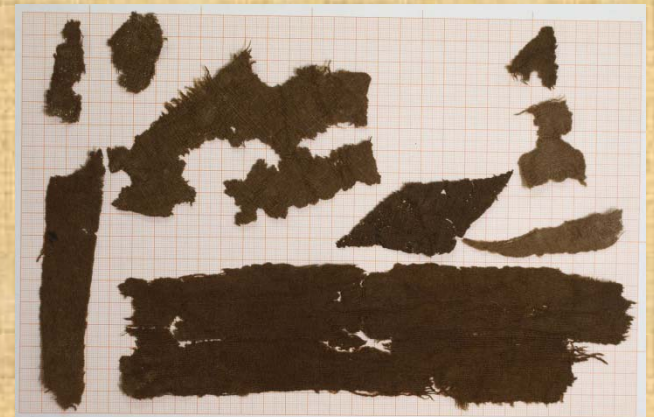
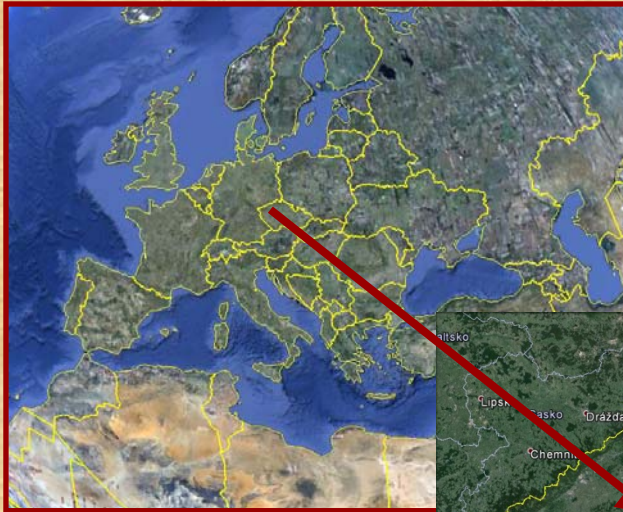


# AN ASSEMBLAGE OF MEDIEVAL ARCHAEOLOGICAL TEXTILES FROM PRAGUE: a Study of Current and Original Colours

David Kohout, *The Institute of Chemical Technology, Prague*  
Helena Březinová, *Institute of Archaeology of the Academy of Sciences  
of the Czech Republic, Prague*



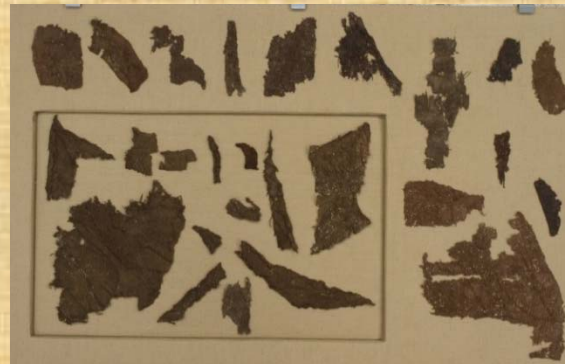
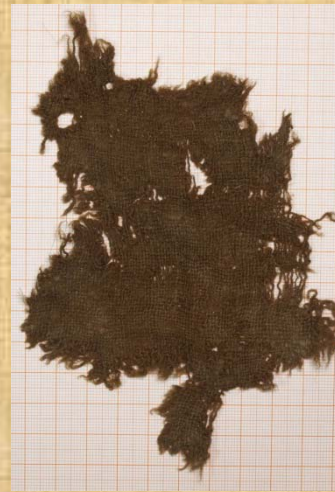
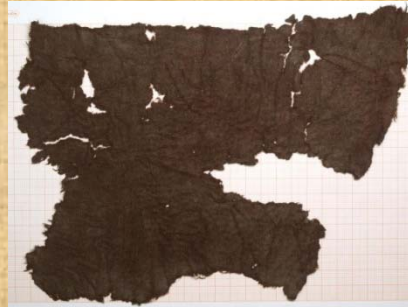
The Czech Republic

Prague



# THE RESEARCH OF MEDIEVAL TEXTILES IN THE CZECH REPUBLIC

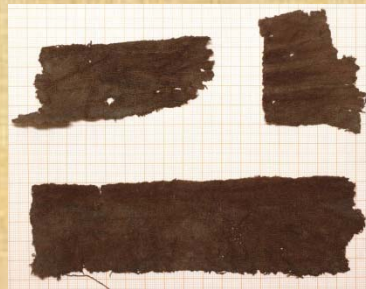
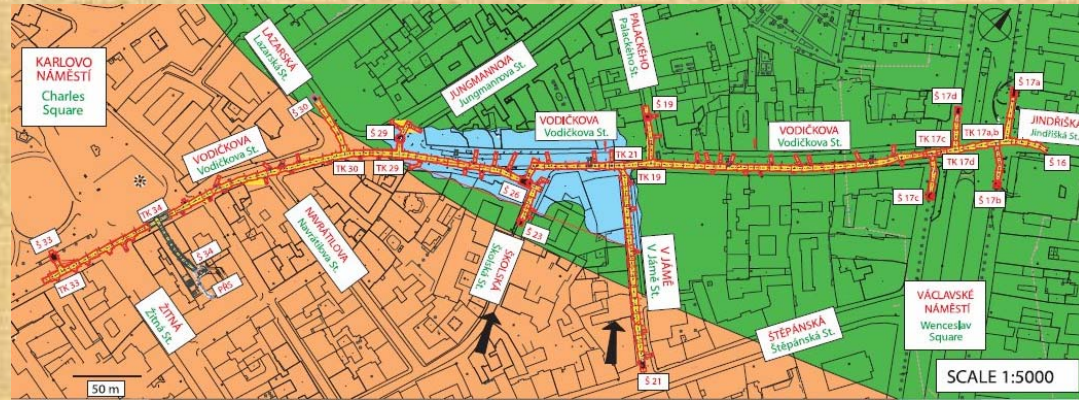
- Remains of common textiles found in waste layers and features, mostly in the urban environment
- No systematic processing and analytical evaluation in the Czech Republic to date
- A large assemblage of 1,500 medieval textile fragments from the centre of Prague
- Modern analytical methods - liquid chromatography with mass spectrometry detection and X-ray fluorescence





