



## Raman spectroscopy in the measurement of tattoo inks - opportunities and challenges

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## Motivation I

- The number of people who have tattoos or plan to get them is increasing
- Laser tattoo removal is a more and more common treatment

**What happens with ink?**

**How does optical radiation interact with ink?**

**How can we know what ink is deposited in the skin?**



## Answers?



JRC TECHNICAL REPORTS



### Safety of tattoos and permanent make-up Compilation of information on legislative framework and analytical methods

Report on Work Package 1  
Administrative Arrangement N. 2014-33617  
Analysis conducted on behalf of DG JUST

Paola Piccinini, Ivana Bianchi, Sazan Pakalin, Chiara Senaldi  
2015



JRC SCIENCE FOR POLICY REPORT

### Safety of tattoos and permanent make-up Final report

Administrative Arrangement N. 2014-33617  
Analysis conducted on behalf of DG JUST

Paola Piccinini, Sazan Pakalin, Laura Contor,  
Ivana Bianchi, Chiara Senaldi

2016

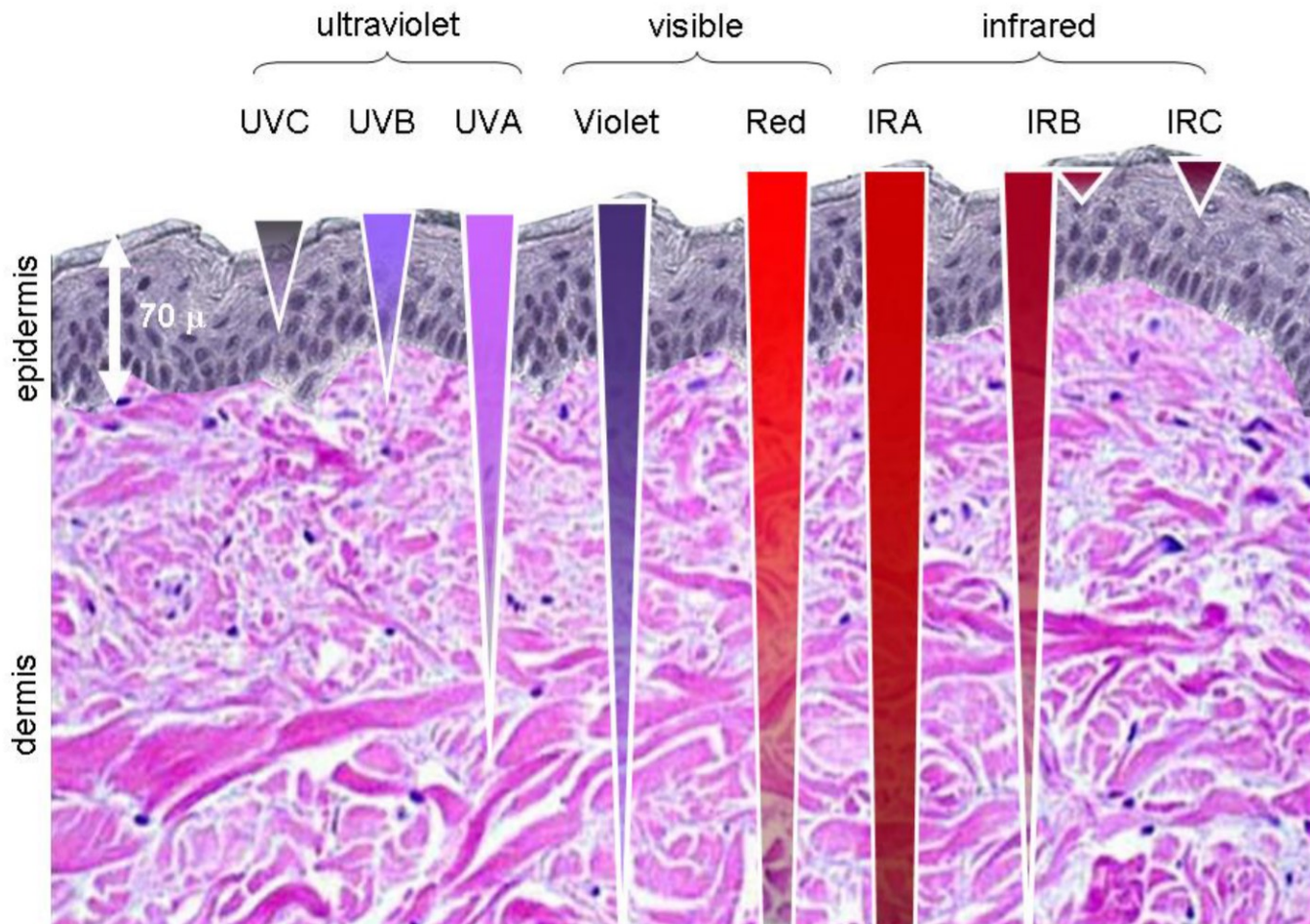
## Tattoo Ink: A Challenge

04.10.2017 | Author / Editor: GUIDO DE

Tattoo removal using laser radiation can carry health risks depending on the breakdown products formed. Scientists have now shown that pyrolysis GC/MS can be used to simulate the breakdown process and determine the compounds formed from a given ink during laser treatment. Phthalocyanine blue (B15:3), for example, was shown to form a cell poison in the process.

