

Prevention of Nickel Release with Barrier Coatings

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Background: Allergic contact dermatitis from nickel is very common in the United States. A barrier coating to be used on personal items such as snaps or watches would be of great use in preventing the consequences of nickel allergy.

Objective: To evaluate various barrier coatings and their ability to yield a negative dimethylglyoxime (DMG) test result.

Methods: Four different barrier coatings were assessed prior to soaking in saline, after soaking in saline for 2 days, and after soaking in saline for 7 days.

Results: Depending on the number of coatings and the time soaked in saline, the different barriers showed different efficacies in yielding a negative DMG test result.

Conclusions: Nickel Guard and Beauty Secrets Hardener were most effective in yielding a negative DMG test result. Beauty Secrets Hardener was the more cost-effective choice.

NICKEL is one of the most common allergens, and it affects at least 5.8% of the general population of the United States.¹ In addition, the North American Contact Dermatitis Group found 16.7% of patch-test clinic patients to be allergic to nickel in 2001 and 2002.² In this allergic population, nickel produces a classic delayed hypersensitivity, or type IV, immunologic reaction. The threshold for eliciting a reaction to nickel varies; amounts as low as 0.01% (0.47 µg) can produce a reaction in extremely sensitive patients.³

The European Union Nickel Directive of 1994 mandated that any products that come into direct and prolonged contact with the skin (earrings, watches, zippers, snaps, etc) may not release more nickel than 0.5 µg/cm² per week. The European Union also declared that the concentration of nickel in post assemblies used after ear piercing may not exceed 0.05%.⁴ However, the United States has yet to make such an initiative, even though the Nickel Directive has been proven to reduce nickel allergy.^{5,6} For this reason, it is important to have methods available to prevent allergic contact dermatitis when nickel-containing products cannot be avoided.

One such method is coating nickel-containing objects such as earrings, snaps, buttons, and watches with a substance that will act as a barrier and prevent nickel from contacting the skin. Certain readily available substances such as cyanoacrylate and clear nail polish may have the ability to effectively do this.^{7,8} After coating, the presence of nickel at

the surface of the object can be tested for with the dimethylglyoxime (DMG) test, which detects nickel in excess of 10 µg.^{9,10} Because the threshold for most patients to develop allergic contact dermatitis from nickel is in excess of 10 µg, this is a very useful test for indicating the presence of clinically relevant amounts of nickel.¹¹ The purpose of this investigation was to determine what substance most effectively coats nickel coins, thereby yielding the ability to prevent allergic contact dermatitis from nickel.

Materials and Methods

In this study, twenty US nickel coins were tested with 1% DMG obtained from Chemotechnique Diagnostics (Vellinge, Sweden) to confirm the presence of nickel. As expected, all twenty nickels reacted positively because a US nickel contains 25% nickel and 75% copper. The nickels were then separated into four groups of five. To each group, a different coating was assigned, including Orly Nail Lacquer (a clear nail polish) (Los Angeles, CA), Beauty Secrets Hardener (a clear nail polish) (Dallas, TX), Kuan Yo Superglue Liquid (cyanoacrylate) (Taipei, Taiwan), and Nickel Guard (a product marketed to coat items to prevent nickel allergy) (Athena Allergy Inc., Huntersville, NC). The ingredients of the clear nail polishes are listed in Table 1; the ingredients of Nickel Guard are proprietary.

In each group, the indicated substance was used to give the nickels one to five coats. Each coat was allowed to completely dry before the next coat was applied. After all the nickels were allowed to dry adequately, the DMG test was used to ascertain the presence of nickel at the surface.

After testing for the presence of nickel, the nickel coins were submerged in a normal saline (0.9% sodium

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Table 1. Ingredients of Clear Nail Polishes

<i>Orly Nail Lacquer</i>		
<i>Ingredients</i>	<i>Other Ingredients That May Be Present</i>	<i>Beauty Secrets Hardener Ingredients</i>
Toluene	Acrylates copolymer	Butyl acetate
Butyl acetate	Adipic acid/neopentyl glycol/trimellitic anhydride copolymer	Ethyl acetate
Ethyl acetate	Alcohol (denatured)	Nitrocellulose
Nitrocellulose	Bismuth oxychloride	Phthalic anhydride/trimellitic anhydride/glycols copolymer
Tosylamide/formaldehyde resin	Black iron oxide	Isopropyl alcohol
Isopropyl alcohol	Blue 1	Camphor
Trimethyl pentanayl diisobutyrate	Citric acid	D & C violet 2
Triphenyl phosphate	Dibutyl adipate	Acetyl tributyl citrate
Camphor	Ethyl tosylamide	
Stearalkonium bentonite	<i>Equiselum arvense</i> (horsetail) extract	
Stearalkonium hectorite	Ferric ammonium ferrocyanide	
Benzophenone-1	Guanine	
	Mica	
	<i>Panax</i> (ginseng root) extract	
	Phthalic anhydride/trimellitic anhydride/glycols copolymer	
	Polyvinyl butyral	
	Red iron oxide	
	Red 6	
	Red 7	
	Red 30	
	Red 34	
	Silica	
	Styrene acrylates copolymer	
	Sucrose acetate isobutyrate	
	Titanium dioxide	
	Violet 2	
	Yellow 5	

chloride) solution at room temperature, a procedure meant to mimic exposure to body sweat and other fluids. After 2 days, the nickels were examined and were once again tested with DMG. The nickels were then resubmerged in normal saline and were given a final examination and testing after an additional 5 days (7 days total).

