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Techniques used for examination, characterisation and analysis of cultural-heritage materials—Some suggestions for the European Research infrastructures(*)

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Summary. — Based on the large survey of techniques of examination, characterisation and analysis of cultural heritage materials, conducted in the frame of the European LabS TECH project, one gives some concrete suggestions in order to improve the practical efficiency of the contributions of the large European Research Infrastructures in the area of cultural heritage. One suggests also some tracks to widen the dissemination of these techniques.

PACS 42.62.Fi – Laser spectroscopy.
PACS 78.70.En – X-ray emission spectra and fluorescence.
PACS 81.70.Fy – Nondestructive testing: optical methods.
PACS 81.70.-q – Methods of materials testing and analysis.

Preamble

The survey did in the frame of the LabS TECH European network (2001-2005), among 126 institutions (museums, libraries, public cultural heritage institutions, universities, public research institutions, technology research centres, restoration workshops, foundations...) in 28 countries permits to give indication of real use of 114 different techniques of examination, characterisation and analysis of cultural heritage component materials. The techniques mentioned by more than 10% of the participating institutions are given in table I.

(*) Paper presented at the Workshop "RICH—Research Infrastructures for Cultural Heritage", Trieste, December 12-13, 2005.

TABLE I. – *LabS TECH—Frequency of the different techniques (01/10/2005). N.B.: 114 different techniques are indicated by the 126 participants.*

Rank	Technique	Number of times mentioned
1	Reflection Light Microscopy	96
2	Scanning Electron Microscopy (SEM)	83
3	Transmission Light Microscopy	81
4	Classical Visible Light Digital Photography	77
5	Classical Visible Light Silver Emulsion Photography	69
6	Infrared Spectrometry	66
7	Visible & Ultraviolet Spectrometry	52
8	Powder Diffractometry	51
9	Diffractometry	51
10	Ultraviolet Fluorescence Photography	50
11	Standard Colorimetry	50
12	Low HV ($< 150\,\text{kV}$) X-ray Radiography	47
13	Digitisation & Image Archiving	46
14	Infrared Spectrometry Microscopy	46
15	Environmental Weathering Tests (Chambers)	45
16	High Performance Liquid Chromatography (HPLC)	40
17	Gas Chromatography (GC)	39
18	Gas Chromatography - Mass Spectrometry (GC-MS)	37
19	Low Angled Photography	35
20	X-ray Fluorescence Analysis - X-ray Tube - Laboratory Fixed Instrument	35
21	Differential Thermal Analysis (DTA/TG/DTG)	35
22	Infrared Silver Emulsion Photography	34
23	Infrared Reflectography Electronic Camera	33
24	Universal Mechanical Testing	32
25	Spectro-Photo-Colorimetry	31
26	Accurate Colour High Resolution Digital Photography	30
27	Ion Chromatography	30
28	High voltage ($150 < \text{HV} < 450\,\text{kV}$) X-ray Radiography	29
29	Thin layer Chromatography (TLC)	27

Table I. – *Continued.*

30	Raman Spectrometry	27
31	Electron Microprobe	26
32	Atomic Emission spectrometry (ICP-AES)	24
33	Atomic Absorption Analysis (AAA)	23
34	X-ray Fluorescence Analysis - X-ray Tube - Portable	23
35	Pyrolysis Gas Chromatography (Py-GC)	20
36	Environmental Natural Weathering Tests (Outdoor)	20
37	Mercury Porosimetry	19
38	Particle Induced X-ray Emission (PIXE)	19
39	Pyrolysis Gas Chromatography - Mass Spectroscopy (Py-GC-MS)	17
40	Inductively Coupled Plasma Mass Spectrometry (ICP-MS)	17
41	Electron Impact Mass Spectrometry (EI-MS)	16
42	Environmental Scanning Electron Microscopy (ESEM)	16
43	Fluorescence Spectrophotometry	14
44	Synchrotron radiation examination	14
45	Specific Surface Area Measurement (BET)	14
46	Rutherford Backscattering Spectrometry (RBS)	14
47	Contact Angle measurement	14
48	Transmission Electron Microscopy (TEM)	13
49	Ultra-Sound Testing	13
50	Scanning Infrared Reflectometry	12
51	Thermoluminescence Dating (TL)	12
52	X-Ray Induced Photoelectron Spectrometry (XPS)	12
53	Laser Ablation Mass Spectrometry	11
54	Liquid Chromatography - Electospray Ionisation (LC-ESI-MS-MS)	11
55	Nuclear Reactions (PIGE - PIGME)	11
56	Ultraviolet Fluorescence Microscopy	10
57	Enviromental monotoring	10
58	Chemical Ionisation Chromatography (CI-MS)	10
59	Particle size analysis	10
60	Mössbauer Spectrometry	10

Less used techniques available in large-scale research facilities are also mentioned:

– Neutron activation analysis	9 times
– XRF produced by PIXE	8
– ^{14}C AMS dating	8
– ERDA	7
– Particle activation analysis	4
– Neutron radiography	3
– Neutron autoradiography	2

Some suggestions

1) With specific reference to access, it is of crucial importance that permanent and competent teams be formed at the Research Infrastructures (RI), to act as a bridge between the curators, the conservators-restorers, archaeologists, art historians etc. and the staff on the Research Infrastructures.

