

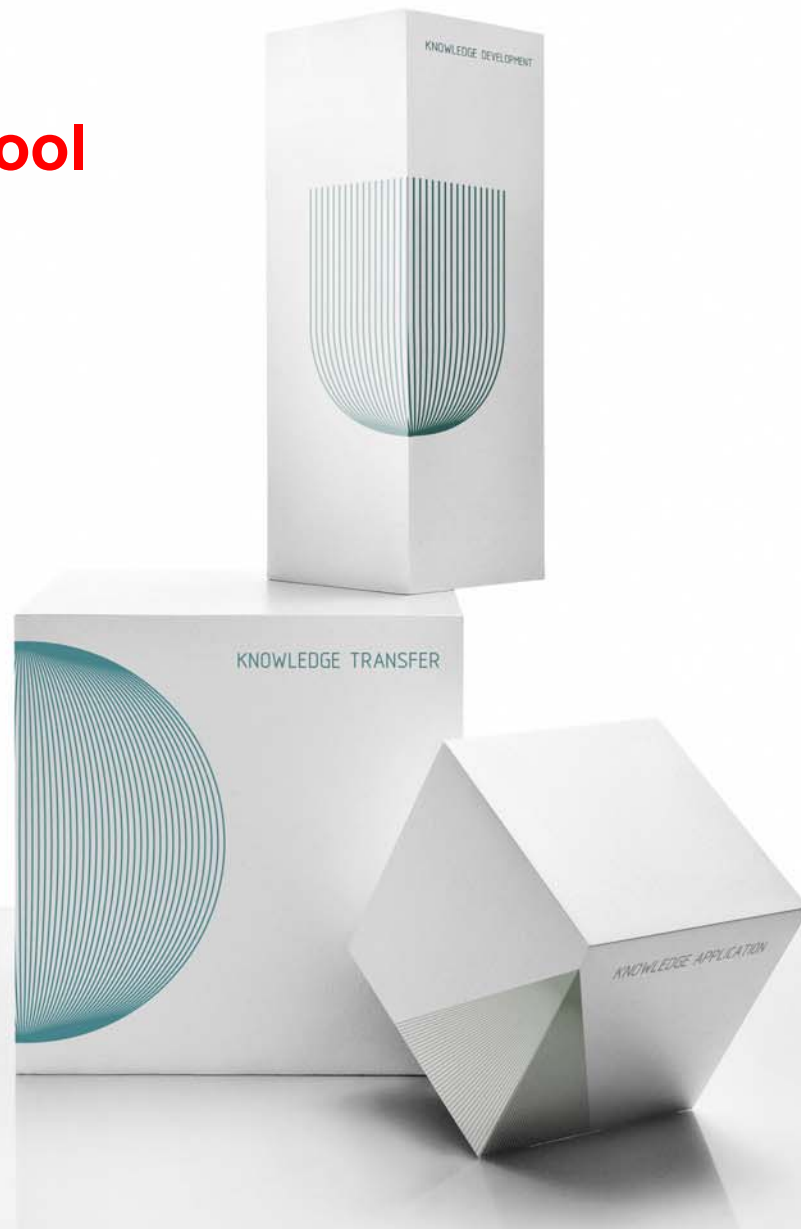


Raman microscopy as a multifunctional analysis tool

K-Analys

Uppsala 5th of May 2009

Allan K. Poulsen





Agenda

What is "The Danish Technological Institute"

Our Raman-microscope

The Raman microscope at work (combined with FTIR)



The Danish Technological Institute

Since 1903

Independent, non-profit institution

724 employees

Offering:

- Courses in technology and management
- supplying advisory services to private and public market players. E.g. consultancy, education and operator tasks
- Scientific research partner working together with companies, organizations, the public authorities, research centres and universities all over the world

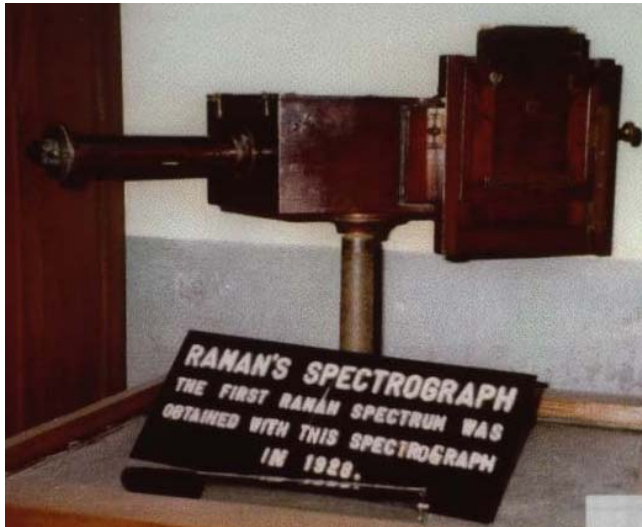
My role: R&D section in the "Chemistry and water centre"

My tasks: Project management, project acquisition and consultancy



Our Renishaw Raman-microscope

Fitted with an FTIR, IlluminatIR II from Smiths Instruments



...And then 81 years later...



