

Nickel release from tools on the Swedish market

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Nickel allergy in women has been thoroughly studied: its prevalence, the most important sources of sensitization, and risk factors for elicitation of dermatitis. Preventive measures have also been introduced. Nickel allergy in men has not, however, been equally focused on. Based on clinical experience, some publications indicating that tools may be a risk factor for nickel allergy and hand eczema in men, and the fact that large occupational groups regularly use tools, we decided to carry out a study, of the prevalence on the market of tools that release nickel. 27% of 565 hand-held tools with metal parts that come into contact with the skin were found to be dimethylglyoxime (DMG) test positive. Release of nickel and other metals into artificial sweat and composition of metals on the surface and in the base alloy were also studied. It is suggested that tool producers should consider nickel allergy and avoid nickel-releasing materials, and that analytical methods, relevant for nickel release from tools, should be further developed.

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While nickel allergy in men is increasing, very little is known about its prevalence, clinical picture, or risk factors for sensitization and for elicitation of allergic contact dermatitis. Nickel allergy is often blamed on the practice of piercing the ears and other parts of the body, and the focus has generally been on nickel allergy in women. Epidemiological studies of the general population have shown that at least 10% of women and 1–2% of men are allergic to nickel (1, 2). Few epidemiological studies focusing on nickel allergy in men, however, have been published. Car mechanics were shown to have a high prevalence of hand eczema (15%) compared to men in the general population (9%) (3, 4). Car mechanics were also shown to have a high prevalence of nickel allergy (8%) (3). Publications on occupational nickel dermatitis have been reviewed (5). Better identification of the environmental risk factors for nickel allergy and associated contact dermatitis in men would be of interest.

Many people, mainly men, use tools both in their jobs and in their leisure hours. In our department, we have found that among male patients who generally have hand eczema, 8% are nickel sensitive and that they often have jobs involving the use of tools. Some of their equipment releases nickel (6). No information is available on the market concerning nickel release from tools, nickel

content or other aspects of interest concerning contact allergy to metals or other substances.

The present aims were to study the prevalence on the market of tools that release nickel, and the level of such nickel release. We also wished to give the National Chemicals Inspectorate, on behalf of which the study was conducted, bases for estimating how far hand-held tools may imply a risk of allergic contact dermatitis, and possible preventive measures.

Materials and Methods

Selection of tools on the market

After a survey of the tool market, 5 of the largest retailers and 1 wholesaler in the Stockholm area were selected for the study. They were: stores for the building sector; for the engineering industry and for electronics; an ironmongery for professionals as well as for handymen; a shop and mail-order company for private persons, and a hairdressers' wholesaler. Tools intended for laboratory use, foodstuff handling, restaurants, medical and dental care, gardening, and the textile industry were not included.

The tools were sampled on visits to the shops. Unused hand-held non-powered tools with metal parts that come into prolonged or repeated contact

with the skin during normal use were selected. The aim was to examine as many as possible of the most frequently sold products and trademarks. Experienced shop assistants were helpful in explaining how some of the tools were used and giving figures on trade.

Data, whenever available, were recorded concerning material, trademark, country of origin, product number and price. Each tool was classified (Table 1) on the basis of the terminology used in the largest tool retailers' product catalogues.

Chemical analysis

Dimethylglyoxime test. The dimethylglyoxime (DMG) test (7) was carried out in the shops to detect nickel release from tools. Parts expected to come into prolonged or repeated contact with the skin in normal use were tested. In some instances, more than 1 part of a tool was tested. A total of 774 spots in 565 tools were tested.

The test solutions were DMG in ethanol 0.8% and ammonia 25%, prepared by the pharmacy. 1–2 drops of each solution were placed on a cotton-wool-tipped stick, which was rubbed for up to 30 s on the object to be tested. The result was recorded and classified as negative (no colour), positive (pink colour) or doubtful (discoloration, not possible to classify). The positives were divided into + (weak pink within 30 s); ++ (strong pink within 30 s) and +++ (strong pink within few s).

Metal release in artificial sweat

The method developed by CEN/TC 283/WG 4 in the preparation of a control standard for the EU Nickel Directive "Reference test method for release of nickel" was used (8–10). The release of nickel and certain other metals from items stored in artificial sweat was analysed.

Tools were selected from among those tested with the DMG test to represent weak, strong,

negative and doubtful reactions. The size of the tools was also considered, for practical reasons. 26 tools and a total of 30 parts were analysed.

The artificial sweat consisted of deionized and aerated water containing sodium chloride 0.5% m/m, lactic acid 0.1% m/m and urea 0.1% m/m. Ammonia was used to adjust the pH to 6.5. The solution was used within 3 h of preparation.

Each tool was placed in a glass or plastic vessel. Tools composed of different parts were dismantled and the parts were treated separately. 10–150 ml artificial sweat was added, to cover the whole or part of the tool. The vessels were closed with lid or para film and stored in an oven at 30°C for 1 week. At the end of the release period, each tool was removed from its vessel and rinsed with 100 μ l deionized water which was added to the solution. Nitric acid (0.4 ml 25%) was added to the solution to prevent deposition of dissolved metals on the surface of test vessels. The area of the tool in contact with the solution (sample area) was calculated.