# FIND CIRCUMSTANCES

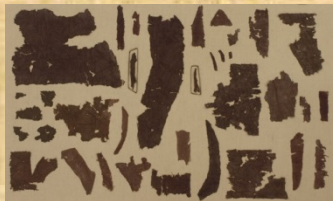
- Rescue archaeological excavations of the entrance shafts of collectors in the centre of Prague
- Prague's New Town (Jungmannova, Vodičkova and Skolská streets)
- In 2004-2007
- A thick formation of organic origin
- Remains of a dump for domestic waste from the nearby lots and for the construction waste from the reconstruction of houses during the 14<sup>th</sup> and 15<sup>th</sup> centuries
- Uncommonly large amount of artefacts made from organic materials – wood, textiles and leather





# LABORATORY TREATMENT OF TEXTILE FRAGMENTS

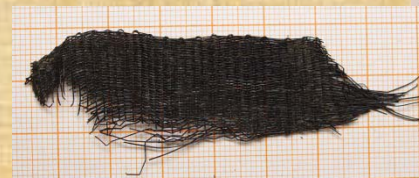
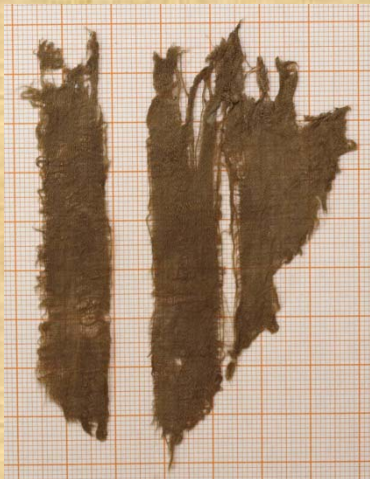
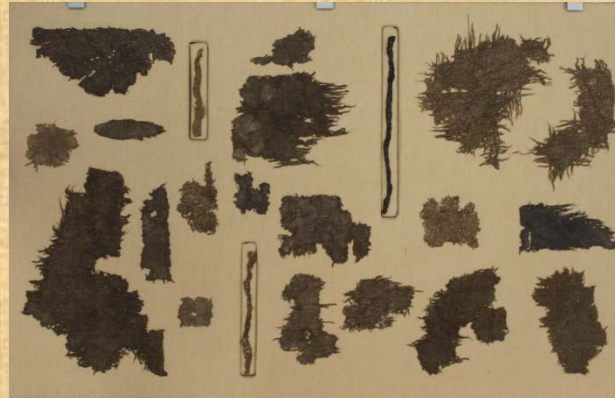
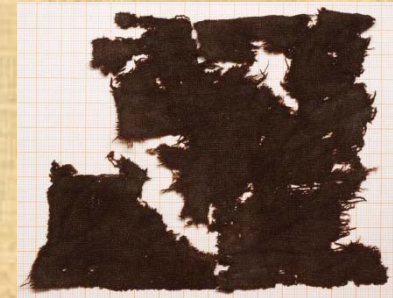
- Specialised restoration laboratory
- Carefully disinfection and mechanical cleaning
- Stored flat - containers on pre-stressed acid-free wood panels with a countersunk bed for individual fragments, lined with unbleached cotton fabric and covered with a pane of glass
- Dimensions of panels 80x50 cm





# VARIABILITY OF THE TEXTILE ASSEMBLAGE

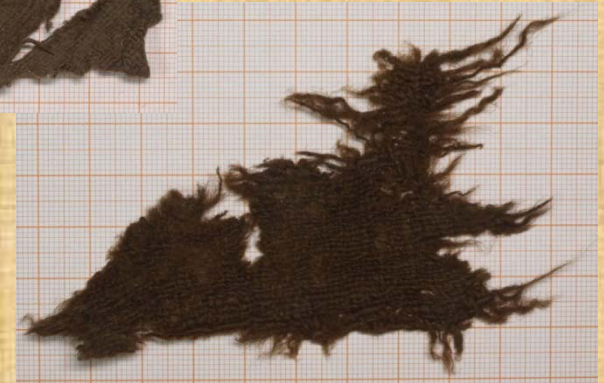
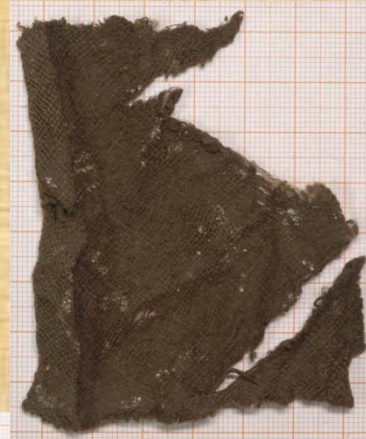
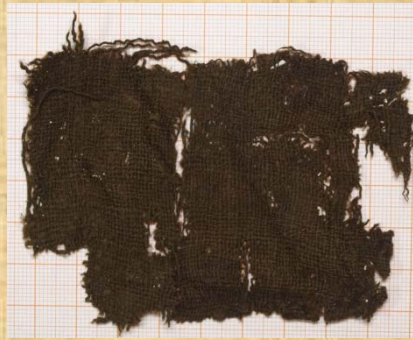
- 1,500 fragments
- 1,350 fragments from 500 different types of fabric
- Sewing thread, bands, twisted cord, felt, unprocessed animal fibre and horsehair



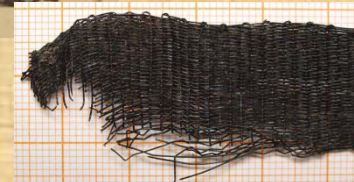


# WOOL AND OTHER FIBRES OF ANIMAL ORIGIN

- Wool cloth with a plain weave (300 specimens)
- Wool cloth with a twill weave (100 specimens)
- Three-quarters of which shows signs of their original fulling



- Other animal fibres - sheet felt, clumps of raw material, horsehair and the textiles made from them





