Visualizing and quantifying human internal black carbon load

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Organisation

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Partners and collaborations

University of Hasselt (UHasselt), Katholieke Universiteit Leuven (KUL)

SCOPE OF THE METHOD

The Method relates to	Environment, Human health
The Method is situated in	Basic Research
Type of method	Other: Imaging technique

DESCRIPTION

Method keywords

black carbon particles
Label-free detection in biological samples
White-light emission
femtosecond pulsed laser illumination

Scientific area keywords

Environmental health
epidemiology
Microscopy
Nanotoxicology

Method description

Worldwide, outdoor air pollution is responsible for 4.2 million premature deaths per year. Both chronic and acute exposure to particulate matter air pollution is a risk factor for heart and lung diseases. One of the atmospheric pollutant particles is represented by soot or black carbon (BC) particles, which are produced during the incomplete combustion of fuels. To evaluate human BC exposure, a direct and label-free approach for detecting such particles in body fluids and tissues was still lacking. We present a novel technique to

finally close the diagnostic gap. We report for the first time white-light generation by CBs under femtosecond pulsed near-infrared light illumination in aqueous environments and demonstrate the potential of this approach in biomedical and diagnostic context. In fact, it was shown that urinary carbon loading can serve as an exposure matrix to carbon-based air pollution, reflecting the passage of soot particles from circulation into urine. Furthermore, using this technique we reported the presence of BC particles in human placentae. This suggests that ambient particulates could be transported towards the fetus and represents a potential mechanisms explaining the health effects of prenatal air pollution from early life onwards. The novel method is straightforward, fast and flexible without the need of sample pretreatment. Moreover, the technique offers several other advantages such as inherent 3D sectioning and high imaging depths making it possible to screen at the cellular and tissue level. In conclusion, this novel diagnostic technique allows to quantify exposure at the personal level including different scenarios like occupational exposure, smog, forest fires, etc.. Additionally, this approach paves the way to unravel the complexity of soot-related health effects.

Lab equipment

Laser scanning microscope equipped with two-photon femtosecond pulsed near-infrared laser.

Method status

History of use
Internally validated
Published in peer reviewed journal

PROS, CONS & FUTURE POTENTIAL

Advantages

Femtosecond pulsed illumination of BC followed by the detection of emitted WL is a straightforward approach without the need for particular sample pretreatment and which can easily be implemented in multiphoton imaging experiments. The nature of the signal makes it very versatile in terms of choice of additional fluorophores for colocalization studies. The ease of the reported approach broadens the potential applicability in the fast-growing field of nanotechnology. Additionally, it will advance epidemiological and toxicological studies because this is the first time a technique is described to directly detect BC particles in a biological setting without any additional treatment or labeling required. This technology allows to screen human tissues and body fluids for the presence of BC owing to the multiphoton approach that results in inherent 3D sectioning and high imaging depths.

Challenges

Screening in a high-throughput manner.

Modifications

Optimization to allow high-throughput screening of different biological samples.

Future & Other applications

Besides advancing the field of nanotechnology, this application can advance epidemiological and toxicological studies as shown in recently published research articles.

REFERENCES, ASSOCIATED DOCUMENTS AND OTHER INFORMATION

References

Bové, H. et al. Biocompatible label-free detection of carbon black particles by femtosecond pulsed laser microscopy. Nano Lett. 16, 3173–3178 (2016).
Saenen, N. D. et al. Children's urinary environmental carbon load. A novel marker reflecting residential ambient air pollution exposure? Am. J. Respir. Crit. Care Med. 196, 873–881 (2017).
Bové, H. et al. Ambient black carbon particles reach the fetal side of human placenta. Nat. Commun. 10, 3866 (2019).

Associated documents

rccm.201704-0797oc.pdf
acs.nanolett.6b00502.pdf
s41467-019-11654-3.pdf

Other remarks

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