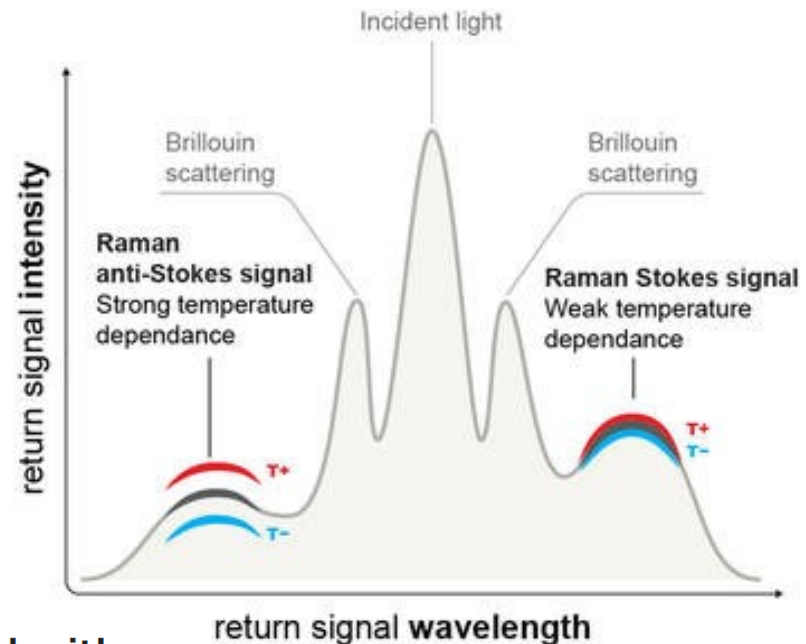
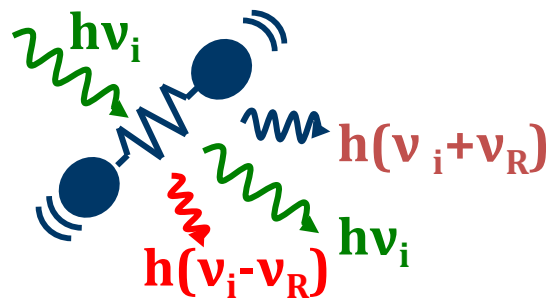


## Optical radiation penetration in the skin





## Raman spectroscopy



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Confocal Raman microscopy combined with optical clearing for identification of inks in multicolored tattooed skin *in vivo*

Maxim E. Darvin,<sup>†a</sup> Johannes Schleusener,<sup>ID</sup> \*<sup>†a</sup> Franziska Parenz,<sup>b</sup> Olaf Seidel,<sup>b</sup> Christoph Krafft,<sup>c</sup> Jürgen Popp,<sup>ID</sup> <sup>c,d</sup> and Jürgen Lademann<sup>a</sup>