Metals in the synthetic sweat after the release procedure, nickel, chromium, cobalt and vanadium, were analysed by inductively coupled plasma detection (ICP). The reporting limit was 0.05 mg/l for nickel, 0.03 for chromium, 0.05 for cobalt and 0.01 for vanadium. The release of each metal was calculated and was expressed as μ g/cm²/week. The reporting limit for metal release per area depended on the size of the sample area in relation to artificial sweat volume, and for nickel it was 0.05 μ g/cm²/week.

The metal release procedure was carried out in our laboratory. The chemical analysis was carried out by Analytica AB, Täby.

Metal content

Nickel, chromium, cobalt and vanadium were analysed semiquantitatively by energy dispersive X-ray fluorescence spectroscopy (EDAX). 10 tools were analysed. Each was placed in the spectroscope and the composition of elements on the surface was analysed. The depth of the surface analysis was approximately 10 μ m. The base alloy was analysed in a 0.5 mm deep drilled hole. Elements at levels higher than 0.1–0.2% were detected. The small sampling areas were then sealed with lacquer. The analysis was carried out before the tools were placed in artificial sweat for the release study (above). The analysis was carried out by Analytica AB, Täby.

Results

DMG test

The results of the DMG test are shown in Table 1. 774 spots were tested in 565 tools. Of the tools

Table 1. Results of the dimethylglyoxime (DMG) test on 565 hand-held tools

Tool type	No. tested tools	DMG test-positive tools	
		no.	(%)
cutting tools	63	24	38
pliers	59	20	34
measuring tools	30	10	33
spanners	147	43	29
clamping tools	30	8	27
striking tools	16	4	25
screwdrivers	199	42	21
hand saws	21	3	14
all tools	565	154	27

tested, 154 (27%) had a positive DMG test. Single test results only were doubtful, due to discoloration. Tools of the same appearance and from the same producer in some cases gave different DMG test results, and many of these had been produced in different countries. This was particularly common among the 1-piece non-adjustable spanners, different parts of which sometimes gave different DMG reactions.

Nickel release in artificial sweat

The results of analysing nickel release from 30 different samples are shown in Table 2. 21 of the 30 samples showed a nickel release above $0.5 \mu\text{g}/\text{cm}^2/\text{week}$, and 8 a release below this value. The highest value was from a bit holder (no. 12) with a nickel release of $56 \mu\text{g}/\text{cm}^2/\text{week}$. There was good correspondence between the nickel release (above or be-

Table 2. Results of DMG test; analysis of release in artificial sweat (by ICP), and of content on the surface and in the base alloy (by EDAX) of nickel, chromium, cobalt and vanadium in 30 samples from 26 tools; only concentrations above the reporting limit are given; no cobalt was detected

Sample no.	Tool type	DMG test result	Metal analysis			
			element	release ($\mu\text{g}/\text{cm}^2/\text{w}$)	on surface (% of all detected elements)	in base alloy (% of all detected elements)
1	multipurpose pliers	+	Ni	0.12	n.a.	n.a.
2	ring spanner	++	Ni	2.6	48.8	
			Cr		50.8	0.6
3	ring spanner	—	Ni	2.1	n.a.	n.a.
4	offset spanner	?	Ni	12	61.2	
			Cr		38.6	0.5
5	offset spanner	—	Ni	7.0	79.8	0.6
			Cr		19.3	0.6
7	single-slot screwdriver	+++	Ni	4.8	n.a.	n.a.
			Cr	0.38		
			V	0.04		
8a	measuring tape	+	Ni	3.8	n.a.	n.a.
8b	measuring tape	+	Ni	4.2	n.a.	n.a.
9a	glass cutter	—	Ni	0.49	n.a.	n.a.
9b	glass cutter	++	Ni	3.0	n.a.	n.a.
9c	glass cutter	+++	Ni	0.91	n.a.	n.a.
11	bit holder	—	Ni			0.3
			Cr		0.9	1.1
12	bit holder	+++	Ni	56	95.9	16.7
			Cr			0.6
13	bit holder	+++	Ni	1.4	n.a.	n.a.
14	electronic screwdriver	+	Ni	5.6	n.a.	n.a.
15	socket wrench	++	Ni	0.24	n.a.	n.a.
16	socket wrench	?	Ni	0.11	n.a.	n.a.
			Cr	0.08		
18	bits	?	Cr			0.2
			V	0.3		
19	Phillips screwdriver	+	Ni	31	n.a.	n.a.
21	hex key	+	Ni	0.81	n.a.	n.a.
			Cr	0.15		
22	hair scissors (stainless)	—	Ni	0.45		0.5
			Cr	28	20.7	13.7
			V	0.08		
23	magnetic bit holder	+	Ni	5.7	n.a.	n.a.
			Cr	0.02		
25	hex key	++	Ni	3.1	n.a.	n.a.
			Cr	0.04		
28	tweezers	++	Ni	1.4	n.a.	n.a.
30	nail scissors	+	Ni	1.4	n.a.	n.a.
31	hair scissors	++	Ni	11	98.4	0.8
			Cr	0.13		
33	tooth thinning scissors	++	Ni	5.2	n.a.	n.a.
34	lock-grip pliers	+++	Ni	2.9	94.8	0.8
35b	precision screwdriver, wheel	+	Ni	6.6	n.a.	n.a.
35c	precision screwdriver, holder	+	Ni	3.2	97.4	1.5
			Cr	0.08		

