

NANOFIBERS FROM POLYVINYL ALCOHOL AND CAN ENLARGE THE SET OF TRAPPED ODOROLOGICAL TRACES

Martin Kralovic, Bruno Sopko, Petr Novotny and Evzen Amler

Quality of indoor environment, University Center for Energy Efficient Buildings, Czech Technical
University in Prague, Buřtěhrad, Czech Republic

Abstract

We tested collecting abilities of nanofibers made from polyvinyl alcohol and calcofluor (PVAC) for odorological trace collection. Our study revealed that spectrum of odorological traces trapped on nanofibrous PVAC adsorbent is more stable and reproducible compared to commonly used ARATEX™. In addition, both PVA and PVAC nanofibers can adhere a large number of traces undetectable by ARATEX. Our results show that functionalization of commonly used adsorbent ARATEX™ with PVA and PVAC nanofibers can vastly increase the accuracy of trace collection and, thus, significantly improve the forensic investigation.

Keywords

chitin, chitosan, forensic mycology

Introduction

The skin, as the human body's largest organ, is colonized in great numbers by diverse microorganisms such as bacteria, fungi, microscopic mites and others, together called as microbiome [1–3]. Based on our immune system, composition of the sweat, choice of cosmetic products and other factors, each of us has his/her own unique population of skin microbes [4]. Everyday, microbial communities on the skin release a lot of various metabolites into the surrounding environment of the human body and the molecules also contribute to specificity of the individual human odour [5]. Such numbers of molecules provide a potential source of information for forensic investigation and personal identification that could be used in the criminal praxis. However, currently, there is no highly specialized adsorbent for collecting mentioned molecules. Moreover, the surrounding environment also contributes to this skin microbiome.

In this study, we focused on mainly fungal metabolites, especially chitin and chitosan molecules. Clearly, fungal metabolites are an important part of human odorological trace. Chitin and chitosan are the natural part of the cell walls of fungi abundantly invading human skin. Fungi have high number of chitinases, enzymes that metabolize chitin a chitosan and thus produce a diverse spectrum of chitin's and

chitosan's metabolites [6, 7]. The metabolites would be collected from the air with a type of adsorbent and then studied. We tested nanofibers from PVAC, mixture of PVA (polyvinyl alcohol) and calcofluor. Calcofluor is a fluorescent dye that binds with molecules of chitin and chitosan, and, thus, calcofluor is commonly used as a fluorescent stain for rapid detection of fungi and other microorganisms [8]. We compared collecting abilities of PVAC with PVA nanofibers with ARATEX™ adsorbents, commonly used for collection of human scent trances in criminal investigations in the Czech Republic [9, 10]. Our goal was to determine which type of the three adsorbents is most suitable to collect fungal metabolites from air.

Material and methods

We used three type of adsorbent. ARATEX™ was bought from CHLUM-TEX LLC. Samples of PVA adsorbent a PVAC were obtained from Nanuntio, Czech Republic. We analysed adsorbents using a scanning electron microscope (SEM) to determine average fibre diameter. Fibre samples were coated with a thin layer of gold using a rotatory pumped coater Quorum Q 150R S device (Quorum Technologies, Lewes, UK) and analysed by SEM (Vega 3; Tescan). To determine average fibre diameter, 100 fibres were randomly

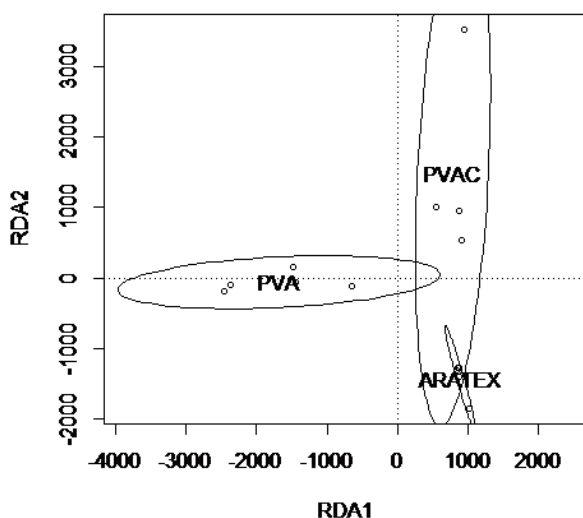


Fig. 2: The results of the RDA analysis of the concentrations of interacting molecules with our sorbents. The sorbents' patterns are clearly different, suggesting distinctive ways of the interaction.