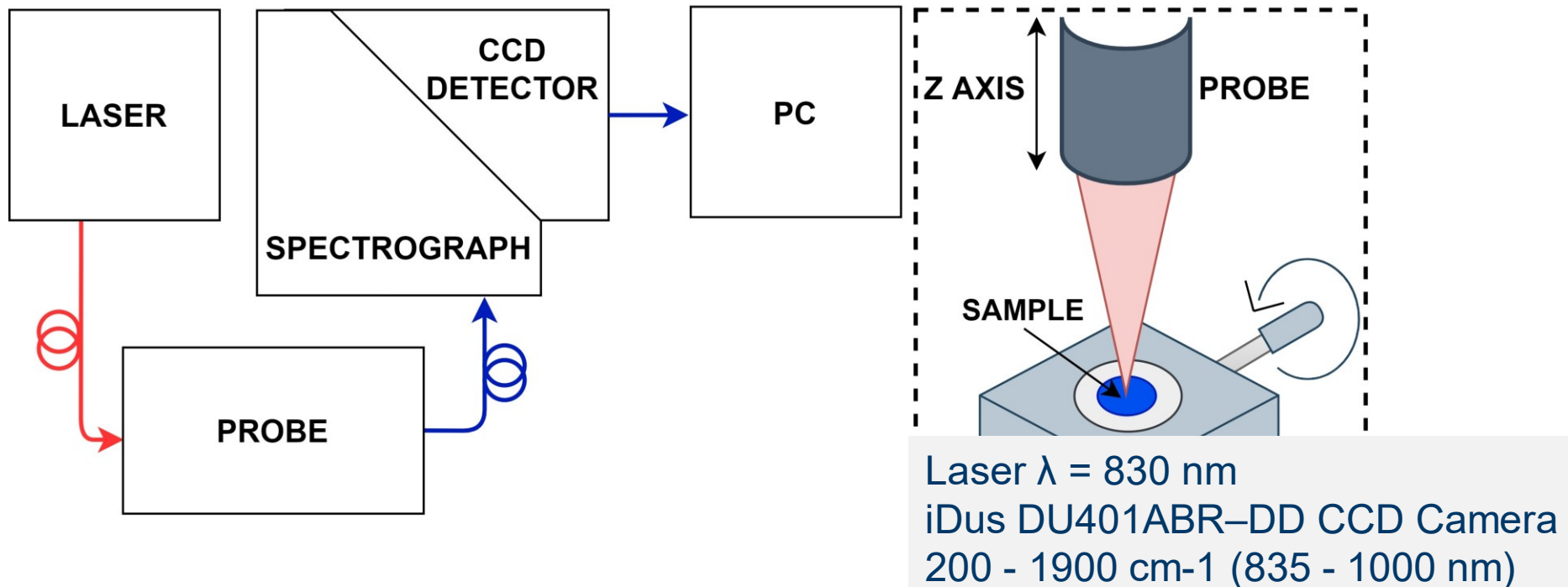


## Raman spectroscopy

Article

### Colored Tattoo Ink Screening Method with Optical Tissue Phantoms and Raman Spectroscopy

Filip Sadura \*<sup>ID</sup>, Maciej S. Wróbel <sup>ID</sup> and Katarzyna Karpienko



