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Surface-enhanced Raman spectroscopy for identification and discrimination of beverage spoilage yeasts using patterned substrates and gold nanoparticles

Sanna Uusitalo,[a] Alexey Popov,[b,z,y] Yury V. Ryabchikov,[c,d] Olga Bibikova,[b] Hanna-Leena Alakomi,[a] Riikka Juvonen,[a] Ville Kontturi,[e] Samuli Siitonen,[e] Andrei Kabashin,[c] Igor Meglinski,[b,z,x,y] Jussi Hiltunen[a*], Arja Laitila[a*]

[a] VTT Technical Research Centre of Finland, Kaitoväylä 1, Oulu, 90590, Finland
[b] Optoelectronics and Measurement Techniques, Faculty of Information Technology and Electrical Engineering, University of Oulu, Erkki-Koiso Kanttilan katu 3, Oulu, 90570 Finland
[c] Aix-Marseille University, CNRS, UMR 7341 CNRS, LP3, Campus de Luminy, Case 917, F-13288, Marseille Cedex 9, France
[d] P.N. Lebedev Physical Institute of Russian Academy of Sciences, 53 Leninskii Prospekt, Moscow 199 991, Russia
[e] Nanocomp Oy Ltd, Ensolantie 6, Lehmo, Finland, 80710
[f] National Research Nuclear University "MEPhI", Institute of Engineering Physics for Biomedicine (PhysBio), 115409 Moscow, Russia
[z] Terahertz Biomedicine Laboratory, ITMO University, 49 Kronverksky Prospekt, St. Petersburg, 197101, Russia
[x] Laboratory of Biosensorics and Eco-Photonics, Irkutsk State University, Irkutsk, 664003, Russia
[y] Interdisciplinary Laboratory of Biophotonics, Tomsk National Research State University, 634050 Tomsk, Russia

Corresponding Author Sanna Uusitalo **(**sanna.uusitalo@vtt.fi)
***** Equally shared supervision

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Abstract

In the beverage industry, the detection of spoilage yeasts such as *Wickerhamomyces anomalus* and *Brettanomyces bruxellensis* can be labourious and time-consuming. In the present study, a simple and repeatable technique was developed for rapid yeast detection using a combination of patterned gold-coated surface-enhanced Raman spectroscopy (SERS) substrates and gold nanoparticles. *W. anomalus* and *B. bruxellensis* showed several characteristic peaks, enabling the discrimination of these yeasts without chemometric analysis. The control yeast used as an indicator yeast, *Rhodotorula mucilaginosa*, showed 7 cell wall-related peaks originating from lipids and haemoproteins. Analysing *W. anomalus* SERS spectra with differently sized and shaped gold nanoparticles revealed the benefit of using either large, spherical, chemically synthesised gold nanoparticles or small, laser-synthesised, gold-silicon nanoparticles for yeast detection. Additionally, the spectra showed differences in SERS signal construction for small molecules and biological cells, as the nanoparticles with best response in biological cell detection did not excel in small molecule detection. The use of small composite gold-silicon nanoparticles in combination with the SERS substrate gave distinctive spectra for all detected yeast species.

Introduction

Yeast spoilage in the beverage industry is a costly problem arising from off-flavours caused by the metabolic end products of the yeast cells (V Loureiro & Querol, 1999; Virgílio Loureiro, 2000). Although yeasts are essential for making beer and wine and are often vital for forming the specific taste of the beverage (Stratford, 2006; Amorim et al., 2016), some yeasts can spoil the final products. In the worst cases, yeast spoilage can lead to exploded cans of soft drinks and cloudy re-fermented products with unwanted off-flavour in beverages (Rodriguez, Thornton & Thornton, 2013; Stratford, 2006). The presence of a few cells of a specific spoilage yeast at any stage of the manufacturing process may result in quality defects that are