Our Renishaw Raman-microscope

Fitted with an FTIR, IlluminatIR II from Smiths Instruments

Raman microscope:

4 laser lines: 785 nm, 633 nm, 514 nm and 488 nm

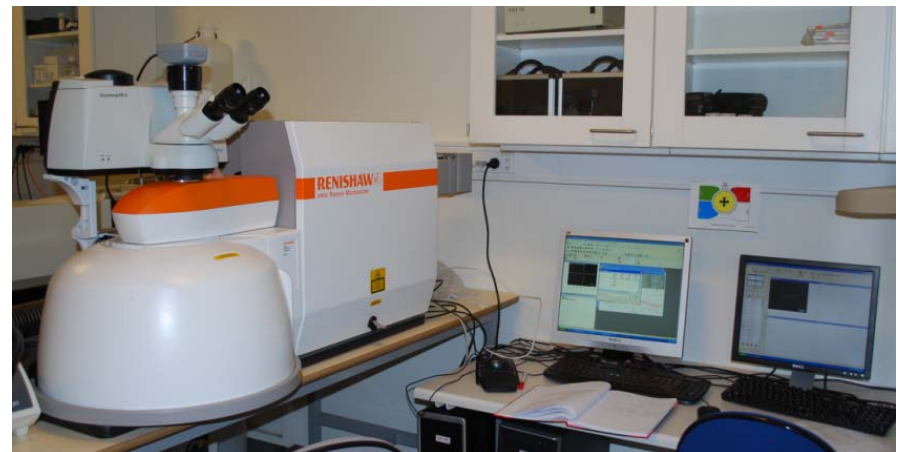
Software for chemometric data handling

Databases containing spectra for polymers,
forensics, minerals and inorganic compounds

FTIR:

ARO: All reflective objective

ATR: Attenuated total reflection





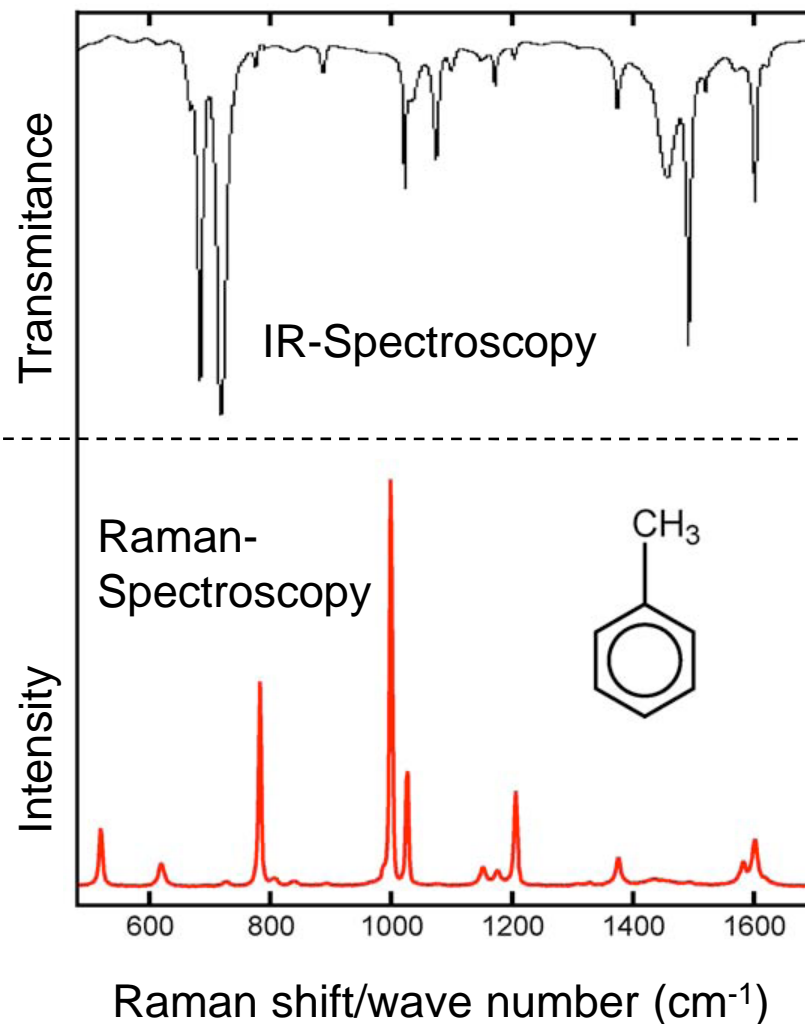
Combined Raman- and IR-spectroscopy

Both methods are well-suited for identification of unknown compounds

More collective experience and software integrated databases using FTIR for identification of compounds