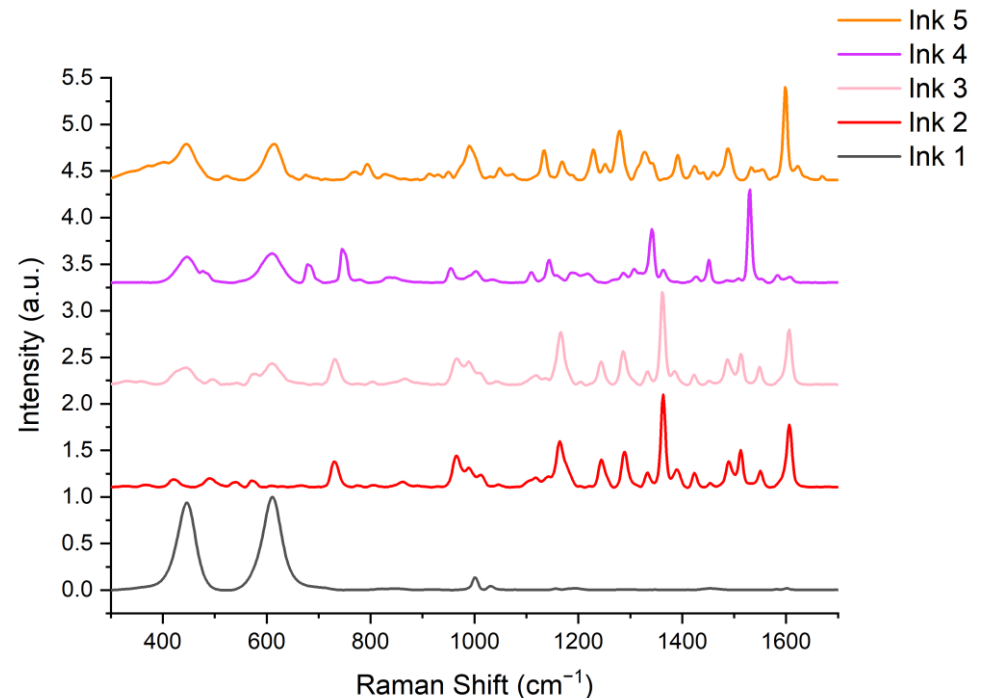




## Materials

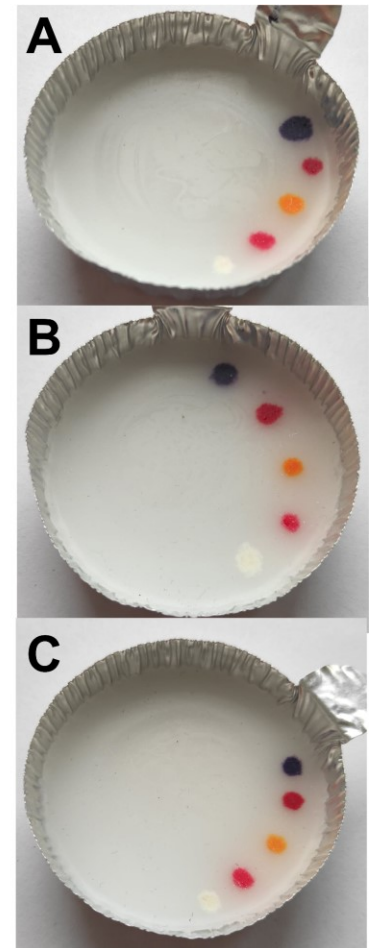
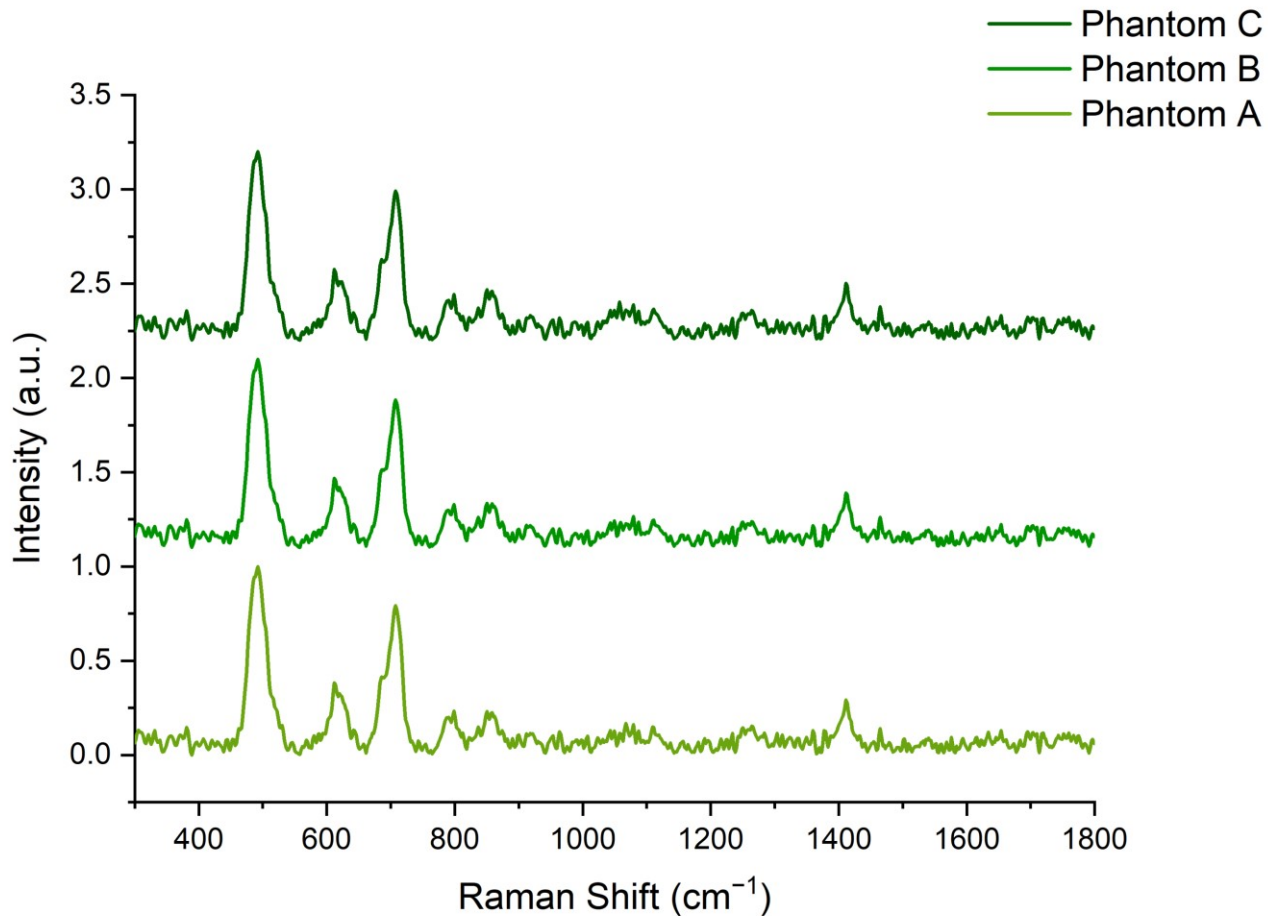
Label (Color)	Ink 1 (White)	Ink 2 (Red)	Ink 3 (Pink)	Ink 4 (Violet)	Ink 5 (Orange)
Name (producer)	White House (World Famous Tattoo INK)	Paul Rogers Red (World Famous Tattoo INK)	Hot Pink (Eternal)	Forbidden City (World Famous Tattoo INK)	Bright Orange (Eternal)
Ingredients	Pigment: C.I.77891, Glycerin, Isopropyl alcohol, Rosin, Hamamelis Virginiana, benzyl alcohol	Water, pigment: C.I.12475, Glycerin, Isopropyl alcohol Rosin, Hamamelis Virginiana, benzyl alcohol	Water, pigment: C.I.77891, C.I.12477, Glycerin, Isopropyl alcohol	Water, pigment: C.I.77891, C.I.12466, C.I.74160, C.I.12475, Glycerin, Isopropyl alcohol, Rosin, Hamamelis Virginiana, DMDM Hydantoin	Water, pigment: C.I.77891, C.I.21160, C.I.21108, Glycerin, Isopropyl alcohol

Raman spectra of inks: smoothed with the Savitzky–Golay method, baseline–corrected, and normalized.