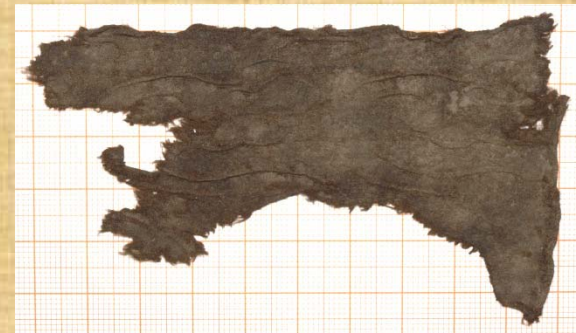
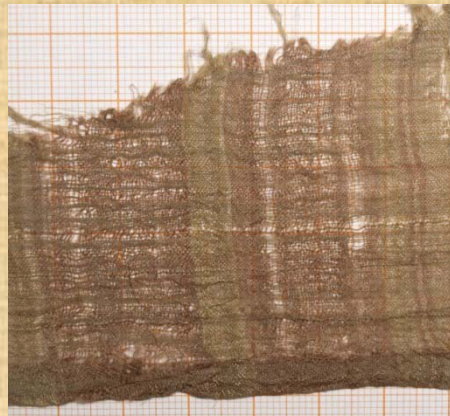
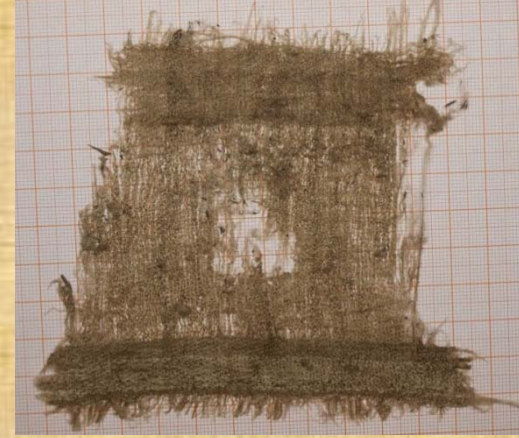
# SILK



- 30 monochromatic and colour patterned silk textiles

- More intricate weaves and patterns (samite, damask, lampas, atlas)

- The remnants of metal threads in the form of gold-plated membranes made from animal material wrapped around a flax core





# PLANT MATERIALS

- Only fifty fragments of textile material made from fibres of plant origin were preserved in the form of the remains of sewing thread, twisted cords and bast fibres





# TEXTILE TECHNIQUES AND TEXTILE PRODUCTS

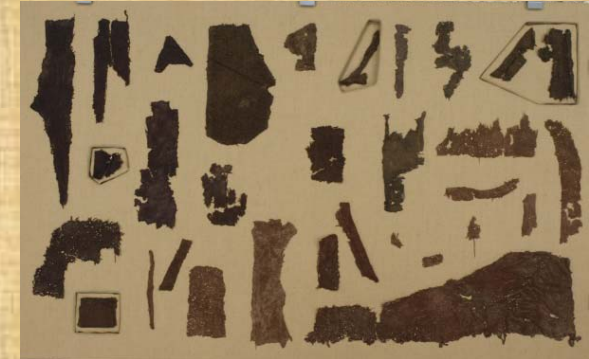
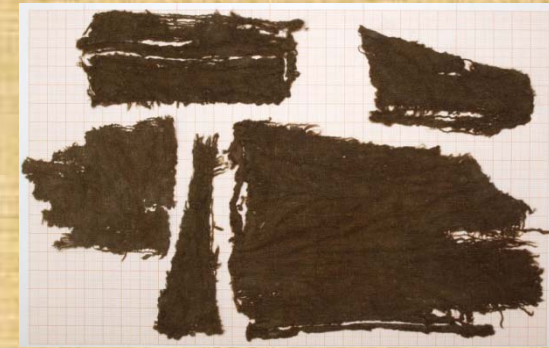
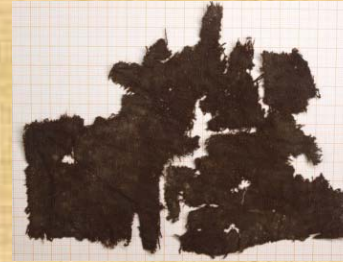
- An important part of the entire assemblage is made up of textiles produced on a loom with various weaves
- Bands woven on tablet looms and looms without a shed
- Cords and string twisted in various ways
- Felt
- Small textile fragments that had already lost their function
- Holes from stitching, sewing thread, fixed side selvages, overcast edges, hems with decorative trims, pleating, button holes, knots and braids





# THE PROFESSIONAL ANALYSIS AND EVALUATION OF THE ASSEMBLAGE

- The project “Medieval Textile and Dyeing Technologies - Archeometry of Textile Finds” supported by the Czech Science Foundation
- In 2014-2016
- Textile and dyeing technologies, description and interpretation of textiles from domestic and imported production
- Textile technology research, an identification of the used fibres, mordants, dyes and colouring sources





# MEDIEVAL TEXTILE COLOUR: DYEING AND MORDANTING

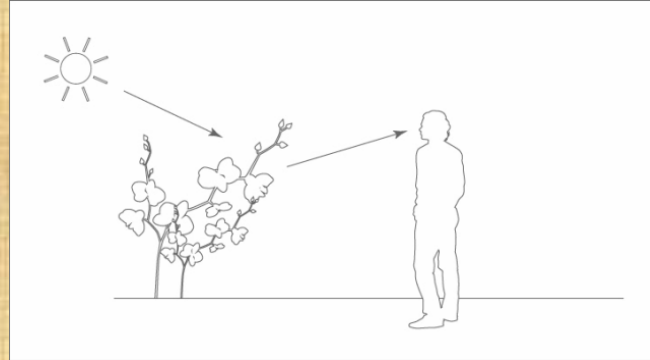
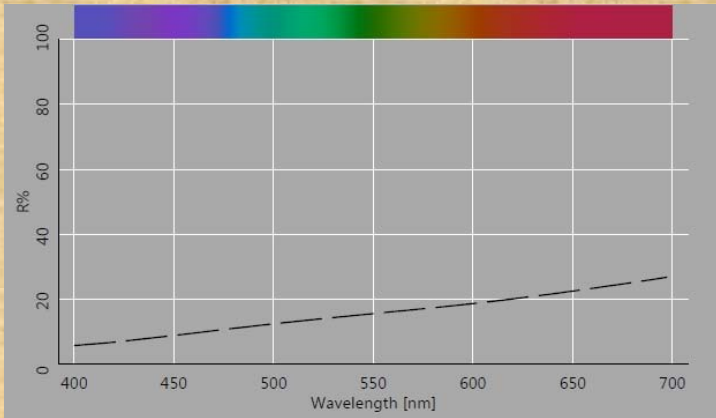
- Original colour: Organic dyes and Inorganic mordants
- Dyes: Liquid Chromatography- Mass Spectrometry (LC-MS)
- Mordants: X-ray fluorescence (SEM-EDX)
- Current colour: Visible Spectroscopy (CieLAB 1976)