Water absorbs light in the IR-spectrum

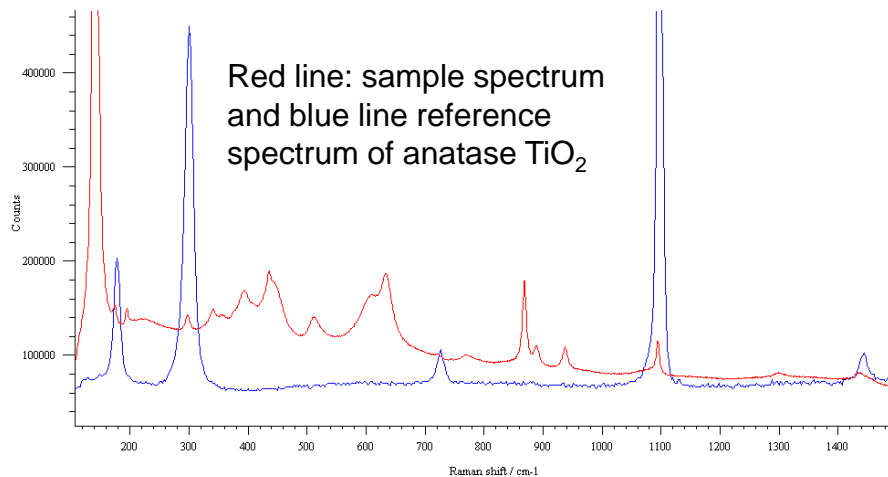
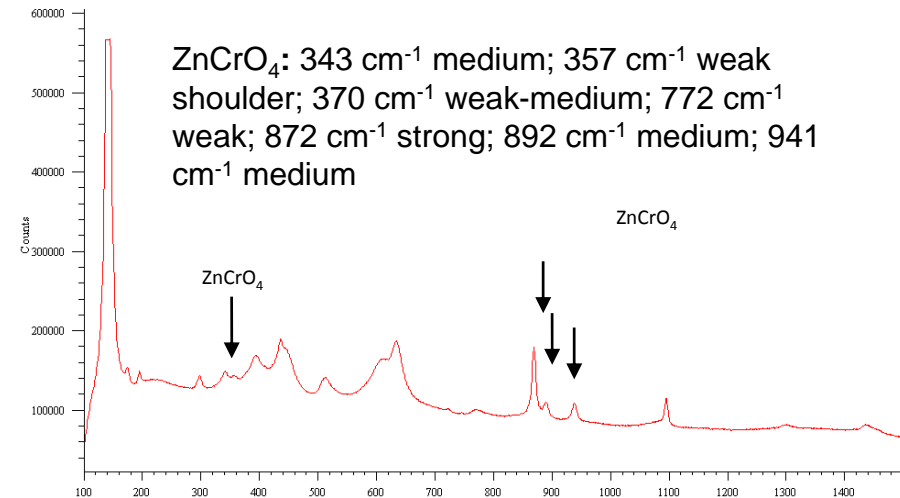
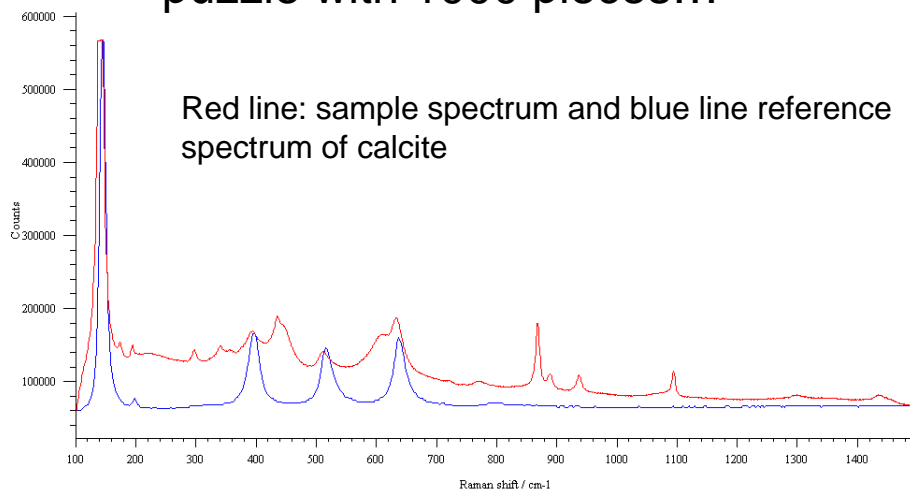
Less destructive





Combined Raman- and IR-spectroscopy

Analysis of yellow wall paint found in a building worthy of preservation. A puzzle with 1000 pieces...



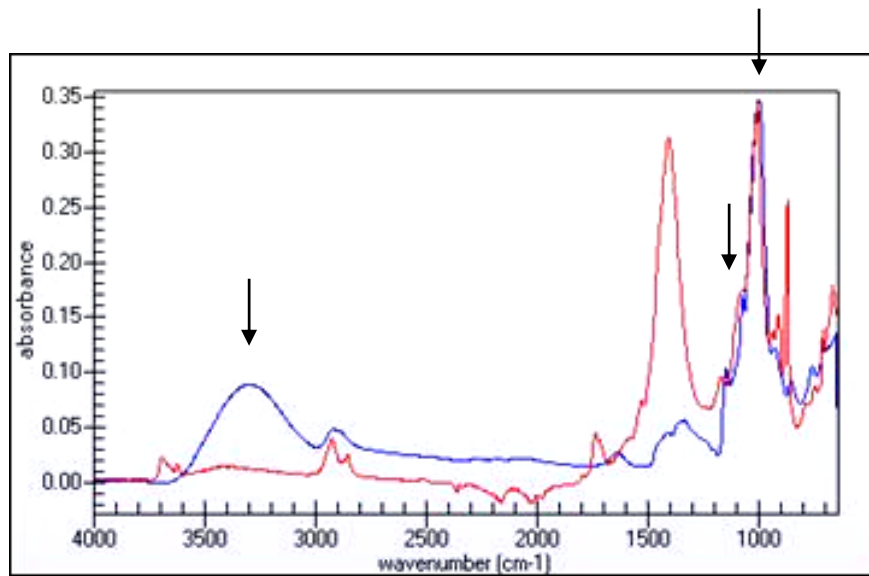
Content detected by Raman:

Pigment: ZnCrO₄
TiO₂
Calcite

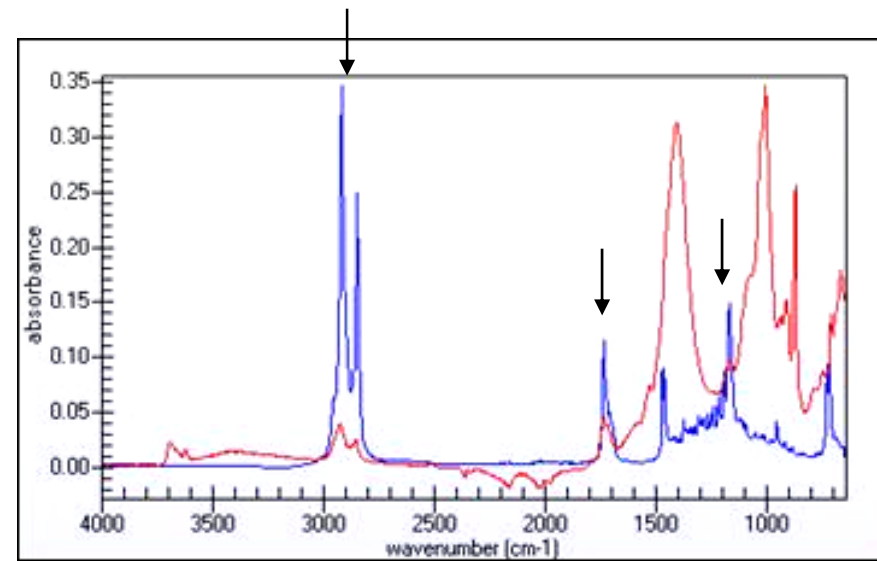


Combined Raman- and IR-spectroscopy

Analysis of yellow wall paint found in a building worthy of preservation. A puzzle with 1000 pieces...



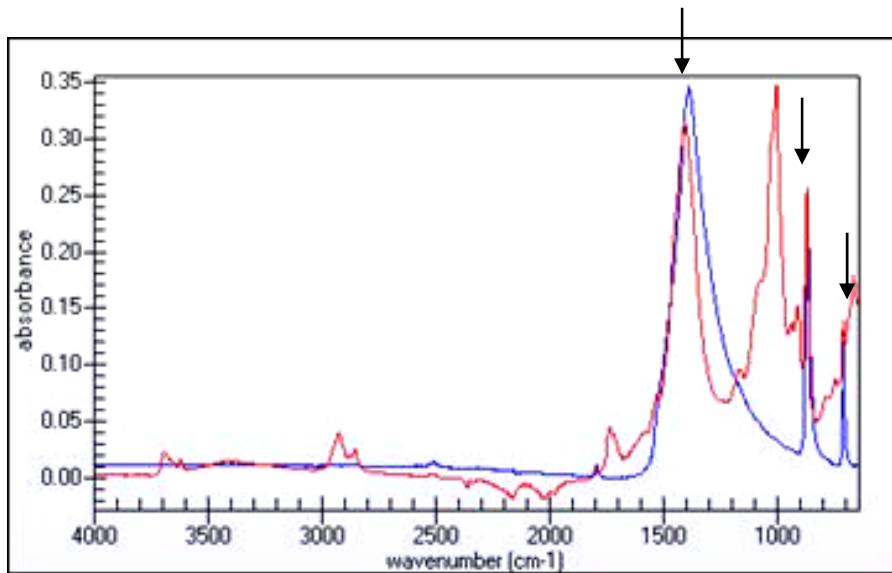
Red line: sample spectrum and blue line reference spectrum of dextrin (starch)



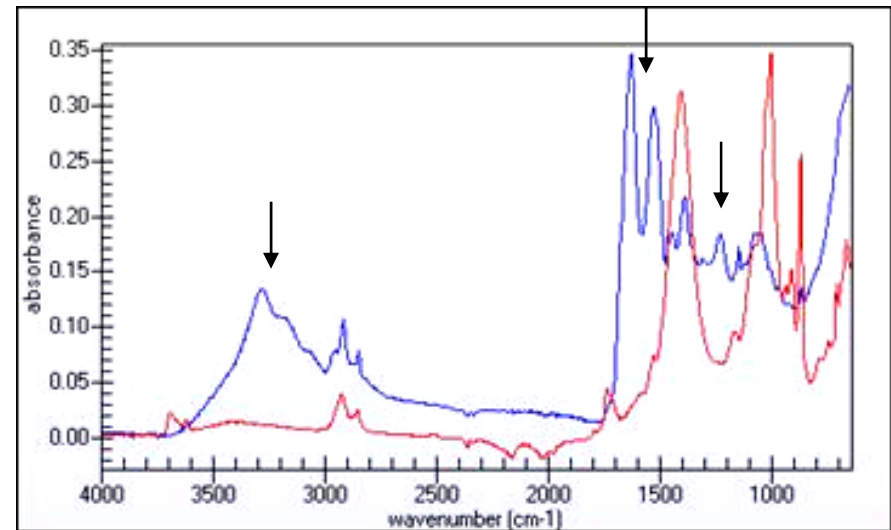
Red line: sample spectrum and blue line reference spectrum of wax