## Materials

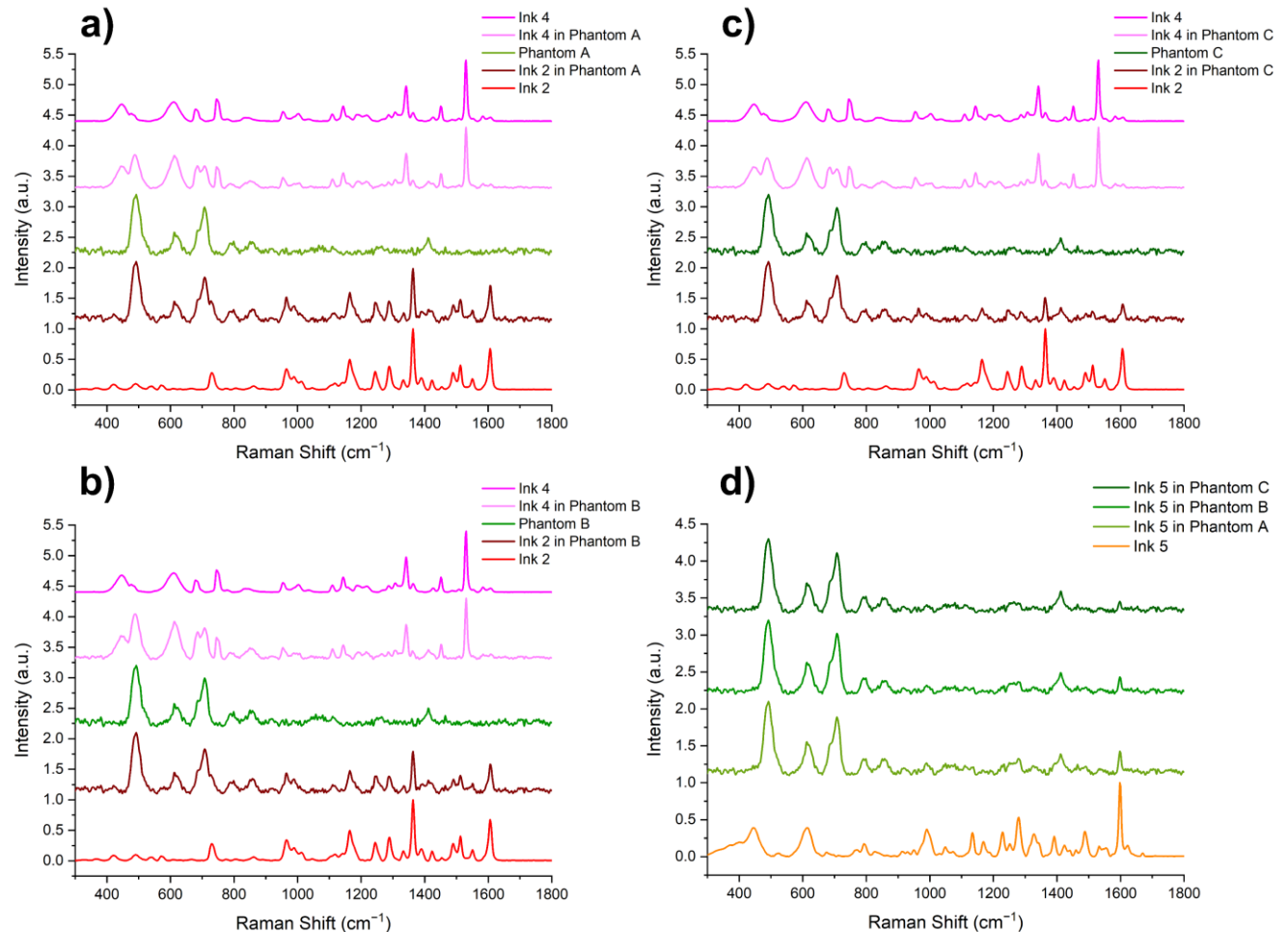


The tattooed Phantoms A–C and the normalized and baseline-corrected Raman spectra





