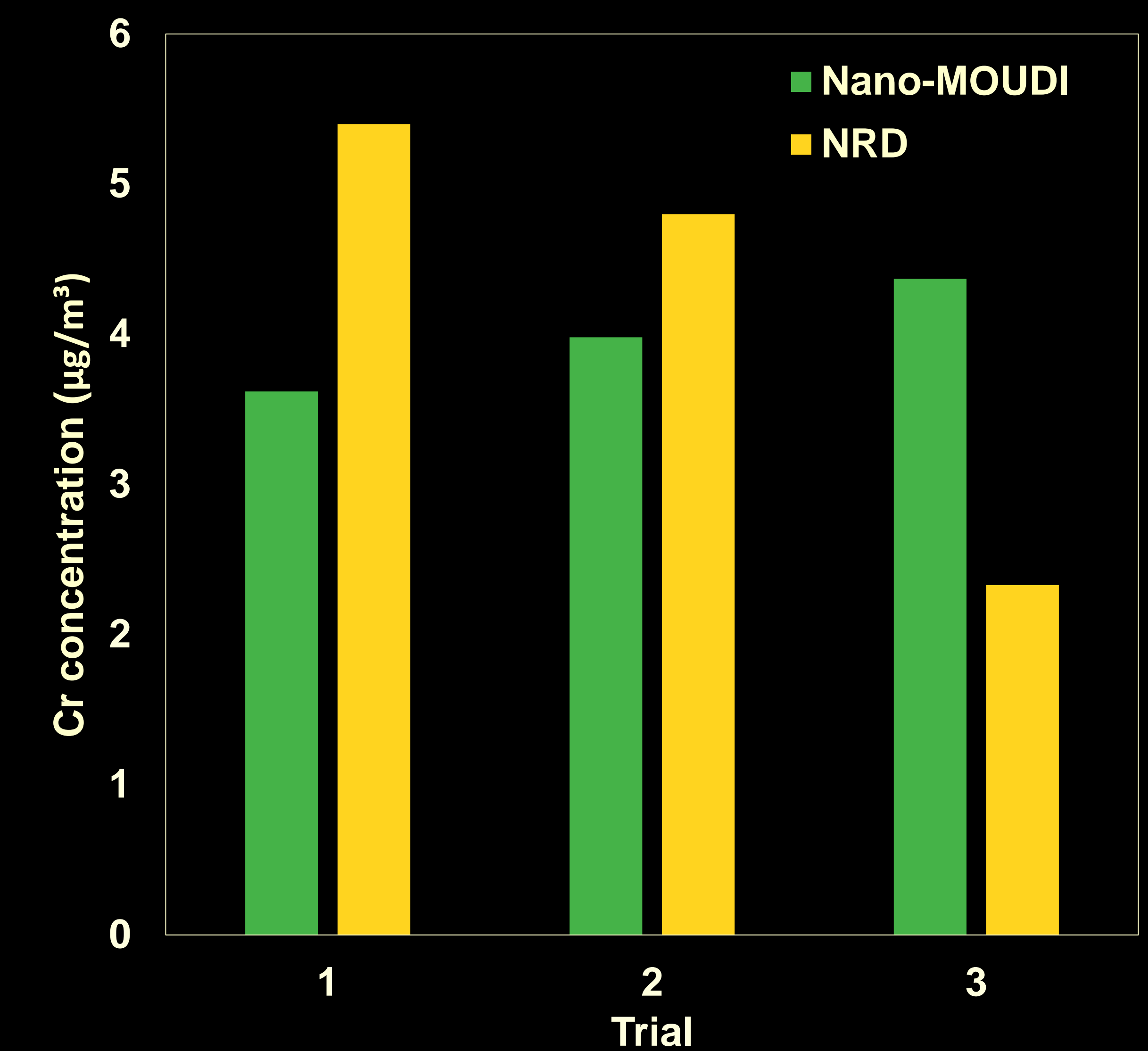
Average MOUDI Fe concentration: $11.55 \mu\text{g}/\text{m}^3 \pm 1.54 \mu\text{g}/\text{m}^3$

Paired t-test: Significant difference ($p < 0.05$)

Fe levels approached limit of detection

Results, continued

Comparison of Cr Concentrations



Average NRD Cr concentration: $4.18 \mu\text{g}/\text{m}^3 \pm 1.63 \mu\text{g}/\text{m}^3$

Average MOUDI Cr concentration: $3.99 \mu\text{g}/\text{m}^3 \pm 0.38 \mu\text{g}/\text{m}^3$

Paired t-test: No significant difference ($p = 0.88$)

Conclusions

The Nano-MOUDI could not be used to validate the collection efficiency of the NRD sampler for Fe particles (< 300 nm).

The Nano-MOUDI validated the collection efficiency of the NRD sampler for Cr particles (< 300 nm).

Additional trials should be run for longer sampling time periods in order to ensure greater concentrations of metal particles are collected for analysis.

Future Research

This method can be developed for use in the field. Both the NRD and Nano-MOUDI can be used to measure exposure to nanoparticles (< 300 nm) in a variety of occupational settings such as welding and industrial painting operations.

Acknowledgements

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