Combined Raman- and IR-spectroscopy

Analysis of yellow wall paint found in a building worthy of preservation. A puzzle with 1000 pieces...



Red line: sample spectrum and blue line reference spectrum of calcite



Red line: sample spectrum and blue line reference spectrum of albumine (egg protein)

The complex Raman and IR-spectra makes it a challenge to find the content of the paint. GC-MS revealed that the paint also contained a sort of an alkyd binder

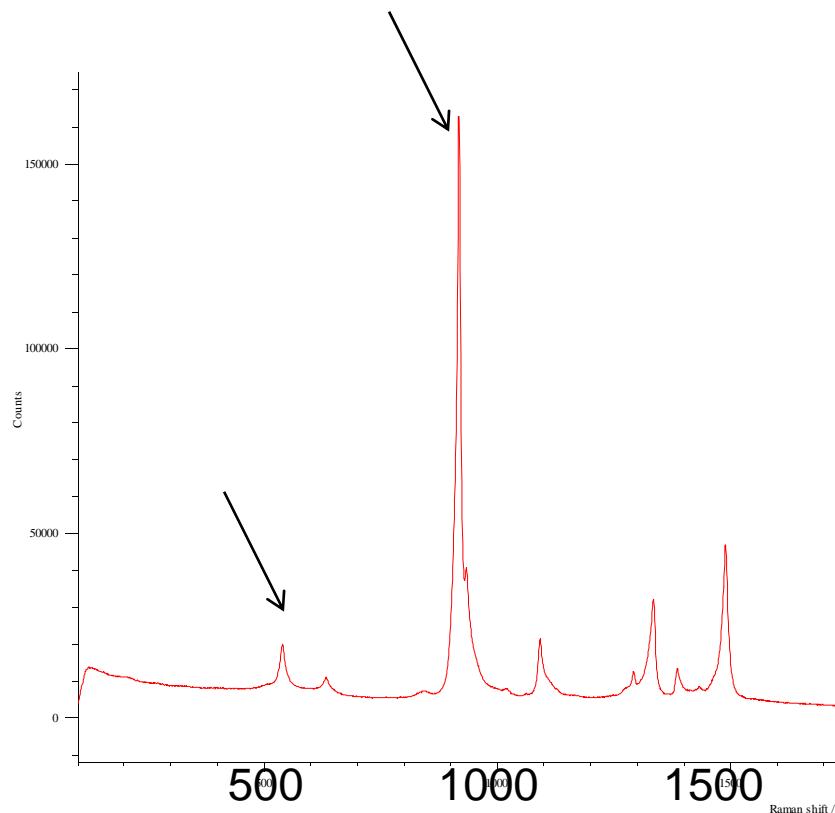


The non-vanilla ice cream

A customer making ice-cream factories had a complaint that a black substance emerged in the ice-cream – the polymer contained glass

Polyoxymethylene sliding
against stainless steel surface

Raman peaks at 540 cm^{-1} and
 930 cm^{-1}



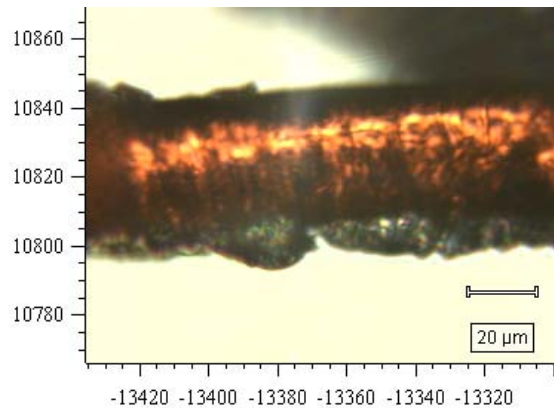
Element	Weight%
Cr	14
Ni	11
Zn	2,81
Si	2,4
Fe	70