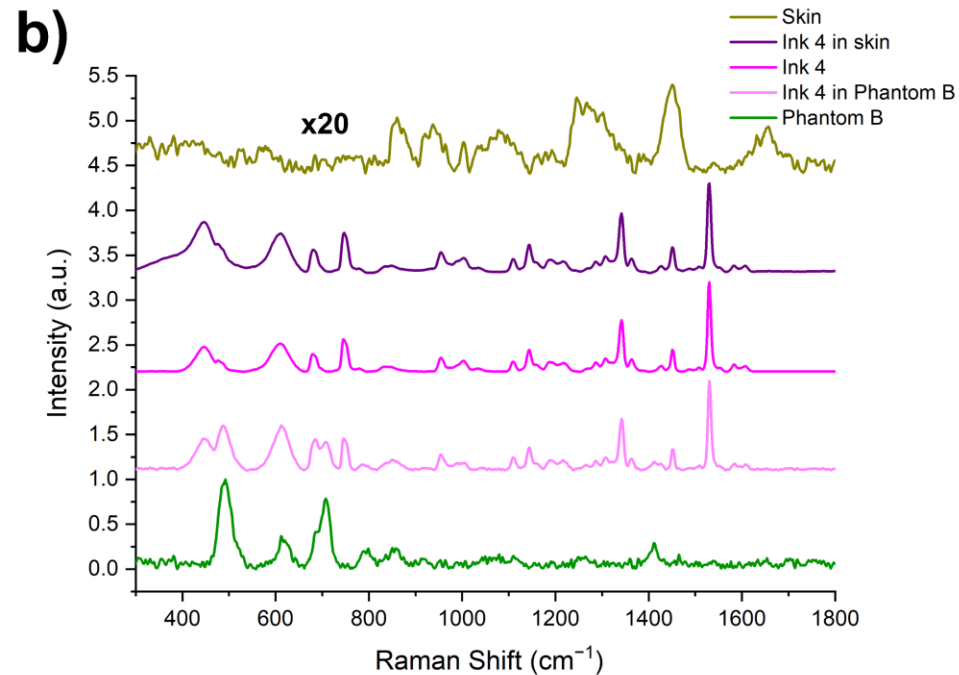
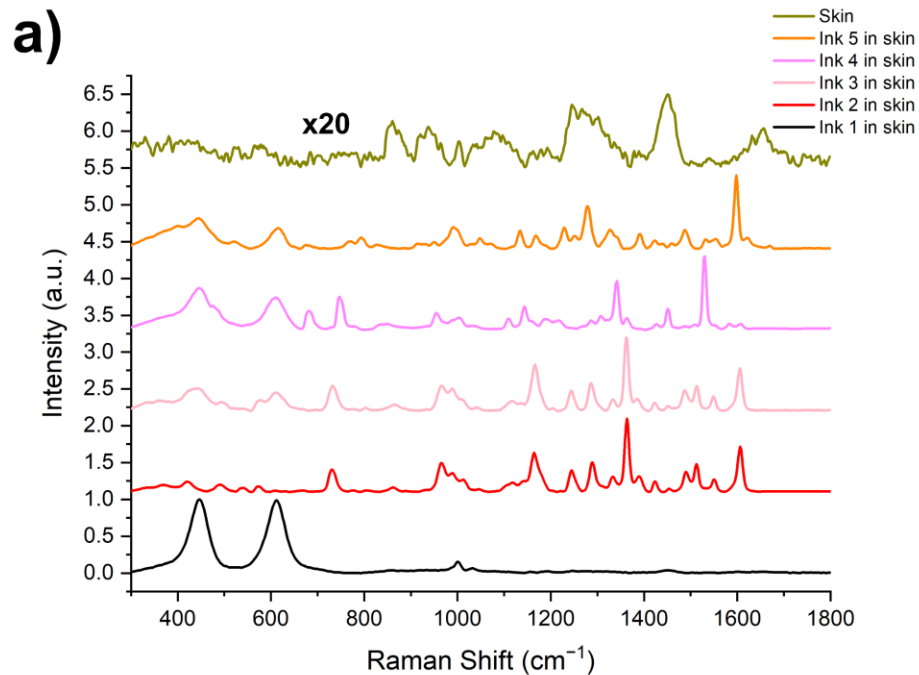
## Results – phantom study



(a–c) Smoothed and baseline-corrected spectra of Phantoms A, B, and C in comparison to the spectra of tattoos made in them with Inks 2 and 4;  
(d) Ink 5 in comparison to Ink 5 injected into Phantoms A, B, and C.



## Results – porcine skin



**(a)** Pre-processed Raman spectra of Inks 1–5 tattooed in porcine skin and the spectrum of pure porcine skin.

**(b)** Comparison between the pure porcine skin and pure Phantom B spectra, as well as comparison between Ink 4 in Phantom B, reference spectrum of Ink 4, and Ink 4 in the porcine skin.



## Opportunities and challenges

Pigments deliver a very intense Raman signal, which is a great advantage when measuring in the skin - the signal coming from the skin is negligible.

Measurement does not require biopsy.

Measurement procedure is fast.

## HOWEVER

Due to the high absorption of a large number of pigments, measurements of tattoo inks are difficult - the samples overheat, the signal blinds the detector - reconfiguration of the measuring system is required.

In skin, tattoo can be accidentally removed during the measurement.