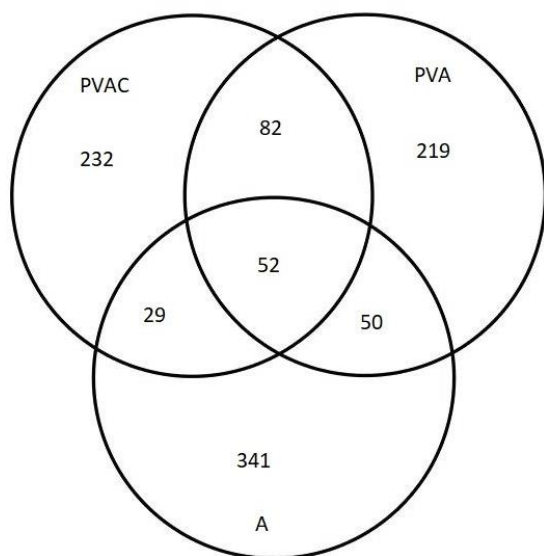


Fig. 3: Venn's diagram of the molecules detected at least once. PVAC describes polyvinyl alcohol enriched by calcofluor, A (Aratex) and PVA pure polyvinyl alcohol nanofibers.

Discussion

In this pilot study, we tested if it is possible to effectively collect forensing metabolites from air using ARATEX™, PVA and PVAC adsorbent. Also, we attempted to estimate which adsorbent type is the most

appropriate for this task. All tested adsorbents had fibrous and highly porous structure that could be suitable as air filter. In comparison to microfibrinous ARATEX™, fibres of PVAC and PVA are sub-micron sized that have higher specific surface area than microfibrinous one to collect molecules. Surprisingly, our results showed that ARATEX™ adsorbent was better in number of caught molecules. Even though, PVA and PVAC in this type of detection highly different affinity.

In case of combining all three adsorbents, the number of detected molecules can rise from 472 to 1043 giving the rise of accuracy up to 10^{343} .

Moreover, there is the possibility of nanofibers providing us with the tool for investigation of our skin microbiome.

Conclusion

Our results show that functionalization of commonly used adsorbent ARATEX™ with PVA and PVAC nanofibers can vastly increase the accuracy of trace collection and, thus, significantly improve the forensic investigation.

Reviewer A: Describe technique, how to added PVA or PVAC to ARATEX™, as you write in conclusion. It is technically realizable? If no, rewrite the text of conclusion.

Conflicts of Interest

The authors declare no conflict of interest.

Acknowledgement

This work has been supported by the Ministry of the Interior within, project No. VI20152018010. We thank Martin Kuchař, Petra Mikšátková, Edita Kofroňová and Gabriela Korbelová for important help with chemical analysis and fibres analysis.

References

- [1] Peterson, J., Garges, S., Giovanni, M., McInnes P., Wang, L., Schloss, J. A., Bonazzi V., McEwen, J. E., Wetterstrand, K. A., Deal, C., Baker, C. C. The NIH human microbiome project. *Genome Res.*, 2009; vol. 19, no. 12, pp. 2317-23.
- [2] Grice, E. A., Segre, J. A. The skin microbiome. *Nat. Rev. Microbiol.* 2011; vol. 9, no. 4, pp. 244.
- [3] Findley, K., Oh, J., Yang, J., Conlan, S., Deming, C., Meyer, J. A., Schoenfeld, D., Nomicos, E., Park, M., Kong, H. H., Segre, J. A. Human skin fungal diversity. *Nature.* 2013; vol. 498, no. 7454, pp. 367.
- [4] Grice, E. A., Kong, H. H., Conlan, S., Deming, C. B., Davis, J., Young, A. C., Bouffard, G. G., Blakesley, R. W., Murray, P. R., Green, E. D., Turner, M. L. Topographical and temporal diversity of the human skin microbiome. *Science.* 2009; vol. 324, no. 5931, pp. 1190-1192.

- [5] Rennie, P. J., Gower, D. B., Holland, K. T., Mallet A. I., Watkins, W. J. The skin microflora and the formation of human axillary odour. *Int J Cosmet Sci.* 1990; vol. 12, no. 5, pp. 197-207.
- [6] Seidl, V. Chitinases of filamentous fungi: a large group of diverse proteins with multiple physiological functions. *Fungal Biol Rev.* 2008; vol. 22, no. 1, pp. 36-42.
- [7] Hartl, L., Zach, S., Seidl-Seiboth, V. Fungal chitinases: diversity, mechanistic properties and biotechnological potential. *Appl. Microbiol. and Biotechnol.* 2012; vol. 93, no. 2, pp. 533-543.
- [8] Monheit, J. E., Cowan, D. F., Moore, D. G. Rapid detection of fungi in tissues using calcofluor white and fluorescence microscopy. *Arch. Pathol. Lab. Med.* 1984; vol. 108, no. 8, pp. 616-618.
- [9] Vyplelová, P., Vokálek, V., Pinc, L., Pacáková, Z., Bartoš, L., Santariová, M., Čapková, Z. Individual human odor fallout as detected by trained canines. *Forensic. Sci Int.* 2014; vol. 234, pp. 13-15.
- [10] Pinc, L., Bartoš, L., Reslova, A., Kotrba, R. Dogs discriminate identical twins. *PLOS One.* 2011; vol. 6, no. 6, e20704.

*Martin Kralovic, MSc.
Quality of indoor environment,
University Center for Energy Efficient Buildings
Czech Technical University in Prague
Třinecká 1024, CZ-273 43 Buštěhrad*

*E-mail: martin.kralovic@cvut.cz
Phone: +420 224 356 735*