XRF data on the black powder

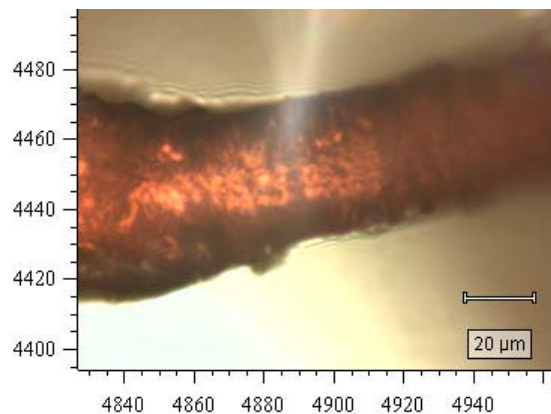
Raman spectroscopy on the black powder



Raman spectroscopy used in forensics

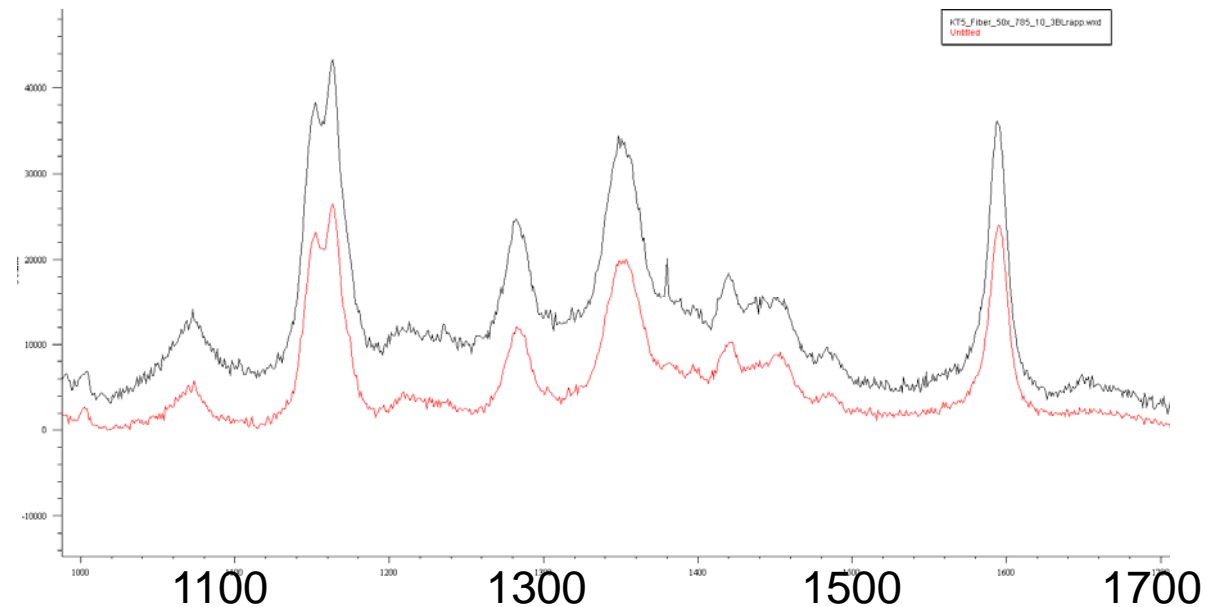


Fiber found on a shoe
from suspect



Fiber from the crime scene

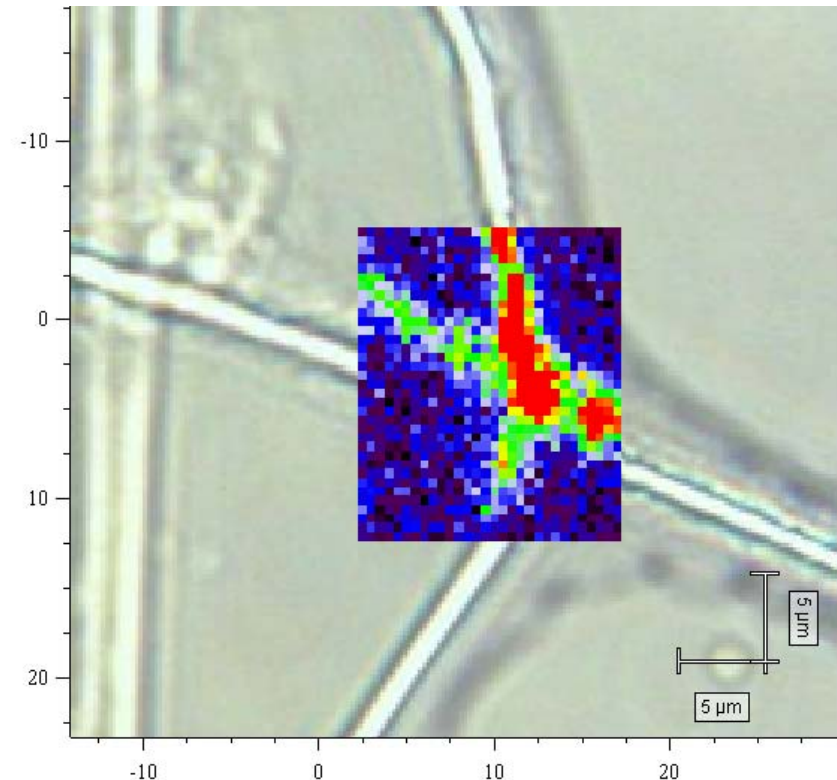
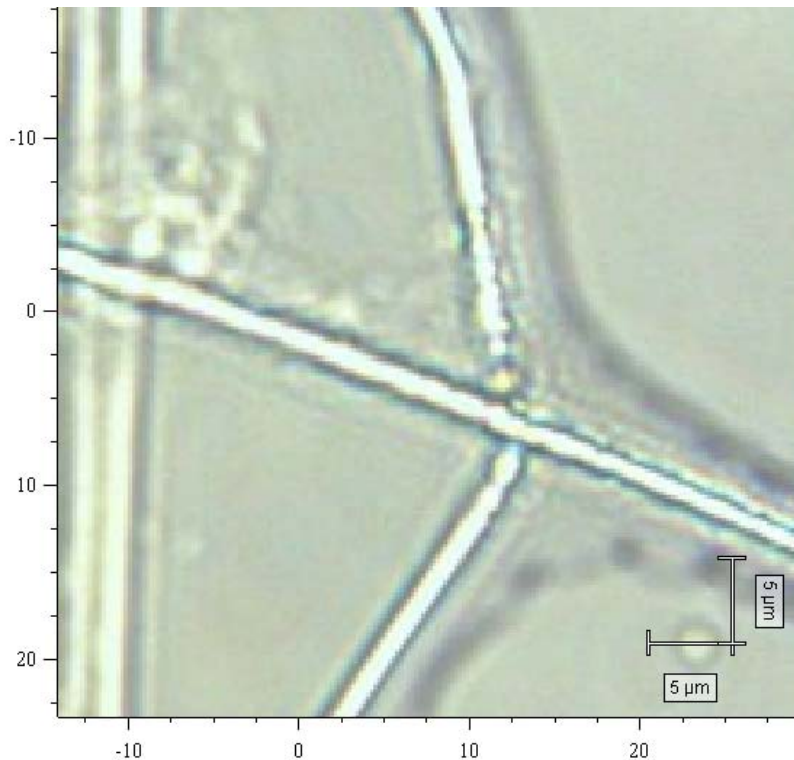
A burglar seen escape from a house