If there is more than one pigment in the ink, the measurement signals may cover each other partly



## Motivation II

[BMJ Case Rep.](#) 2010; 2010: bcr0120102607.

PMCID: PMC3030111

Published online 2010 Oct 8. doi: [10.1136/bcr.01.2010.2607](https://doi.org/10.1136/bcr.01.2010.2607)

Reminder of important clinical lesson

### **Tattoo pigment mimicking metastatic malignant melanoma in an axillary sentinel lymph node**

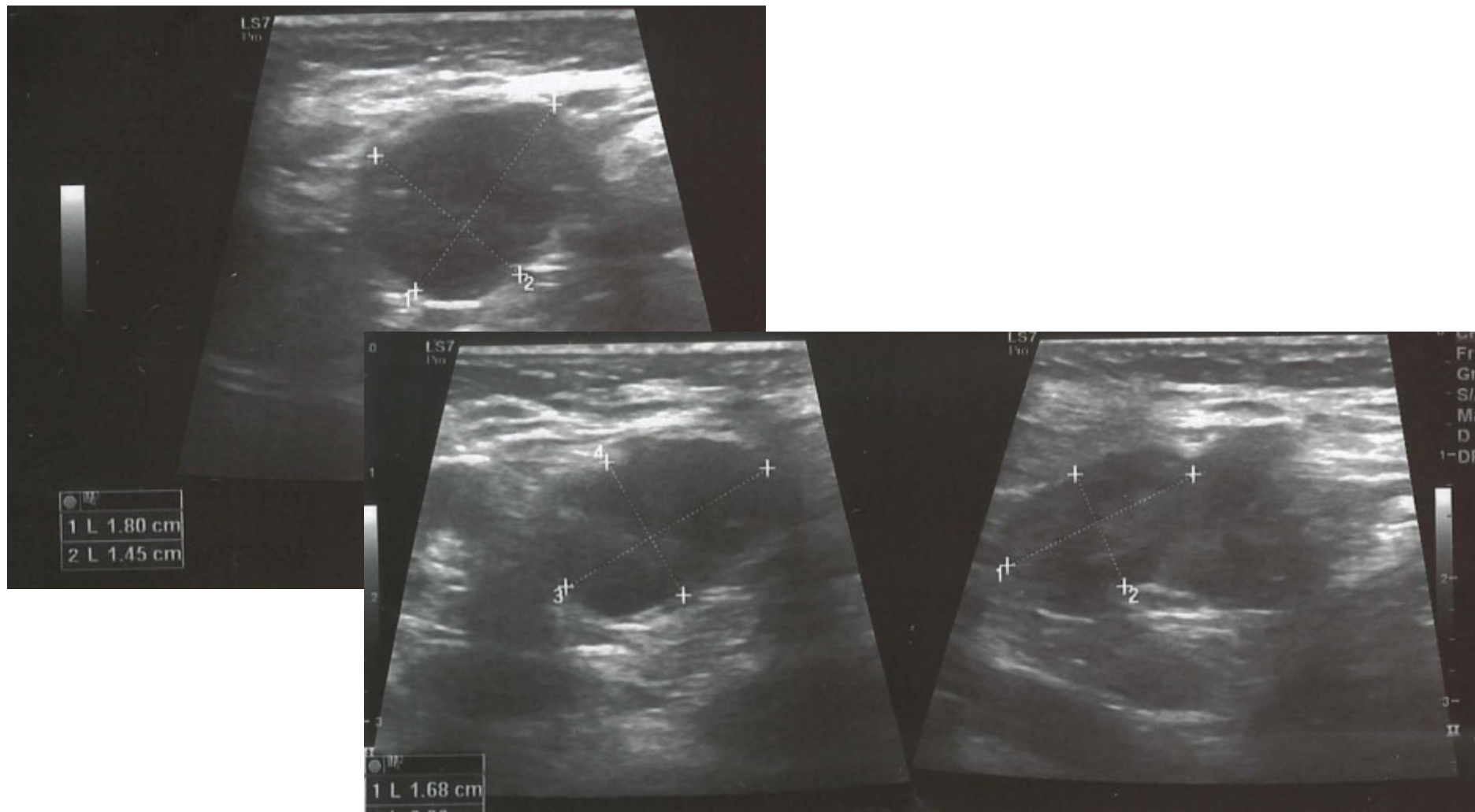
[A McDermott](#),<sup>1</sup> [G T O'Donoghue](#),<sup>1</sup> and [M Kerin](#)<sup>2</sup>

# **Tattoo Pigment–Induced Granulomatous Lymphadenopathy Mimicking Lymphoma**

Jad Othman, MBBS, Elizabeth Robbins, BM, Edmund M. Lau, BSc, MBBS, PhD, Cindy Mak, MBBS, ...



