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Comparative analysis of textile metal threads from liturgical vestments and folk costumes in Croatia

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ABSTRACT

Textile is essential for everyday life in all societies. It is used in clothes for protection and warmth but also to indicate class and position, show wealth and social status. Threads from precious metals have also been used in combination with fibres for decoration in order to create luxury fabrics for secular and religious elites.

We performed elemental analysis of 17th to 20th century metal threads from various textile articles of liturgical vestments and festive folk costumes collected in the museums of northern, southern and central Croatian regions.

In order to determine elemental concentrations in threads we performed comparative X-ray Spectroscopy measurements using: (i) Scanning Electron Microscopy with Energy Dispersive X-ray Spectroscopy (SEM-EDX) at the Faculty of Textile Technology, (ii) X-ray Fluorescence Spectroscopy (XRF) at the Croatian Conservation Institute and (iii) Particle Induced X-ray Spectroscopy (PIXE) at the Ruđer Bošković Institute Tandem Accelerator Facility using ion micro beam. Rutherford Backscattering Spectroscopy (RBS) was performed as well on selected samples. SEM-EDX investigations of cross-sections along with the surfaces were also performed.

In this work we report and discuss the results obtained by the three X-ray methods and RBS for major (gold, silver, copper) and minor elements on different threads like stripes, wires and “srma” (metal thread wrapped around textile yarn).

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1. Introduction

Metal threads are part of the historical Croatian textiles of great value, used usually for decoration of festive folk costumes and liturgical vestments (Fig. 1). Textiles containing metal threads are inevitable items of cultural, social and religious life, representing something festive, expensive and worth of respect [1]. Primarily, metal threads have been abundant and frequently used on liturgical vestments, giving all the splendour and grandeur to the clothes, worn during the celebration of the holy Mass. Metal threads were also used in the Croatian festive folk costumes worn for the special ceremonial occasions, such as the uniform for the “Sinjska Alka”, an equestrian competition inscribed in the UNESCO Intangible Cultural Heritage list in 2010.

Historically, metal threads were primarily made of gold, silver or copper alloys, but recently aluminium is mostly used. Aluminium has silver shine that can replace and imitate silver and after a special procedure can even get a gold colour [2,3].

The oldest metal threads were narrow stripes, cut from a hammered foil and directly incorporated in textile (Fig. 2a). Later on the technology evolved to production of combined textile metallic yarns and metal wires. Combined textile metallic yarn was made of metal stripes or just one spiral wrapped around the textile yarn, which represent the core, called “srma” (Fig. 2b). This increased flexibility and even allowed different applicability. Metal wires with circular cross section were produced by drawing a metal rod through progressively smaller holes (Fig. 2c) [4–6]. All the three types of metal threads analysed in this study are from various Croatian museums from all regions and include different textile items such as liturgical vestments and folk costumes.

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Fig. 1. Historical textile from which some samples of metal threads were taken: a) Folk costume (apron), Osijek, beginning of the 20th century; b) Liturgical vestment (antependium), Novigrad, 19th century.

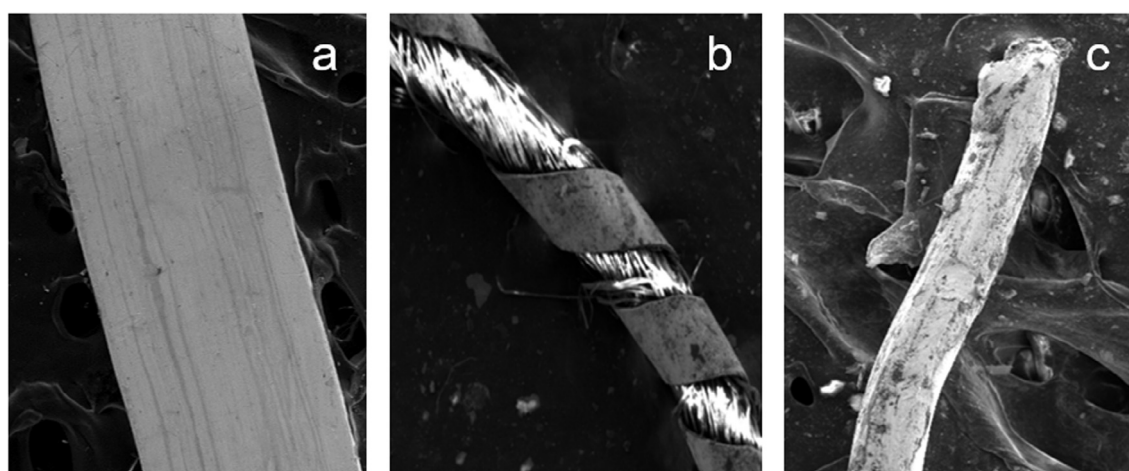


Fig. 2. Backscatter images of three different types of the metal threads investigated by SEM-EDX: a) narrow stripes; b) combined textile metallic yarn ("srma"); c) metal wire.

The study is focused on elemental analysis of the collected samples using X-ray Spectroscopy techniques: (i) Scanning Electron Microscopy with Energy Dispersive X-ray Spectroscopy (SEM-EDX) [6–8], (ii) X-ray Fluorescence Spectroscopy (XRF) [9–11] and (iii) Particle Induced X-ray Spectroscopy (PIXE) [12,13], together with Rutherford Backscattering Spectroscopy (RBS). These X-ray Spectroscopy techniques are very common for elemental analysis of cultural heritage samples, while RBS can give additional complementary information on the layered structure of such materials. The result of this study could provide valuable information about the ancient manufacturing techniques and appropriate treatment for cleaning and conservation [3,9,14,15].

2. Experimental

2.1. Material and methods

Forty samples of the metal threads from historical textiles, liturgical vestment and folk costumes were analysed. Samples taken out of the liturgical vestments are from the area of Dalmatia, Central Croatia and North-West Croatia, and folk costumes from the area of Dalmatia and East Croatia. The oldest samples, from 17th and 18th century, are from liturgical vestments of the treasure of the Zagreb Cathedral. Croatian festive folk costumes, such as those related to the "Sinjska Alka", are from the 19th and 20th century [1]. Sampling was performed with special permission of restorers and

conservators, their supervision and cooperation in such way that the valuable historic textile is not damaged.

SEM-EDX analysis was performed at the Faculty of Textile Technology using Tescan MIRA Field Emission (FE) SEM, with the operating voltage 20 kV and working distance 25 mm. The spectra were acquired by Bruker Quantax EDX system with XFlash[®] SDD detector capable to detect elements from boron to uranium. For each sample surface analysis was performed at several points and the average concentrations have been reported. Samples were also measured at cross sections, in which case several points were selected at the central part of each cross section and again the average concentrations have been reported.

XRF measurements were performed at the Croatian Conservation Institute using Artax spectrometer, manufactured by Bruker and equipped with an Rh anode X-ray tube. The voltage used was 50 kV, electron beam current intensity of 0.7 mA, with a collimated X-ray beam of 0.6 mm. X-rays were detected by the XFlash[®] SDD detector, capable to detect elements from potassium to uranium.

PIXE measurements were performed at the Ruđer Bošković Institute ion microprobe facility, which is described in detail elsewhere [16]. The 1 MV Tandetron accelerator provided 2 MeV proton beam which was focused by a triplet magnetic quadrupole lens system to a 2 μm spot size and raster scanned over selected sample areas. A rectangular or squared scan patterns were used with a different size (between $100 \times 100 \mu\text{m}^2$ and $1.3 \times 1.3 \text{mm}^2$) and a variable number of pixels (up to 128×128). PIXE spectra

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