Ramanspectra of the two fibers
50x objective, 785 nm laser

Mapping

Bacterias found in contaminated tap-water



Beggiatoa-like cells. Containing a sulphur cluster
514 nm laser, 100x objective, 1050 acquisitions in 20 minutes, intensity
at a point 474 cm^{-1}



Using long exposure time

The Raman signal is weak -

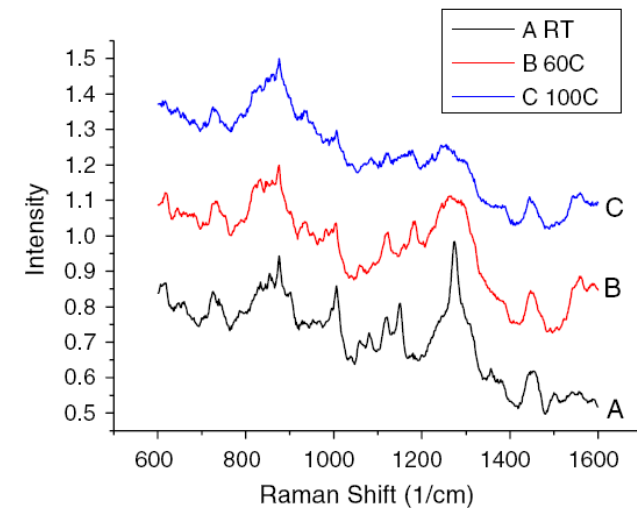
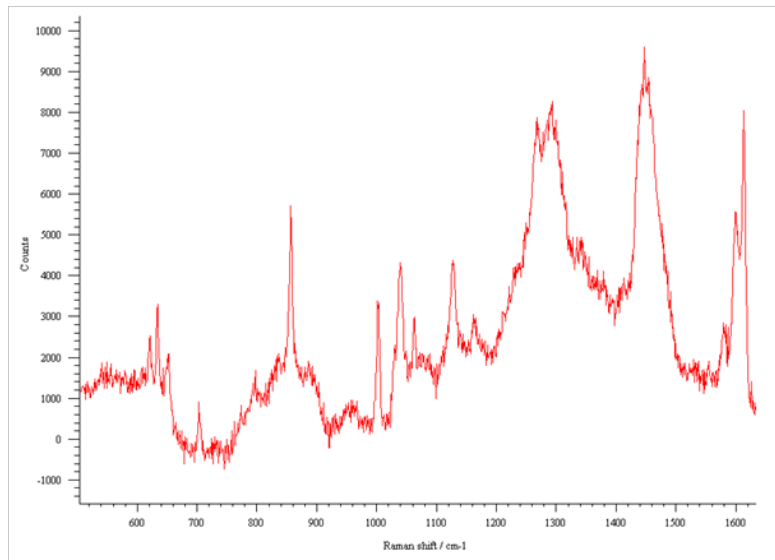


Fig. 5 SERS spectra of insulin at different temperatures (RT, 60, 100°C)

Raman spectrum of insulin found in very low concentration.