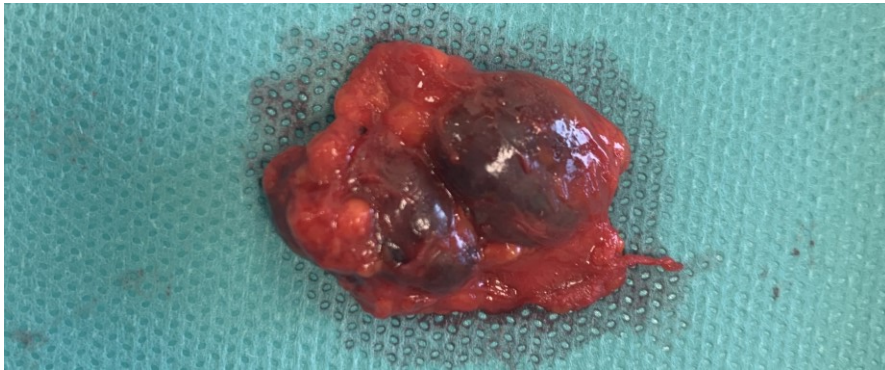
## Case study







## Lymph node removal



### **Makroskopowo:**

A1-3 – większy węzeł chłonny (3), A4 – mniejszy węzeł chłonny (1).  
A – 3 fragmenty tkanki tłuszczowej wielk. do 3,0cm, na przekrojach których znaleziono 2 węzły chłonne: beżowy wielk. 0,5cm, kremowo-szarawy wielk. 3,0cm.

### **Mikroskopowo:**

Węzeł chłonny o zachowanej strukturze: dominuje rozrost grudkowy (bcl6+, bcl2-), głównie z guzami pierwotnymi, otoczonymi strefą brzezną i płaszczą (cyklina D1-, bcl2+), z towarzyszącą proliferacją obszaru okołogrudkowego, w którym poza rozplemem małych limfocytów T stwierdza się obecność pojedynczo rozproszonych histiocytów o jasnej cytoplazmie. Zwraca uwagę liczna populacja makrofagów obciążonych pigmentem (tatuaz? anthracosis? melanina?). Brak cech

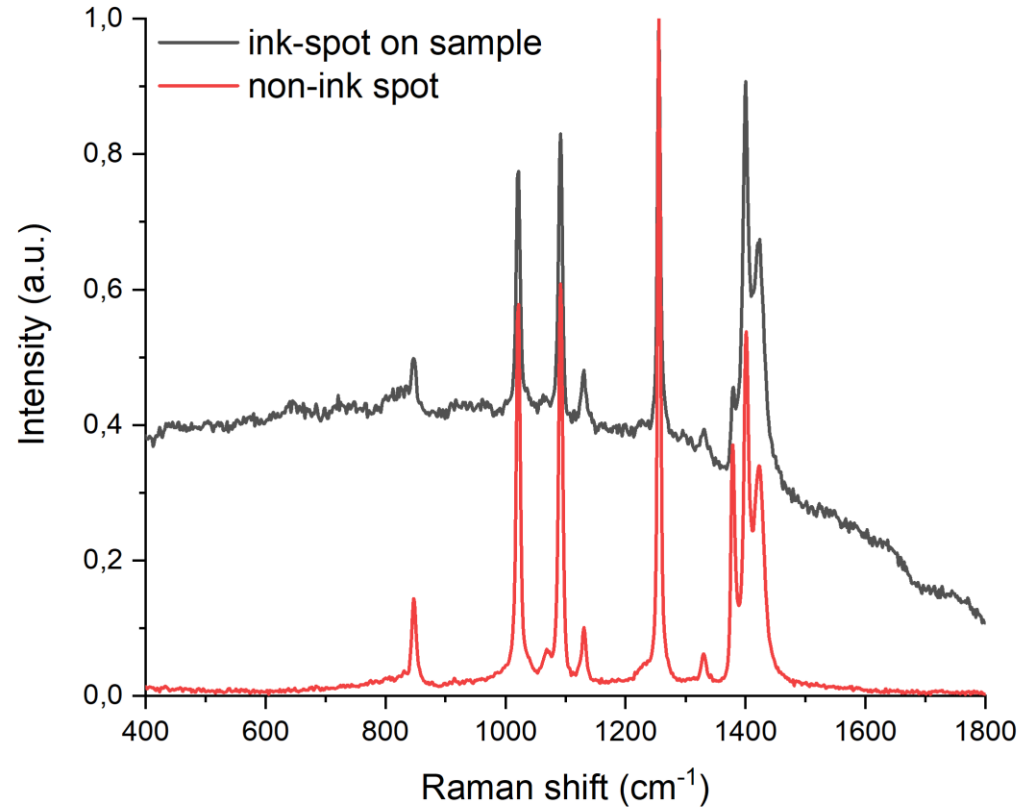
There is a large population of pigment-laden macrophages (tattoo? anthracosis? melanin)

obrzękle spływa ciemności do węzła.





## Raman experiment





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**HISTORY IS WISDOM  
FUTURE IS CHALLENGE**