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Fluorescent Technique for Macroscopic Detection of Electrical Metallization

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Summary. A fluorescence method for the detection of trace metals was investigated to visualize in situ latent current marks or electrical metallic traces on cloth. The main electrodes metallization (iron, copper, zinc, aluminum, nickel, chromium, and brass) can be identified by spraying a 0.2% solution of 8-hydroxyquinoline in ethanol followed by observation under shortwave UV light. Advantages and disadvantages of this technique are compared with previously described methods.

Key words: Current mark, detection of metallization – Metallization, detection in latent current marks – Trace metal detection technique

Zusammenfassung. Es wird über die Entdeckung von Metallspuren mittels Fluoreszenz berichtet, wodurch in situ latente Strommarken oder Metallspuren auf Kleidern sichtbar gemacht werden. Die häufigste Elektrodenmetallisation (Eisen, Kupfer, Zink, Aluminium, Chrom, Nickel und Messing) kann durch Besprühen von 0,2% 8-Hydroxyquinolin in Isopropanol, oder besser in Ethanol, dargestellt werden. Vor- und Nachteile dieser Technik gegenüber den vorhergehenden Methoden werden diskutiert.

Schlüsselwörter: Strommarke, Metallisation – Metallisation, Darstellung bei unsichtbaren Strommarken – Metallspurendarstellung

Recently, we proposed the macroscopic detection of "electrical" metallization (M) to reveal latent current marks (LCM) (Pierucci and Danesino 1980). By spraying the skin with multiple revelation systems, we succeeded in directly demonstrating the metals most frequently involved in electrocution: iron, copper, zinc, aluminum, chromium, nickel, and brass.

We used the following two alternative sequences (solutions: w/v): (a) 10% ammonium sulfide—H_2O—0.2% solochromocyanine in 1% HCl or (b) 0.5% 2 nitroso-l-naphtol in acetone—H_2O—0.2% solochromocyanine in 1% HCl.

We found electrical metallization on clothes or shoes if these were interposed between electrodes and skin.

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In this paper we show the results of investigations employing a fluorescent trace metal detection technique (TMDT).

Materials and Methods

Electrical applications were experimentally made on the wet skin of many corpses. Sometimes, cloth was interposed between the electrodes and the skin. Latent current marks were produced by means of a device described previously (Pierucci and Danesino 1980). The experimental conditions used were: alternating current, 220 V; frequency 50 Hz; exposure periods 0.2–0.3 s.

The electrodes (cross-section: 6 mm, with the exception of brass electrodes which were 14 mm), made of pure metals or alloys (iron, copper, zinc, aluminum, nickel, chromium, and brass), were applied in pairs and held close to the skin manually, with as constant a pressure as possible (Pierucci and Danesino 1980).

Thermal lesions were also studied, and they were obtained by contact with hot objects made of the metals and alloys mentioned above.

Preliminary observations under short-wave (254 nm) and long-wave (366 nm) UV light were carried out on the electrically treated skin or cloth and on thermal lesions.

Both electrical and thermal metallizations were studied by spraying the skin and cloth with 0.2% solution of 8-hydroxyquinoline in ethanol or in isopropanol (Stevens and Messler 1974). Then, skin and cloth were washed with 80% ethanol or isopropanol, respectively. Any reaction was observed under both day and UV light (254 nm and 366 nm).

The fluorescent technique was tested after use of multiple revelation systems, too (see above).

We tried also to develop fluorescent reaction on filter paper (Whatman No. 1), holding the paper close to the skin.

After using the fluorescent technique for LCM, skin specimens were submitted to histological-histochemical examination (both ethanol-fixed paraffin and cryostat fresh sections; "blank" sections, H & E, Garvin sequence according to Danesino (1978), M investigation by means of specific histochemical reactions (Pearse 1972).

Results

Preliminary observations under both short- and long-wave UV light of thermal injuries and of the electrically treated skin or cloth, revealed no significant reactions. Nonspecific fluorescent particles are often previously removed by washing with 50% ethanol.

After spraying the skin and cloth with 0.2% solution of 8-hydroxiquinoline in ethanol, both electrical and thermal metallization are easily revealed. Sometimes, traces of iron and chromium are evident also under daylight in the form of weakly black spots. When viewed under UV light (254 nm wave length), areas of metallization either emit fluorescent colors, or yield a quenching of the yellow background fluorescence and appear in the form of dark purplish-black spots. Among the investigated metals or alloys, zinc, aluminum, and sometimes brass emit positive fluorescence. Lead traces are sometimes present in site of plaster application. Iron, copper, chromium, nickel, and sometimes brass cause a quenching of the background fluorescence. By washing with 80% ethanol we can remove eventual surplus of background fluorescence as well as fluorescence of metal particles possibly soiling the skin.

