Professional Development Dermatology

UCD CHARLES INSTITUTE SEMINAR SERIES

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Breaking barriers on the volatile footprint

Attendees at UCD's Charles Institute Seminar Series heard a presentation on the promising potential for prospective markers of systemic and cutaneous disease

The Charles Institute, Ireland's national dermatology research and education centre, played host to a range of guest speakers who covered a variety of topics ranging from skin cancer to psoriasis, among others. The series, which was sponsored by RELIFE (part of the A.Menarini group), was designed to provide expert advice from a range of distinguished national and international experts in their respective fields and was chaired by Prof Desmond Tobin, Professor of Dermatological Science at UCD School of Medicine and Director of the Charles Institute of Dermatology. Each seminar in the series was broadcast to attendees with a special interest in dermatology in other locations, who accessed each talk remotely via an audio-visual link.

Attendees at the seminar series heard a presentation from Dr Emer Duffy (PhD) of the Insight Centre for Data Analytics, National Centre for Sensor Research at Dublin City University, who spoke on the topic 'Sniffing the Barrier — Probing Skin Function Through the Volatile Footprint'.

Dr Duffy presented some of the research in which she has been involved in recent years in which, among a number of other fields, she looked at the potential for portable analytical platforms. This is currently the main focus of research in her group at DCU, which is working on a better understanding of epidermal wearable platforms for tracking patients' health status via volatile organic compounds.

Pollution

Dr Duffy presented a case study for attendees and explained that she is interested not only in volatile organic compounds, but also in compounds that originate from the environment. "Volatile compounds are a diverse group of chemicals that easily become vapours or gases," she said. "They are ubiquitous in our environment and are transferred through the air by diffusion, so we encounter them in our everyday lives." They emanate from a number of sources, said Dr Duffy, including emissions from industry or vehicles, personal care products such as perfume, the food and drink we consume, as well as plants and animals, which use volatile compounds for signalling.

Dr Duffy's research has uncovered interesting results in terms of cosmetics and has shown that perfume compounds produce different smells, depending on the wearer, and that air pollution has effects on the skin's chemistry. "The air pollution we are exposed to affects the surface of our skin, and that can give rise to different volatile emissions, depending on the type of pollution that is in the air," she explained. Work is also ongoing to determine whether there are different age- or sex-specific volatile markers and while some such volatiles have been identified, this research is in the early stages, she told the attendees.

She also referenced a study around alcohol consumption and skin emissions, which showed that 40 minutes after consuming a shot of whiskey, ethanol emissions from the skin spike significantly.

Dr Duffy outlined the current methods of assessing emissions from skin, pointing out that there is currently a heavy reliance on mass spectrometry. This is expensive instrumentation and may not always be readily available and the process can be somewhat laborious for the participant, but it does produce high-quality data, she pointed out. There are also a variety of 'offline' analysis methods requiring a sample preparation step, such as the 'bag method', whereby part or all of the human body is placed into a specially-designed polymer-coated fibre 'bag' until a sample is collected, possibly followed by a concentration step using a method called solid phase micro-extraction (SPME). "This fibre traps volatile organic compounds, essentially acting as a sponge to collect them and concentrate them over time." This method has also been used to study volatile emissions from biopsy samples in order to identify biomarkers, she added.

"The wearable platform that we have devised encloses this SMPE fibre and is worn on the skin for a specific amount of time, allowing the sample to concentrate on the polymer fibre," explained Dr Duffy. "We then directly inject this fibre into a gas chromatograph and that is where separation of all the different gasses occurs… we get an individual signal from every individual gas. We were surprised initially by how many gasses are actually coming through the skin — it's quite a complex sample to analyse and a real analytical challenge."

In terms of the time required to collect a sample with the wearable platform, Dr Duffy told the attendees that it was important to understand the equilibrium between the gasses and the fibre and "the take-home message from this is that we reached our absorption equilibrium after around 15 minutes. This kind of sampling time is not too bad for participants and it is usually pretty easy to get them to agree to wearing the sampler for this amount of time," she said.