785 nm laser, 50x LD objective, 1 hour to obtain spectrum

Wang et al. 2009, microfluidics and nanofluidics, vol 6, iss. 3, 411 - 417

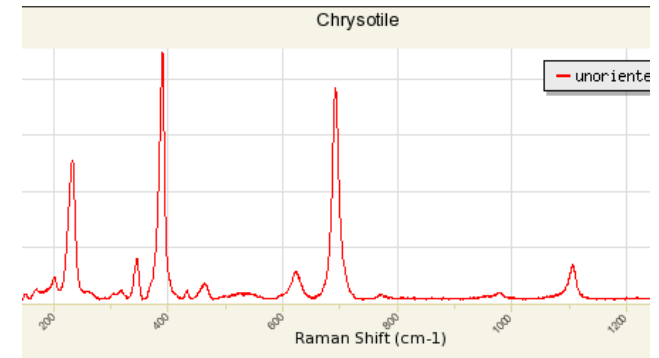


Asbestos

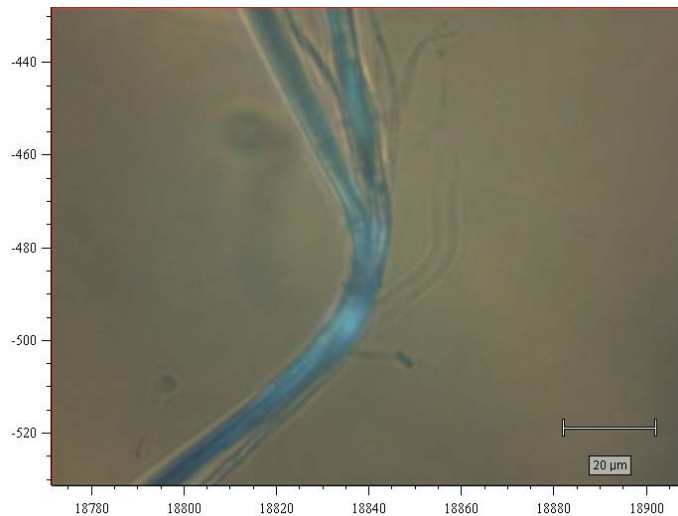
Raman spectroscopy for identification of asbestos

6 common types of asbestos

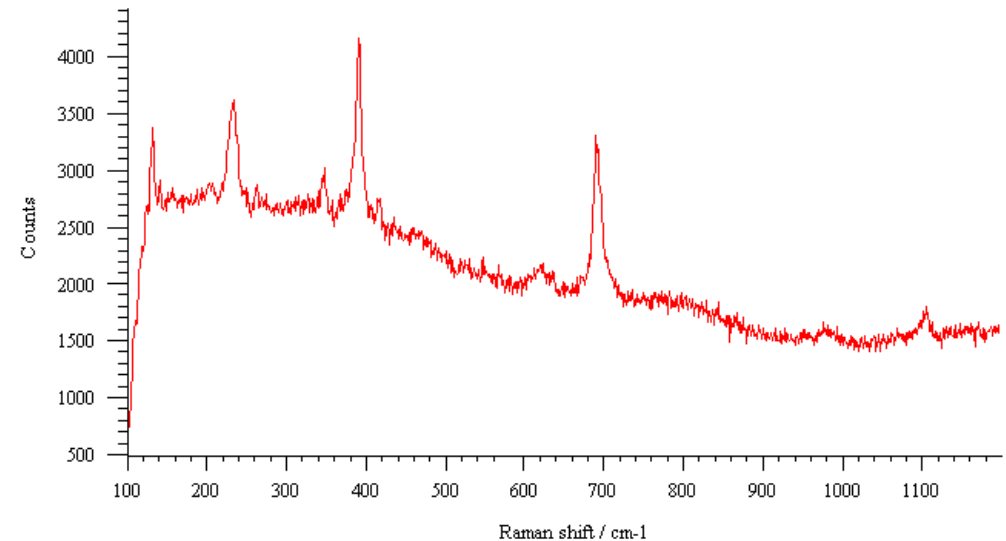
E.g. chrysotile: $[\text{Mg}_3\text{Si}_2\text{O}_5(\text{OH})_4]$



Database spectrum of chrysotile



Fiber from insulation found in a building



Raman spectrum of fiber



Projects and issues studied by Raman spectroscopy

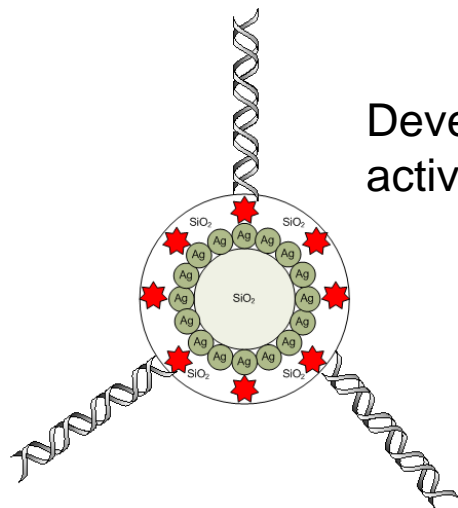


Particles found in clean room –
approx 1 – 20 μm

Diamond-like carbon films
Asbestos
Crystals
Particles
Fat in dough
Etc.



Black particles approx 10 μm in
diameter in hydraulic oil



Development of new SERS
active particles



Studies of biofilm in
pipes and heat
exchangers



Thank you for your attention

Thanks to K-Analys for arranging the meeting