It is essential to have at least 1 person 100% devoted to CH problems at each RI, with the task to help "delivering" the specific proposals through a "majeutic" process.

2) With specific reference to infrastructure policy, it is essential that some time be devoted to service (routine) examinations.

For routine techniques, it is essential to develop the following elements:

– Protocols, best practices, analysis softwares.

– Reference materials and databases.

3) Effort should not be focussed exclusively on "aristocratic" science and "aristocratic" art and/or art history, but also on the long-term behaviour and conservation of "standard" collections.

4) Preventive conservation must not be forgotten.

A paradox: to know perfectly Leonardo da Vinci's painting technique with the help of synchrotron radiation and to waste definitively the collection of his masterpieces in one human generation, due to stupid air conditioning parameters, or to the gesture of an architect and/or a politic decision maker!

Example of technology transfer (C2RMF): adaptation, from the semiconductor and electronics industry, of air corrosivity sensors (surface resistivity sensors or quartz crystal microbalances), and improvement of the information given by these sensors using X-ray diffractometry, PIXE and RBS analysis. . . . Identification of the alteration processes and their initial kinetics for Ag, Cu, Al, Fe. . . .

Important issues are:

– Compatibility tests of materials used for restoration/consolidation, conservation, civil engineering, temporary exhibits, transportation containers. . . .

– Tests of newly available materials: glues, varnishes, silicon products, plastic films for protection, paper and paperboards, wood derivates (chipboards, plywood, . . .).

5) Portal

5.1—Possibility to introduce all the RI volunteer labs in the Labs TECH database which will migrate on the EU-ARTECH website and to extend this database to emerging techniques.

5.2—Creation of a RI-CH portal, to serve both as a link to repositories of expertise and, ultimately, as a "one-stop-shop".

5.3—As many European projects deal with "Science & technology" for "Cultural heritage", why not create and maintain a European "portal of portals" like CoOL (Conservation on Line) (http://palimpsest.stanford.edu), operated by Stanford University?

6) Other miscellaneous suggestions, without any priority order:

a) Possibility of establishing a privileged access route, for example through CH beam allocation panels, as a useful first step.

b) Possibility to establish a network of RI researchers that are familiar with the various techniques, and could be used as first contacts.

c) One should consider together and on an equal footing:

– Access to classical large size RIs.

– Access to clusters of portable instrumentation.

d) The techniques available in the RIs must be more widely disseminated (*e.g.*, with dedicated training courses).

e) Attempt to interest producers of materials in use in the cultural heritage area: pigments, dyes, colours, paper, glass, ceramics, stones, precious metals, wood, leather, textiles. . . .

f) Interest in associating instrumentation manufacturers (radiation detectors, optical sensors, spectroscopy equipment) and laboratories developing dedicated software (spectroscopy, mapping software).

g) Idea of an itinerant temporary exhibit with the Sciences & Techniques Museums: Deutsches Museum—München (http://www.deutsches-museum.de), Istituto e Museo di Storia della Scienza—Firenze (http://galileo.imss.firenze.it/indice.html), Musée des Arts et Metiers—Paris (http://www.arts-et-metiers.net), National Museum of Science & Industry—London (http://www.nmsi.ac.uk), Museum of History of Science—Oxford (http://www.mhs.ox.ac.uk), Museum Boerhaave—Leiden (http://www.museumboerhaave.nl), Cosmo-Caixa—Barcelona (http://portal1.lacaixa.es/Docs/Chan/99/1-99-10-00000001.html?dest=1-99-10-00000000) . . . .

h) Lasers devoted to restoration: it is important that one or more laboratories are labelled as "central nodes" for training purposes and as repositories of relevant expertise.

i) Possibility of co-operation with IAEA.

Presently, 2 projects based on use of nuclear techniques for the benefit of cultural heritage are conducted by IAEA:

– Nuclear techniques for the protection of Cultural Heritage artefacts in the Mediterranean Region (RER/1/006).

– Applications of nuclear analytical techniques to investigate the authenticity of art objects (CRP).

j) Possibility of co-operation with UNESCO.

By similarity with the memorandum of agreement signed between UNESCO (World Cultural Heritage) and ESA on space applications for heritage conservation, one could imagine a similar protocol between UNESCO and the European RIs. (http://portal.unesco.org/ci/en/ev.php-URL_ID=11543&URL_DO=DO_TOPIC&URL_SECTION=201.html& http://www.esa.int/esaEO/SEMKZ9WO4HD_index_0.html)