Results

When the coins were coated with Orly Nail Lacquer, Beauty Secrets Hardener, Kuan Yo Superglue Liquid, or Nickel Guard, all numbers of coats were equally effective in

preventing nickel from reaching the surface, according to the DMG test (Table 2).

After the nickels had been soaked in normal saline for 2 days, the Orly Nail Lacquer peeled off of the nickels that had three, four, and five coats, thereby leading to positive DMG test results (Fig 1). Nickels with one or two coats still had negative DMG test results. The nickels coated with Beauty Secrets Hardener and Nickel Guard all remained DMG negative. However, the coatings on the coins with three, four, or five coats of Beauty Secrets Hardener and five coats of Nickel Guard took on a cloudy appearance after being soaked in the saline. After soaking for 2 days, all the nickels coated with Kuan Yo Superglue Liquid were

Table 2. Results of Dimethylglyoxime Tests

Coating No.	Barrier Coating											
	Orly Nail Lacquer			Beauty Secrets Hardener			Kuan Yo Superglue Liquid			Nickel Guard		
	0 Days	2 Days	7 Days	0 Days	2 Days	7 Days	0 Days	2 Days	7 Days	0 Days	2 Days	7 Days
0	+	+	+	+	+	+	+	+	+	+	+	+
1	—	—	—	—	—	—	—	+	+	—	—	—
2	—	—	+	—	—	—	—	—	+	—	—	—
3	—	+	+	—	—	—	—	—	+	—	—	—
4	—	+	+	—	—	+	—	—	+	—	—	—
5	—	+	+	—	—	—	—	—	—	—	—	—

+ = positive results; — = negative results.

DMG negative, except for the nickel coated only once, which was DMG positive (see Table 2).

After soaking for 5 more days (7 days total), several more of the nickels became DMG positive. In addition to the nickels covered with three, four, or five coats of Orly Nail Lacquer, the nickel with two coats became DMG positive after the nail polish peeled off. Only the nickel with one coat of Orly Nail Lacquer remained DMG negative. All of the nickels coated with Nickel Guard and Beauty Secrets Hardener continued to yield negative test results with DMG, except for the coin that had been coated four times with Beauty Secrets Hardener. The polish did not peel off of this nickel as the Orly Nail Lacquer had done; rather, a small crack formed in the coating that allowed the DMG to penetrate and react with the coin's surface. Finally, the nickels coated with one, two, three, or four layers of Kuan Yo Superglue Liquid had a positive

reaction to the DMG test. Only the nickel coated five times with Kuan Yo Superglue Liquid remained unreactive (see Table 2).

Discussion

When it is impossible to completely avoid watches, snaps, and other items that contain nickel, an alternative for allergic individuals is to coat the object with a substance that will prevent nickel from coming in contact with the skin. This coating must also have a smaller chance of causing allergic contact dermatitis than nickel would. In this study, nickel coins were coated with Orly Nail Lacquer, Beauty Secrets Hardener, Kuan Yo Superglue Liquid, and Nickel Guard. All of these substances equally prevented nickel from reaching the surface after the coins were initially coated. However, after being soaked in saline, the Orly Nail Lacquer had a propensity to peel off, rendering it an ineffective barrier. Therefore, the Orly Nail Lacquer should not be used in situations where the coated item would come into contact with body sweat or be submersed in other liquids.

Although the Kuan Yo Superglue Liquid did not peel off, submersion in saline tended to readily yield positive DMG test results unless five coatings were applied. Because it would be very cumbersome to apply five or more coats of Kuan Yo Superglue Liquid to an object, this would be an inconvenient way to coat items. The Kuan Yo Superglue Liquid was also very sticky, took a long time to dry between coats, and generally did not seem to be well suited for coating personal items such as jewelry.

Tosylamide/formaldehyde resin is the most commonly used polymer in nail polish, and the North American Contact Dermatitis Group found that 1.5% of their patch test clinic patients were allergic to this resin.¹² It is



Figure 1. When nickels coated with three, four, or five coatings of Orly Nail Lacquer were soaked in saline for 2 days, the coatings peeled off of the nickels.

Table 3. Barrier Coating Cost Comparison

<i>Barrier Coating</i>	<i>Price per Milliliter (\$US)</i>
Orly Nail Lacquer	0.29
Beauty Secrets Hardener	0.22
Kuan Yo Superglue Liquid	0.48
Nickel Guard	1.80

important that a substance that is used to cover up nickel-containing items be free of any common allergens, such as tosylamide/formaldehyde resin, so that allergic contact dermatitis from the protective coating does not result. Both Beauty Secrets Hardener and Nickel Guard are free of tosylamide/formaldehyde resin.

After exposure to the saline, both the Beauty Secrets Hardener and Nickel Guard seemed to have a similar ability to effectively coat nickels. However, Nickel Guard is marketed for the purpose of preventing nickel allergy and is much more expensive than clear nail polish. Table 3 compares the prices per milliliter for each barrier coating used in this study. Overall, it is more cost effective to buy an inexpensive clear nail polish that is free of tosylamide/formaldehyde resin, such as Beauty Secrets Hardener. This barrier coating is successful in preventing exposure to nickel and thus allergic contact dermatitis with the testing methods from this study.

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