

Assessment of chromium(VI) release from 848 jewellery items by use of a diphenylcarbazine spot test

David Bregnbak¹, Jeanne D. Johansen¹, Dathan Hamann², Carsten R. Hamann³, Curtis Hamann⁴, Radoslaw Spiewak⁵, Torkil Menné¹, Claus Zachariae¹, Morten S. Jellesen⁶ and Jacob P. Thyssen¹

¹Department of Dermato-Allergology, Copenhagen University Hospital Gentofte, University of Copenhagen, Hellerup 2900, Denmark, ²Division of Dermatology, Department of Internal Medicine, The Ohio State University, Columbus 43221, OH, USA, ³Department of Internal Medicine, Loma Linda University, Loma Linda 92350, CA, USA, ⁴Contact Dermatitis Institute, Phoenix 85008, AZ, USA, ⁵Department of Experimental Dermatology and Cosmetology, Jagiellonian University Medical College, Krakow 31-008, Poland, and ⁶Department of Mechanical Engineering, Materials and Surface Engineering, Technical University of Denmark, Lyngby 2800, Denmark

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We recently evaluated and validated a diphenylcarbazine (DPC)-based screening spot test that can detect the release of chromium(VI) ions (≥ 0.5 ppm) from various metallic items and leather goods (1). We then screened a selection of metal screws, leather shoes, and gloves, as well as 50 earrings, and identified chromium(VI) release from one earring. In the present study, we used the DPC spot test

to assess chromium(VI) release in a much larger sample of jewellery items ($n = 848$), 160 (19%) of which had previously been shown to contain chromium when analysed with X-ray fluorescence spectroscopy (2).

Materials and Methods

A sample of 848 jewellery items were examined for chromium(VI) release with the DPC spot test (Table 1). In brief, the samples came from market surveys performed to detect nickel and cobalt release. In total, 307 items were purchased in Copenhagen, Denmark between December 2008 and March 2009 (166 earrings, 15 bracelets, 15 rings, and 111 hair clasps), 188 earrings were purchased in Warsaw, Poland in January 2010, 203 earrings were purchased in London, United Kingdom in January 2010, and 150 earrings and other items of body-piercing

Correspondence: David Bregnbak, Department of Dermatology, Gentofte Hospital, Kildegårdsvej 28, Opgang 15, DK-2900, Hellerup, Denmark. Tel: +45 39773755; Fax: +45 39 777 118. E-mail: david.kaspar.bregnbak@regionh.dk

Conflicts of interest: D. Hamann and C. R. Hamann are the sons of C. Hamann, owner and CEO of SmartPractice, which manufactures and sells patch test products and spot tests. The remaining authors have no conflict of interest to declare.

Table 1. Jewellery samples and chromium content (2)

Country of purchase	Total number of jewellery samples n	Jewellery items containing chromium when examined with X-ray fluorescence spectroscopy % (n)	Jewellery items with a chromium content above 10.5%, indicating the alloy to be stainless steel % (n)
UK	203	18.7 (38)	71.1 (27)
Poland	188	14.9 (28)	64.3 (18)
Denmark	307	13.0 (40)	62.5 (25)
Japan	150	36.0 (54)	92.6 (50)
Total	848	18.9 (160)	75.0 (120)

jewellery were purchased in Tokyo and Hiroshima, Japan between June 2010 and October 2012 (2). A DPC-based chromium spot test was prepared as previously described in detail (1). The jewellery was examined with a white cotton stick soaked in the premade DPC solution and rubbed firmly for 30 seconds against the parts of the jewellery that, during normal wear, would come into direct skin contact. A final reading of each spot test was performed after 2 min, and a reddish–purple colour reaction on the cotton stick indicated chromium(VI) release from the tested object (≥ 0.5 ppm) (1).

Results

DPC spot testing showed no results consistent with chromium(VI) release above 0.5 ppm in 848 jewellery items, 19% of which had been previously shown to contain chromium (2).

Discussion

This study showed that none of 848 jewellery items released chromium(VI) in amounts that could elicit a positive DPC spot test reaction. We have now DPC spot tested a total of 898 pieces of jewellery, and have so far found only one item that released chromium(VI) [prevalence estimate 0.1% (95%CI: 0.0–0.62%)].

Our findings indicate that jewellery, including jewellery containing chromium, in general, does not pose a significant risk for chromium(VI) release exceeding 0.5 ppm. Importantly, Hansen et al. (3) showed that 4 of 18 patients reacted to 2 ppm chromium(VI), but estimated that even 1 ppm chromium(VI) could elicit dermatitis in 10% of chromium-allergic patients. However, Basketter et al., in a comprehensive review article, concluded that household and other consumer products should not contain > 5 ppm

of chromium, but that, for an even greater degree of protection, the ultimate target level should be 1 ppm (4). The DPC spot test detects chromium(VI) release at 0.5 ppm, and we therefore submit that it can help clinicians to rapidly screen and reliably identify chromium exposure sources that may be problematic for even the very sensitive chromium-allergic patient. Importantly, although chromium(III) release must also be taken into consideration in the risk assessment of jewellery, it is not detected by the DPC spot test.

Chromium is widely used as an alloy element in stainless steel, in which the weight percentage of chromium is at least 10.5 (5). This composition gives a passivating film on the surface, preventing oxidation and thereby the release of chromium. More than 95% of the tested jewellery items did not contain chromium or had a minimum chromium content of 10.5%, consistent with stainless steel (Table 1). This may explain the many negative DPC spot test results. Besides jewellery, the surfaces of many metal products are chromated to prevent corrosion, to prevent surface oxidation, or to provide a particular surface appearance. Allergic contact dermatitis caused by metallic items containing chromium, notably mobile phones, has been reported (5–7).

In conclusion, jewellery rarely releases chromium(VI) in amounts that are detectable by the DPC spot test. As we found no false-positive test reactions, we conclude that the DPC spot test has high specificity, but acknowledge that there is a need for further studies using several more advanced methods with much higher sensitivity.

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