DMG test result: +, ++, +++=positive; ?=doubtful; n.a.=tool not analysed by EDAX.

Table 3. Nickel release in artificial sweat compared with the result of DMG test in hand-held tools

DMG test result	Nickel release		
	range ($\mu\text{g}/\text{cm}^2/\text{week}$)	<0.5 ($\mu\text{g}/\text{cm}^2/\text{week}$) (no.)	>0.5 ($\mu\text{g}/\text{cm}^2/\text{week}$) (no.)
positive ($n=21$)	0.12–56	3	18
negative ($n=8$)	0.11–12 ^a	5	3 ^a

^a 2 objects included which possibly had uneven distribution of nickel on the surface.

low 0.5 $\mu\text{g}/\text{cm}^2/\text{week}$) in artificial sweat and the result of the DMG test (positive or negative) (Table 3). When the strength of the DMG test reaction (+, ++, +++) was compared with the value of the nickel release the correspondence was not as good. Many tools were corroded during the procedure, and some became rusty after only 24 h in the artificial sweat.

Release of other metals

Analysis results for the release of chromium, cobalt and vanadium from the same 30 samples are also shown in Table 2. Chromium was detected in 8 samples (no. 7, 16, 21, 22, 23, 25, 31 and 35c). Cobalt was not detected in any sample. Vanadium was detected in 3 samples (no. 7, 18 and 22).

Metal content

The results of the analysis of elements on the surface and in the base alloy of the 10 tools or tool parts analysed with EDAX are shown in Table 2.

Discussion

One quarter of hand-held tools with metal parts that come into contact with the skin were DMG test positive on these parts (Table 1). These tools may elicit allergic contact dermatitis in people already nickel-sensitive, and present a risk factor for induction of nickel allergy.

No relevant information concerning nickel release, nickel content, composition of the alloys and coatings was available, either from catalogues, markings on the tools, producers or retailers (11). On the contrary, the sparse information given was often misleading or false. Basic information concerning producer or country of origin was not always available.

Different DMG test results were seen in specimens of the same product that had been produced in different countries. According to 1 producer, this may be due to different composition or quality variations from plant to plant (G Gezelius, Sandvik Saws and Tools, Sweden, personal communication). Where a different DMG test result was obtained in different parts of the same tool, the ex-

planation might be uneven surface treatment by plating or lacquering. It was not possible to draw any conclusion concerning possible relationship between price and DMG test result (11). The analysis of metals in the artificial sweat, on the surfaces and in the base alloys showed that the tools in the present study were made of a broad spectrum of compositions (Table 2). These factors all make it difficult for patients, workers and buyers to avoid nickel-releasing tools.

For a rough estimate of how many persons are using hand-held tools in their jobs during a substantial part of the day, statistics from the Population and Housing Census 1990 were used (11, 12). 23 occupational groups were classified as tool users. On the basis of the classification, it was calculated that approximately 560 000 workers were regularly using hand-held tools in their jobs, which represents 12% of the total work force in Sweden (4.5 million of the 8.6 million inhabitants). The largest groups were toolmakers, machine tool setters and operators; machinery fitters; machine assemblers and engine mechanics; electrical fitters and wiremen; construction carpenters, and building caretakers, all with a male predominance. Hairdressers and beauticians were the only groups with female predominance, and electrical and electronics workers had equal sex distribution.

Tool production and trade represent large economic turnovers. The products most frequently sold are screwdrivers, spanners and knives (R Karm, Svensk Handel, personal communication, 13). The market is highly international: 44% of the tools in the present study were produced in Europe, 20% in the Americas, 10% in Asia and 26% were of unknown origin (11).

Allergy has not previously been considered when designing tools. We suggest that tool producers should consider nickel allergy and avoid nickel-releasing materials for their products. Methods for analysing nickel release from tools should be further developed. They should take into account surface wear, since tools may have a very long lifetime. The DMG test is quick, simple and cheap; limitations, however, are that only very small areas are tested, and altered surface due to wear is not considered (14). Analysis of nickel release from tools in artificial sweat is complicated, slow and

expensive, but it may be used as a reference method (9). Practical difficulties, however, arise when dealing with large tools. The wear and corrosion test developed for the nickel directive (15) is suitable for jewellery, etc, but its suitability for iron-rich and large tools is doubtful.

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