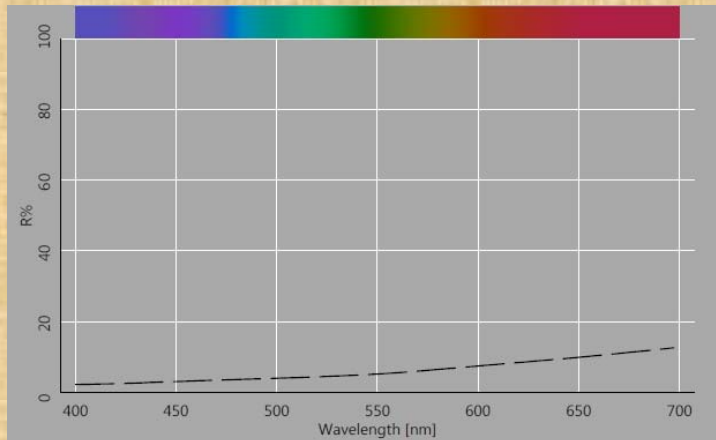


# CURRENT COLOUR: VISIBLE SPECTROSCOPY REFLECTION SPECTRA

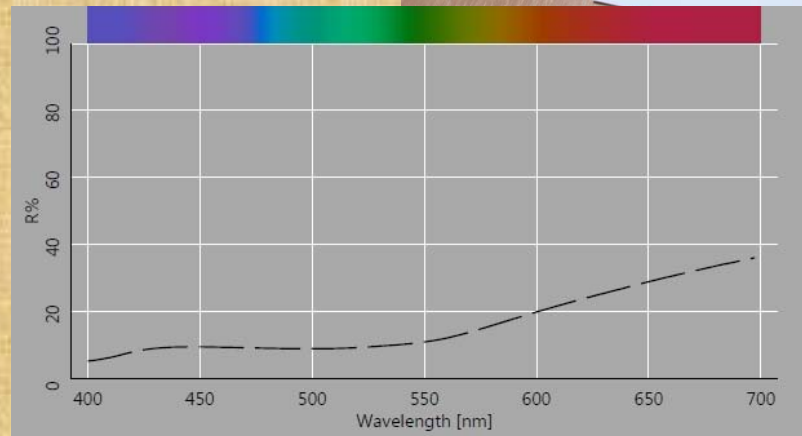
Yellow colour



Brown colour

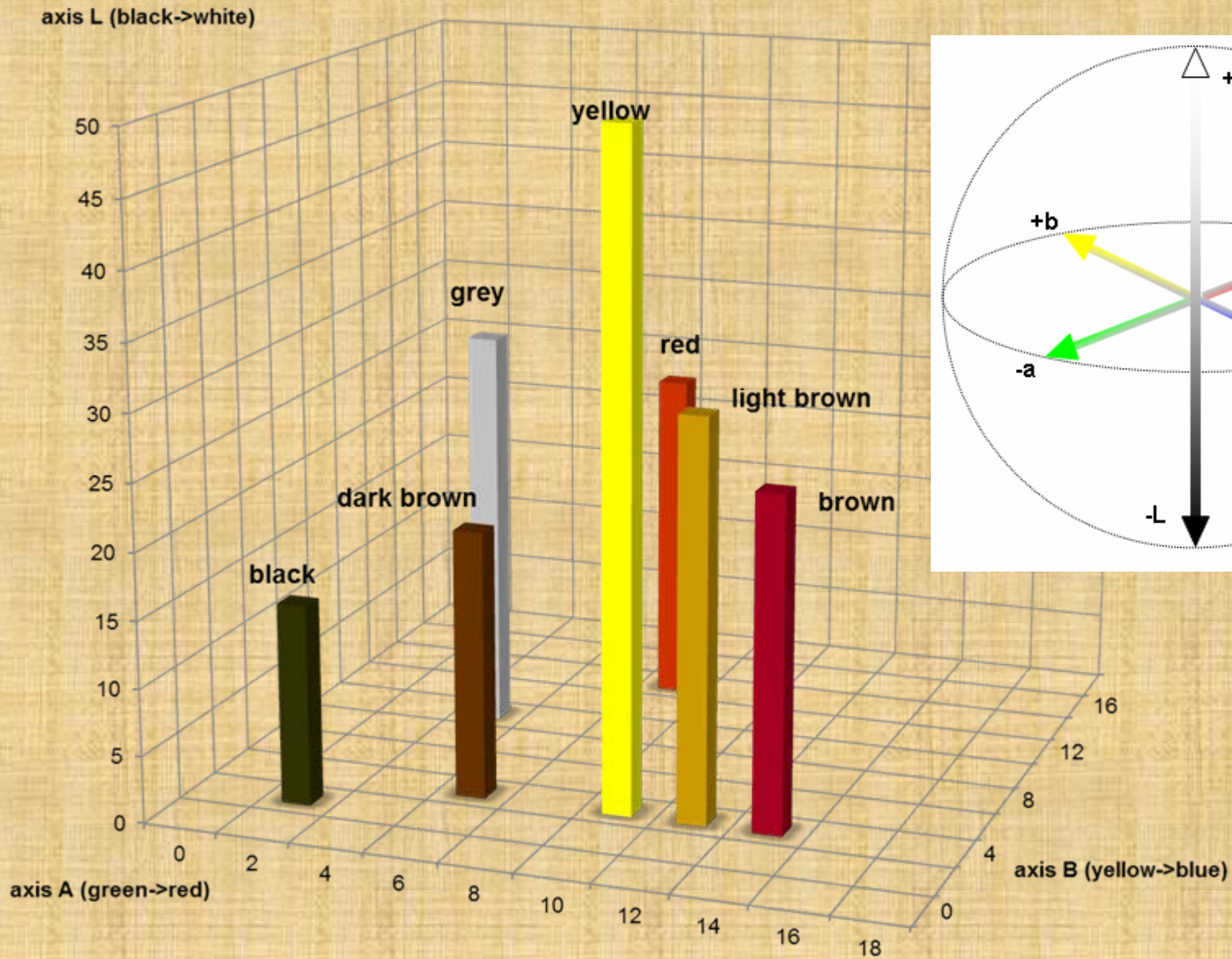


Red colour





# CIE LAB COLOUR SPACE EXACT COLOURS OF FRAGMENTS



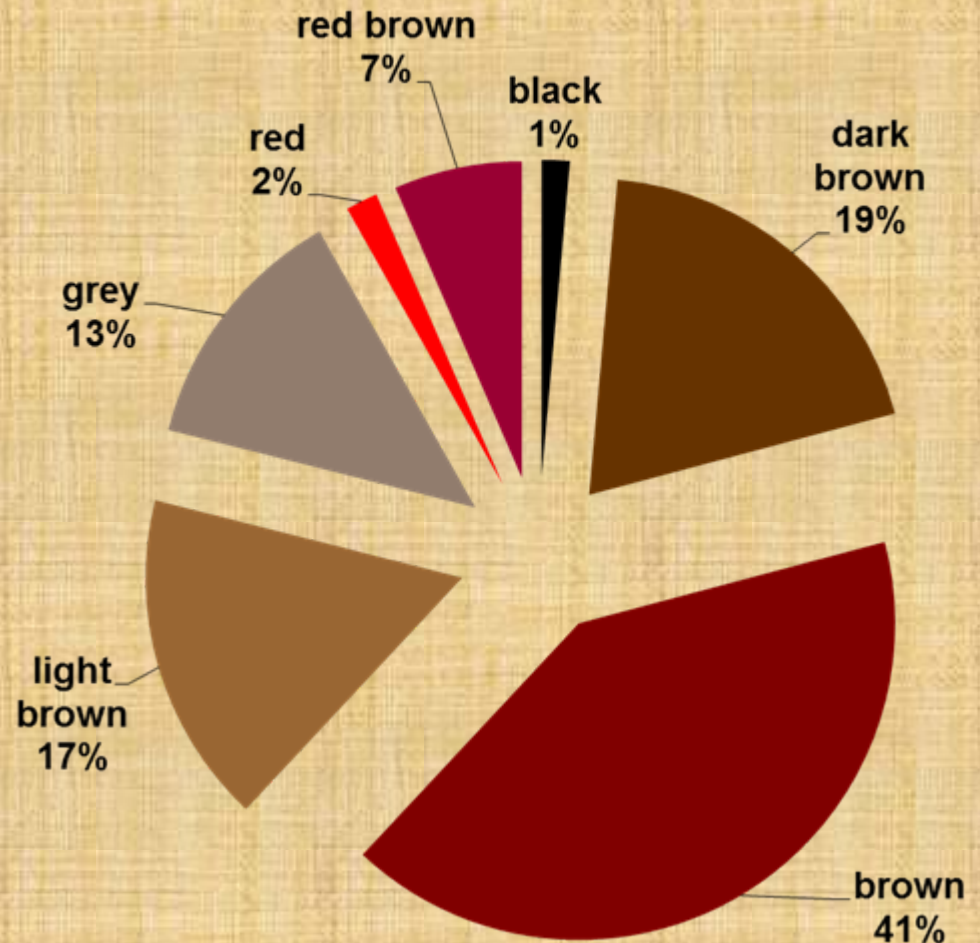


# PRESERVED COLOUR DIFFERENCES OF PROTEIN FIBERS (SILK AND WOOL)

Current colour of 28 silk fragments