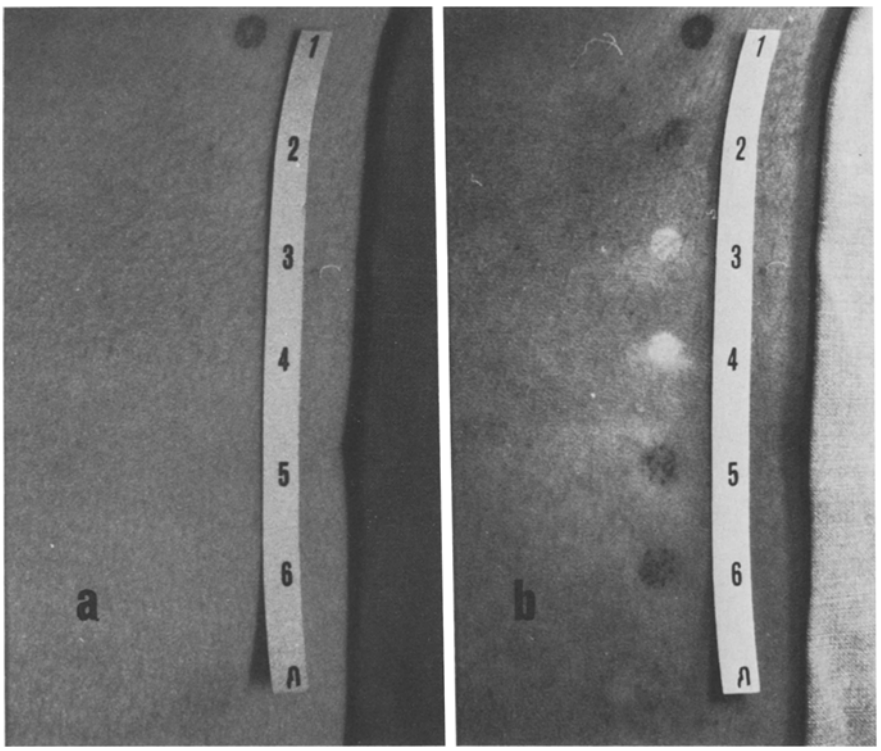

Fig. 1 a, b. Detection of metallization in latent current marks by means of 8-hydroxyquinoline 0.2% in ethanol. **a** Observation under day and **b** short-wave UV light. *1 = iron; 2 = copper; 3 = zinc; 4 = aluminum; 5 = nickel; 6 = chromium; 0 = brass*

Metallization fluorescent reaction can be developed on filter paper; however, it is difficult and unsuitable to hold the paper close to the skin, particularly to the hands.

Electrical metallization fluorescence does not always appear "target"-shaped, and only rarely so in case of positive emission; therefore, it is difficult to differentiate between electrical and thermal injuries by this method.

After negative results (Pierucci and Danesino 1980) of multiple revelation systems (ammonium sulfide; 2.nitroso.1.naphtol; etc.), the fluorescent method sometimes reacts positively.

Histologically, "blank" cryostat fresh sections generally show weak epidermic fluorescence under UV light, whereas the fluorescence is negative in paraffin sections. Metal-specific histochemical reactions (Pearse 1972) are usually negative or faintly positive in paraffin and in fresh sections.

Discussion

Experimental results proved the fluorescent technique to be suitable for macroscopic detection of electrical metallization in the LCM. We used in particular 0.2%

solution of 8-hydroxyquinoline in alcohol as one of the trace metal detection reagents. It is known that the 8-hydroxyquinoline undergoes a chelating reaction with various metallic ions present on the skin surface to form oxinate complexes, and these under UV light either emit positive fluorescence or cause a quenching of background fluorescence (Stevens and Messler 1974).

By spraying the 8-hydroxyquinoline reagent on suspected skin surface or on cloth, and observing under short-wave UV light (254 nm), we can immediately reveal the main electrodes metallization: iron, copper, zinc, aluminum, chromium, nickel, and brass. Sometimes iron and nickel are evident under day light, too. Among not directly investigated but occasionally tested metals, we also noted lead traces by this method.

The fluorescent technique proved to be a very sensitive device to demonstrate electrical metallization and hence LCM (Böhm 1967; Pierucci and Danesino 1980). The macroscopic evidence of metallization is obviously a likely sign of probability (Pierucci and Danesino 1980). In addition, electrical metallization does not always result characteristically "target"-shaped (Böhm 1967) from this method. The certain diagnosis will in any case be performed by means of successive, usual investigations.

Fluorescent MTDT is very simple and thus useful for common practice. Disadvantages are the necessity of using UV light and a dark room. It is true that metallization-fluorescent reaction can be developed on filter paper, but this device is complex and unsuitable. Metal-specific histochemical behavior on skin specimens is negatively influenced by previous fluorescence reaction: the reaction products are moderately soluble in the reagent.

The fluorescent TMDT results extremely advantageous on cloth, especially if dark, as in this case usual reactions are not evident.

Other trace metal detection reagents, such as ferrozine (Goldman and Thornton 1976) or pyridyldipheniltriazine (Thornton and Stoney 1977), would be tested in the next experimental trials in this kind of investigation.

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