Dr Duffy presented results from a small study on skin chemistry using the wearable platform, which showed a variety of compound classes present in the skin of the participants, such as hydrocarbons, aldehydes, acids, ketones and esters, the latter of which were believed to derive from cosmetics. In all, 26 compounds were recovered. "There were differences between the female and male participants due to volatile acids and skin PH… the separation we see on principal component 1 is due to males having a lower average skin PH of around 4.9, versus female levels of 5.5, and the males also had higher concentrations of volatile acids," said Dr Duffy. "When we extract the volatile acids data and compare it with skin PH data, we see a very interesting correlation, which was surprising to us. That's definitely the subject of further investigation."

Unique emissions

In summary, Dr Duffy told the seminar: "Through non-invasive characterisation of volatile skin emissions using a wearable sampler approach — with gas chromatography and mass spectrometry, in addition to early results from our sensor platform — we have seen unique emissions for males and females," said Dr Duffy. "We also saw that skin emissions changed after we damaged the skin barrier by tape-stripping and dysregulation of compounds directly from squalene and fatty acids. We have also seen that air pollution can affect the skin barrier by reacting with skin surface lipids, and volatile reaction points are potential inflammatory mediators. We saw that these increased after exposure to ozone and our tape-stripping experiments showed significant penetration of volatile reaction products into the stratum corneum — this has potential in estimating the flux of species of greater concern," she continued.

"This non-invasive approach could be valuable in studying barrier function, tissue damage or wound infection and healing and could have applicability to cell culture and human research alike; I have modified the approach and used it on 3D skin equivalents, so that is possible. I think this is a great opportunity to develop non-invasive approaches to measuring skin properties and evaluate treatment efficacy and detect disease or infection at an early stage. But we need clinical guidance and materials science to make this happen."

The challenges of bringing this concept to full implementation include the need for a standardised sampling and analysis approach, explained Dr Duffy. "There are a lot of different [sampling] methods out there in the literature and careful elucidation of endogenous volatiles is going to be really important. Care must also be taken in understanding where they are coming from and knowing what comes from cosmetics, the environment, or glands.

"It will also be important to support compound ID; we use retention index matching and standard chemicals. There are also interesting opportunities in measuring dermal exposure using this method and I am developing the sensor platform as a personal exposure monitor for volatile chemicals in the environment… but interesting results are already there in terms of tracking penetration, and this could be an interesting way of tracking penetration of chemicals into the stratum corneum. This is relevant for inflammatory conditions and there has been interest from cosmetics companies in developing topical antioxidants to attenuate any [adverse] effects."

Evolution

During a lively Q&A session, Dr Duffy explained that research has shown how breast milk emits an odour that is attractive to babies, even if the milk has been expressed and the baby is not in close proximity to its mother.

In this regard, Prof Tobin referenced a study published recently in Nature Communications, which showed that skin actually expresses olfactory receptors that pre-existed the development of our sense of smell in evolution. This system of receptors has a similar mechanism of signalling that occurs in the nose, suggesting "a two-way system, whereby a baby might be sensing the odours from its mother through the skin, rather than solely through the nose".

Dr Emer Duffy

Further, he asked: "In terms of the comparison between skin and breath, you have pointed out that skin may be the new matrix for sensing beyond breath. What kind of volatiles come from breath in health and illness, and how would these compare with the skin organs — are they very disparate, or do they overlap?" Dr Duffy replied: "There are certain compounds that overlap, such as ammonia, which can be present in high concentrations in both breath and skin, but possibly higher in skin. Dietary influences also overlap, for example alcohol, but breath is challenging in a different way to skin because of the humidity factor, for example. A large proportion of a breath sample would consist of water vapour, which makes it more difficult to collect and analyse."

Speaking with the ***Medical Independent (MI)*** following her presentation, Dr Duffy explained that the work of she and her colleagues is building a scientific understanding of the instinctive abilities conferred by nature and evolution. The much-publicised examples of dogs accurately detecting certain cancers by smell alone is one example. "We are really just catching up with what nature has already given us, and the same could be said for medicine," said Dr Duffy. "Doctors themselves have used smell to detect disease for a long time, such as the ancient Greek and Chinese healers."

In terms of the device development and its potential for personalised medicine, Dr Duffy told ***MI***: "I think that is a few years down the road but there are some exciting possibilities, such as monitoring treatment — if we could do that via skin, that would be helpful. However, I am most interested in the skin itself — if we could develop some type of wearable platform that could monitor function and predict an episode of eczema, for example. Also, the non-invasive aspect of such a device is significant, so the wearable platform could be an important development for the future."

RELIFE has had no input into the content of this article or series of seminars