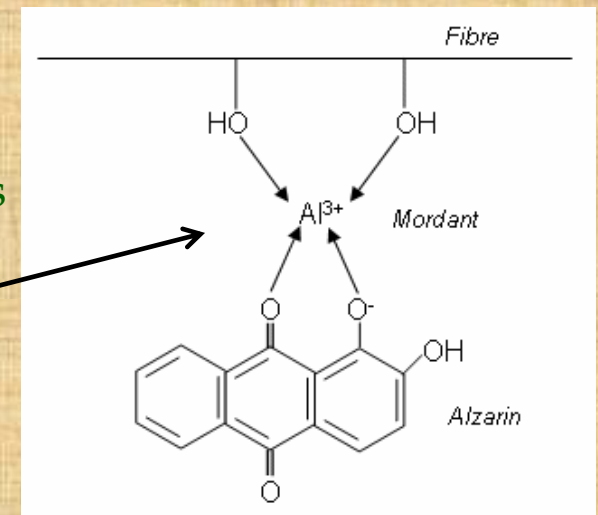
Current colour of 540 woolen fragments



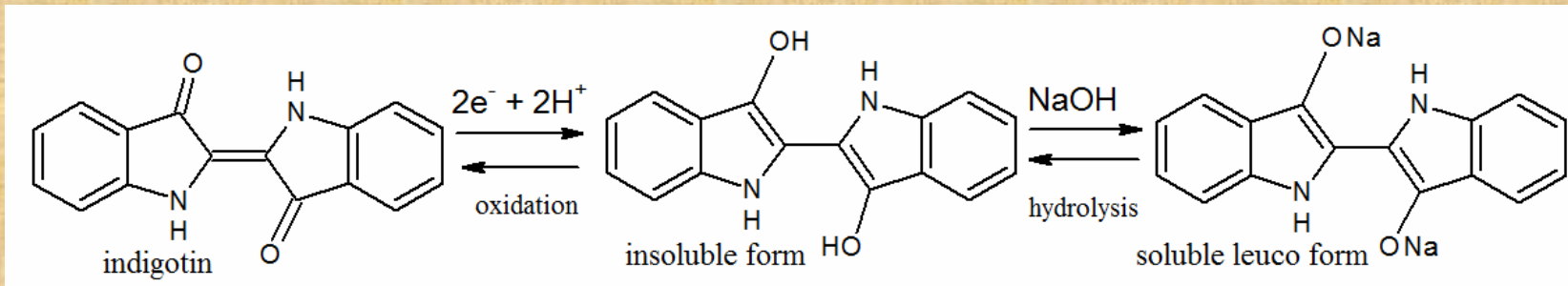


# DYEING PROCESS

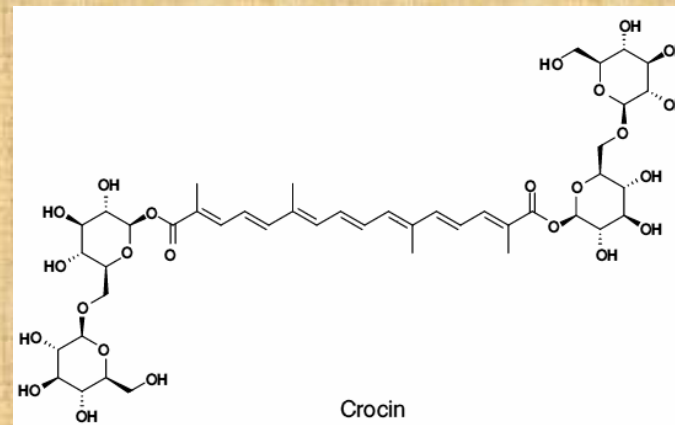
- **Mordant dyes:** most represented historical textile dyes red, yellow, brown/black  
mordants: central compound of complex bond ions of Al, Fe, Cu and organic tannins



