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Case study

Enhancing the sensitivity of extraction for the detection of nicotine in complex samples

Nicotine is considered a so-called 'emerging lifestyle contaminant'. Elefteria Psillakis at the Technical University of Crete, Greece, used HiSorb™ sample probes to improve the sensitivity of her extraction technique to enable the detection of low levels of nicotine among 4000 compounds.

TECHNICAL UNIVERSITY OF CRETE

Customer:
Technical University of Crete, Greece

Application:
VOCs from the degradation of nicotine leachates from cigarettes

Challenge:
To improve the sensitivity of the extraction technique to enable identification of 1 ppm of nicotine in complex matrices

Solution:
Enhancing the sensitivity of high-capacity sorptive extraction by immersing HiSorb probes in samples

Results:
Enhanced sensitivity to enable detection of up to 1 ppm of nicotine among 4000 compounds

Nicotine leachates are a widespread environmental problem

Nicotine has been widely detected in water and wastewater. A significant source of nicotine contamination in natural waters is leachates from discarded cigarettes – the most littered items in urban areas and along coastlines. Elefteria Psillakis, professor of water chemistry at the Technical University of Crete, Greece, and her team have embarked on a new and upcoming area of research – investigating nicotine's fate in the environment. The project was funded by Philip Morris Products SA (Investigator-Initiated Study award) and the results were published in a peer-reviewed environmental chemistry journal.[1]

Their recent investigation involved analysing the photodegradation of nicotine in water leachates from conventional cigarette butts and 'heat-not-burn' cigarettes (the new generation of tobacco products with a fast-expanding market). For this, the team used high-capacity sorptive extraction followed by thermal desorption–gas chromatography–mass spectrometry (TD–GC–MS).

Overcoming a challenging matrix

One of the challenges the group faced was finding an extraction technique sensitive enough to deal with low sample volumes. This would enable them to closely monitor nicotine's degradation and identify the formation of photodegradation products among the over 4000 other compounds present in the cigarette leachates.

> **"HiSorb did amazingly well. We were able to monitor the degradation of nicotine in a complex matrix down to a concentration of 1 ppm using conventional GC–MS."**

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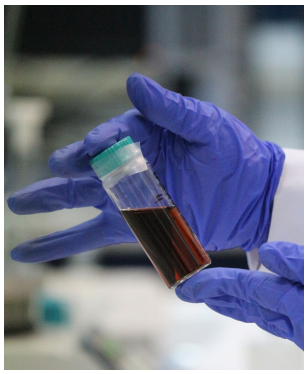
"Our photoreactor had a low volume capacity and solid-phase extraction was not an option. We tried many sample extraction methods to overcome this challenge – such as headspace–solid-phase microextraction and headspace–HiSorb – but their sensitivity was not good," said Psillakis. Finally, they discovered that immersing the HiSorb probes in the samples enabled them to obtain the sensitivity they needed.

"HiSorb did amazingly well with such a complex matrix. With its high-capacity sorbents, we were able to monitor the degradation of nicotine in a very complex matrix down to a concentration of 1 ppm using conventional GC–MS."

Psillakis was concerned that the probes would be damaged by repeatedly immersing them in the leachate samples; however, she was impressed with how robust they were. "I couldn't tell the difference between used and new probes," she remarked.



Cigarette leachate.

Comparing conventional and heat-not-burn cigarettes

During preliminary studies using HiSorb high-capacity sorptive extraction with TD–GC–MS, the group found that in heat-not-burn cigarettes, ~70% of the total and bioavailable nicotine content remains in the tobacco sticks after operation. This percentage drops to 15% in conventional cigarettes due to the reduction in mass after smoking. This means that heat-not-burn cigarettes have the potential to release larger amounts of nicotine in water bodies when improperly discarded in the environment.

Another finding was that after 30 minutes of irradiation under a UV lamp, the nicotine had disappeared from the water samples, and Psillakis suggested that this method has the potential to remove nicotine from wastewater at treatment plants in the future. However, she said that more studies are needed because even though the nicotine was gone, the total organic carbon number values remained the same, which meant that the nicotine had been transformed into by-products.

The group was able to derive the chemical structures of different by-products. However, "there are many other compounds. With one-dimensional GC and a single quadrupole MS, it's impossible to identify them in such a complex matrix," said Psillakis. This is because they consisted of isomers or they co-eluted with other by-products. Psillakis said that they would need multi-dimensional GC to identify them in the future.

References

1. S. Alberti, M. Sotiropoulou, E. Fernandez, N. Solomou, M. Ferretti and E. Psillakis, UV-254 degradation of nicotine in natural waters and leachates produced from cigarette butts and heat-not-burn tobacco products, *Environmental Research*, 2021, 194: 110695, https://doi.org/10.1016/j.envres.2020.110695.

WANT TO LEARN MORE?
For details on the equipment used in this case-study, visit **chem.markes.com/CS2**

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Elefteria Psillakis and her team focus on understanding and applying green sample preparation methods to the identification and quantification of emerging and persistent organic pollutants, and study the degradation of organic contaminants in natural and engineered systems.

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