- **Vat dyes:** blue indigo and Tyrian purple



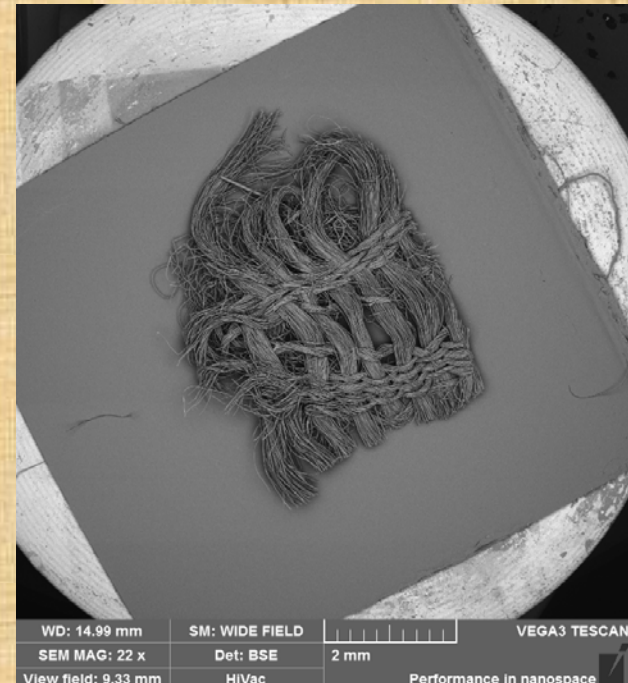
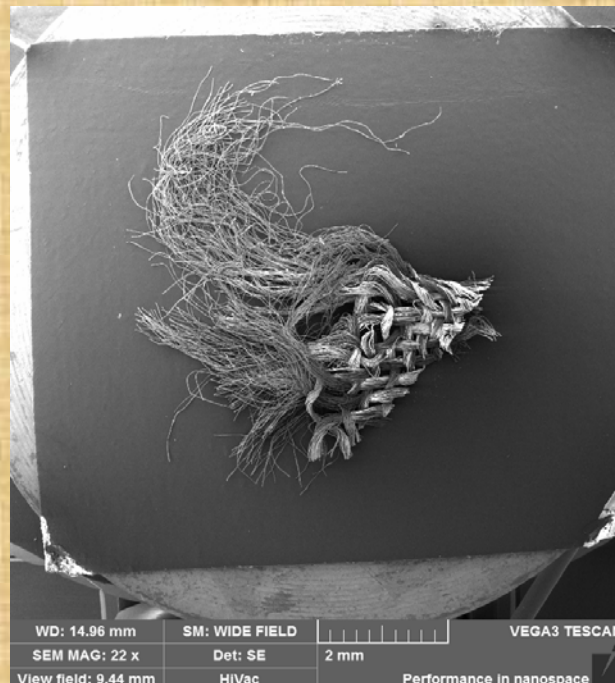
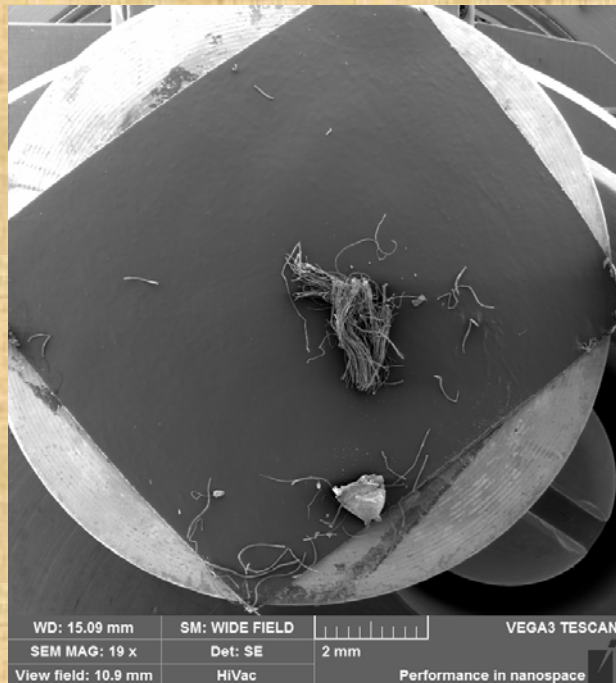
- **Direct dyes:**  
high affinity for a fiber, unstable





# EXTRACTION PROCESS OF DYES

- One step extraction: 100  $\mu$ L 48% methanol, 48% dichloromethane, 4% formic acid
- Ultrasonic bath at 60°C for 30 minutes -> filtration of solid particles
- Dillution: by the follow condition of the analysis (starting mobile phase composition)
- Amount of consumption of samples viewed by SEM (1 mg of fibers)





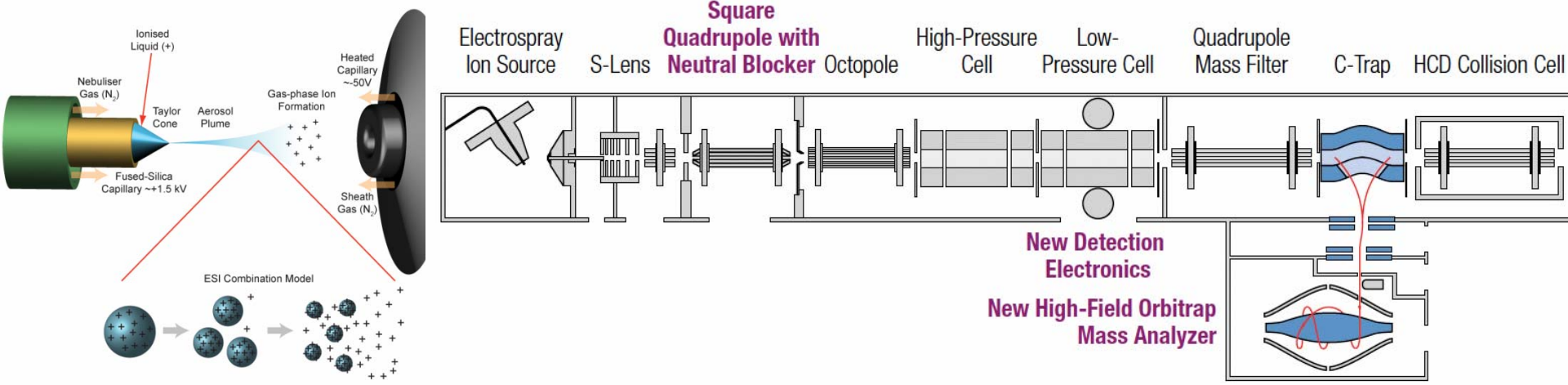
# MONITORING OF ORGANIC COMPOUNDS BY HPLC - MS

- **Separation:** High Performance Liquid Chromatography -HPLC  
mobil phase: acetonitrile (0,1% HCOOH) and water (0,1% HCOOH)
- **Ionization:** Electrospray -ESI  
atmospheric pressure soft ionization -negative mode- ions of molecule  $[M-H]^-$   
-positive mode- ions of molecule  $[M+H]^+$
- **Detection:** Mass Spectrometry -MS  
Orbitrap is monitoring high resolution mass to charge of ionized molecules

Chemical quality is determined by retention times of chromatographic parameters (HPLC) and summary chemical structure is detected by mass spectrometry (MS)

ESI

MS

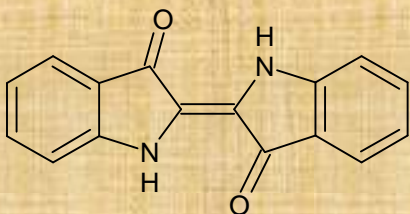




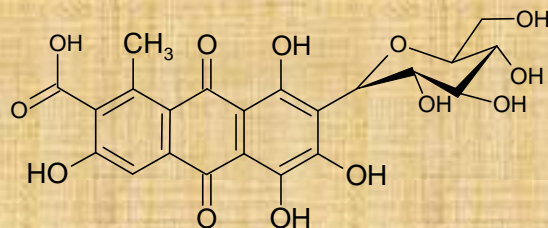
# NATURAL DYES

| dye type       | analyte                | formula               | m/z      | natural source   |
|----------------|------------------------|-----------------------|----------|--|
| polyene        | <b>crocin</b>          | $C_{44}H_{64}O_{24}$  | 975.3715 | <i>Crocus sativus</i> , <i>Gardenia jasmoides Ellis</i>  |
| indol          | <b>indigotin</b>       | $C_{16}H_{10}N_2O_2$  | 261,0670 | <i>Isatis tinctoria</i> , <i>Indigofera tinctoria</i> , <i>Polygonum tinctorium</i>            |
| brom indol     | <b>dibromindigotin</b> | $C_{16}H_6Br_2N_2O_2$ | 414.8723 | <i>Murex trunculus</i> , <i>Bolinus brandaris</i> , <i>Stramonita haemastoma</i>               |
| naphthoquinone | <b>juglon</b>          | $C_{10}H_6O_3$        | 174.0322 | <i>Juglans regia</i> , <i>J. cinerea</i> , <i>J. nigra</i>                                     |
| anthraquinone  | <b>alizarin</b>        | $C_{14}H_8O_4$        | 239,0350 | <i>Rubia tinctorum</i> , <i>Rubia peregrina</i> , <i>Galium verum</i> , <i>Galium Odoratum</i> |
| flavonoid      | <b>luteolin</b>        | $C_{15}H_{10}O_6$     | 285,0405 | <i>Reseda luteola</i> , <i>Genista tinctoria</i> , <i>Serratula tinctoria</i>                  |
| neoflavonoid   | <b>brazilein</b>       | $C_{16}H_{12}O_5$     | 283,0612 | <i>Caesalpinia echinata</i> , <i>C. sappan</i>   |
| tannins        | <b>ellagic acid</b>    | $C_{14}H_6O_8$        | 300,9990 | <i>Quercus sp.</i> , <i>Quercus infectoria</i>   |

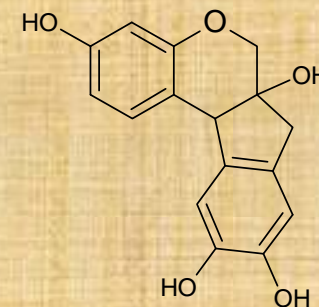
## indigotin



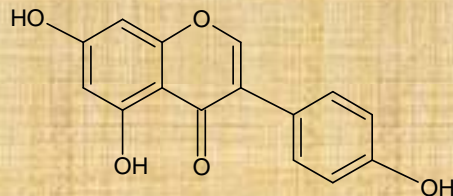
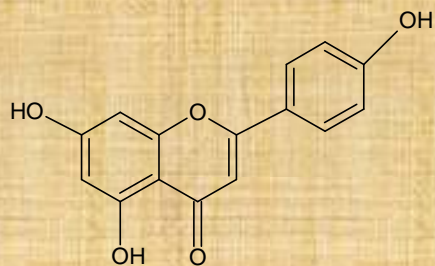
## anthraquinones



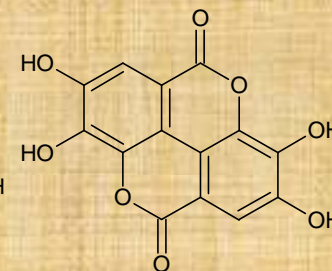
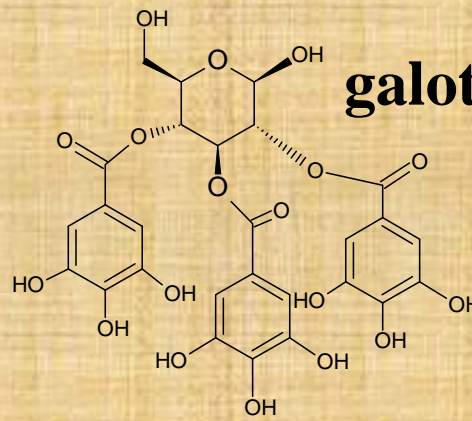
## neoflavonoids



## flavonoids



## galotannins

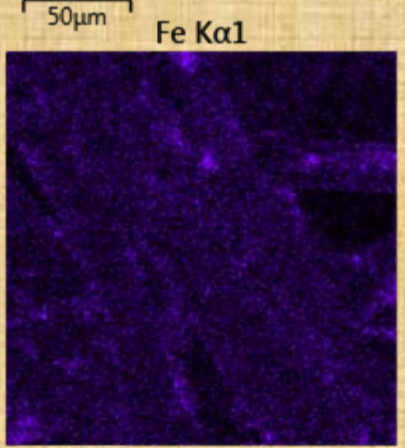
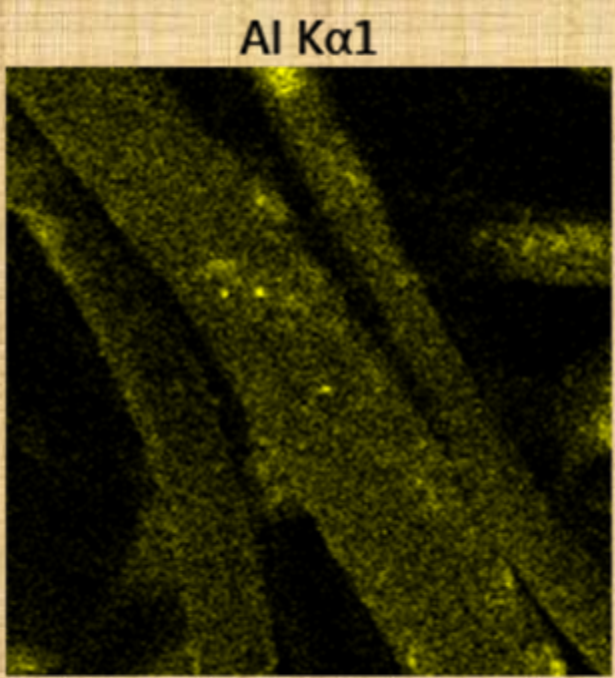
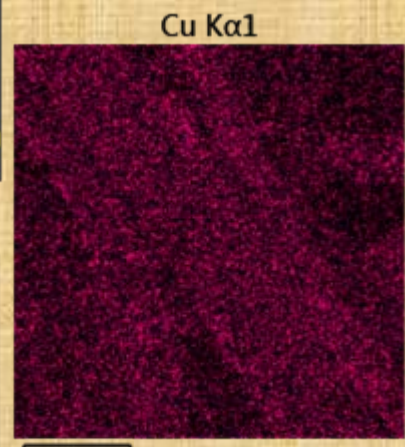
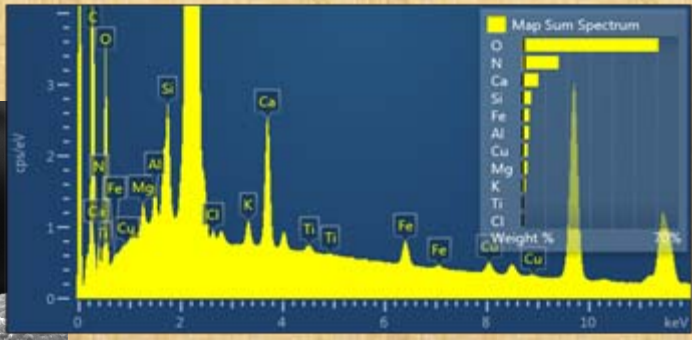
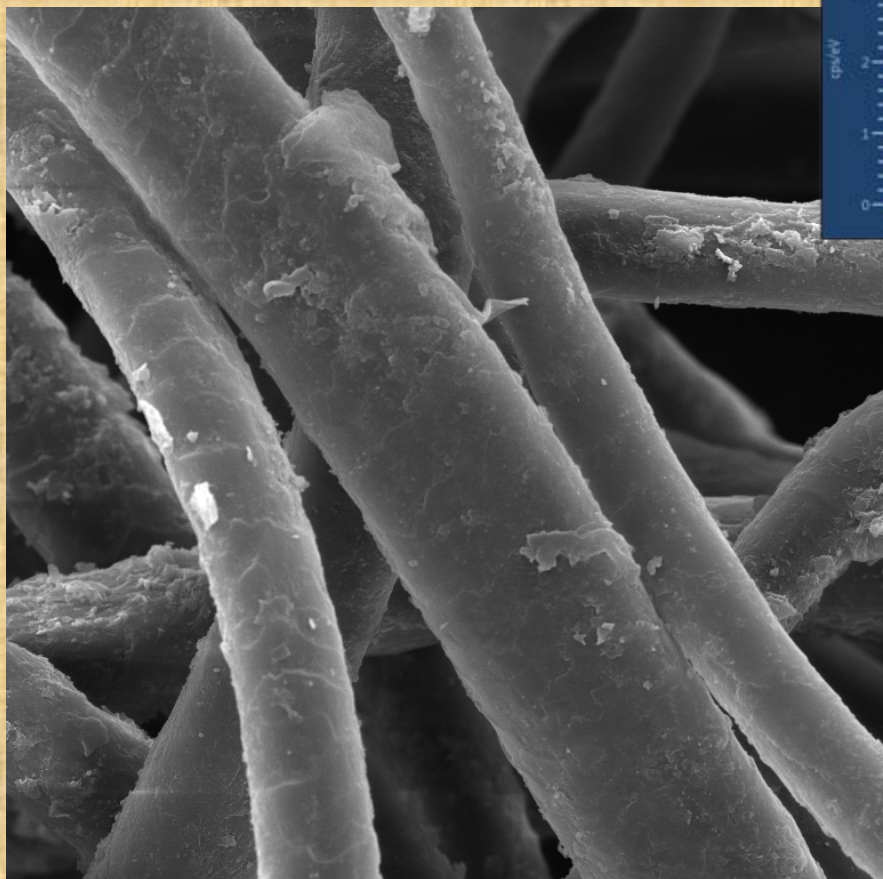




# MONITORING OF INORGANIC COMPOUNDS BY SEM-EDS

## ELECTRON MICROSCOPY

- Scanning electron microscopy with energy dispersive detector
- Mapping of elements



|                    |                |                          |
|--------------------|----------------|--------------------------|
| WD: 15.06 mm       | SM: RESOLUTION | VEGA3 TESCAN             |
| SEM MAG: 1.12 kx   | Det: SE        | 50 μm                    |
| View field: 185 μm | HiVac          | Performance in nanospace |



# DYEING METHODS

- **Basic colour** : red, yellow, blue and brown
- **Composed colour**: re-dyed methods
  - green: yellow + blue
  - orange: yellow + red
  - black: blue + brown + (red)
- **Mordants**:
  - Al- alum -  $\text{KAl}(\text{SO}_4) \cdot 12\text{H}_2\text{O}$
  - Fe- blue vitriol/iron fillings
  - Cu- green vitriol/verdigris
  - Organic mordants - tannins





# EXAMPLE OF THE INTERPRETATION SYNTESIS OF THE DATA: FRAGMENT 1-V31-27

- Yellow silk stripe  
mordant Al + flavonoids
- Black wool stripe  
mordant Fe + tannis + indigo
- Red wool stripe  
mordant Al + alizarin
- Brown wool warp





**Thank you for your attention!**

