

Is there a good *in vivo* method to show whether gloves are sufficiently protective when a nail technician is exposed to (meth)acrylates? An *in vivo* pilot study

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We report a case of a non-atopic, 37-year-old nail technician who developed blisters, itching, scaling, and redness, that is, allergic contact dermatitis (ACD), on the hands and fingers owing to sensitization to methacrylates and acrylates, in this article called (meth)acrylates, only months after finishing her trainee period. The protective effect of gloves was studied in an *in vivo* system simulating a nail technician's work exposure to (meth)acrylates.

Case Report

The patient was initially tested with the baseline series of our department (Chemotechnique Diagnostics, Vellinge, Sweden) and an acrylate series consisting of seven (meth)acrylates (Table 1) and her own seven nail gels containing (meth)acrylates. Four gels (A–D) were quite new to the patient, whereas three gels (E–G) had been used more often previously. A material safety data sheet was only found for Acrylate Crystal Nails® builder clear gel (B) and Acrylate Crystal Nails® xtreme white gel (D), two of the four gels (A–D) that the patient had continued to work with after the first patch test session. Both contained polyurethane acrylate oligomer; in D it was specified as di-HEMA trimethylhexyl dicarbamate (INCI name; 80–90%) and in B as polyurethane acrylate oligomer (75–85%). In addition, B also contained isobornyl methacrylate 15–25% and D contained hydroxypropyl methacrylate 1–10% (Table 1). Three gels (E–G) that were initially patch tested were discarded by the patient prior to the open chamber test.

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Table 1. Patch test results on D4 and D7 from testing the acrylic series (nos. 1–7) and the patient's own nail acrylic gels (A–G)

Test substance	Concentration (%)	D4	D7
1. 2-Hydroxyethyl methacrylate	2.0	+	++
2. Bis-GMA	2.0	–	–
3. Triethylene glycol diacrylate	0.1	++	+++
4. 2-Hydroxypropyl methacrylate	2.0	(+)	+
5. 1,4-Butanediol diacrylate	0.1	+	+
6. Ethylene glycol dimethacrylate	2.0	–	–
7. Ethyl cyanoacrylate	10.0	–	–
A. Acrylate Crystal nails xtreme titanium gel	0.1	(+)	+
B. Acrylate crystal nails builder clear gel	0.1	++	++
C. Acrylate crystal nails cover pink gel	0.1	–	–
D. Acrylate crystal nails xtreme white gel*	0.1	+	+
E. Acrylate white gel	0.1	++	++
F. Acrylate master ultraviolet gel	0.1	–	–
G. Acrylate good nails soak off gel	0.1	+	+

All substances/products were diluted in petrolatum.

Bis-GMA, bisphenol A glycerolate dimethacrylate.

*Contains hydroxypropyl methacrylate.

Finn Chambers® (diameter, 8 mm) (SmartPractice, Phoenix, AZ, USA) on Scanpor® tape (Norgesplaster, Vennesla, Norway) were used for the patch testing. Twenty milligrams of each petrolatum test preparation was placed in each chamber (1). The tests were applied on the patient's upper back, and left under occlusion for 48 h. Readings were performed on day (D) 4 and D7, and scored according to the guidelines of the ICDRG. The patient did not react to any of the tested substances in the baseline series (Table 1).

The patient's work as a nail technician was studied by visiting her workplace, a beauty salon in the city of Malmö, Sweden. We observed her working, and special attention was given to the amount of time

Table 2. Gloves tested in the study.

Glove	Gloves (commercial name)	Manufacturer (supplier)	Thickness (mm)*	Material
a	Ansell Touch N Tuff Nitrile black®	Ansell	0.12	Nitrile
b	Ansell Touch N Tuff Nitrile green®	Ansell	0.09	Nitrile
c	Ansell Touch N Tuff Dermashield Neoprene green®	Ansell	0.08	Neoprene/polychloroprene
Negative control	Ansell Barrier White (corresponding to 4H®)	Ansell	0.04	Polyethylene and ethylene-vinyl alcohol

Data are according to the manufacturer/supplier, with the exception of thickness on the palm of gloves, which was measured at our laboratory.

*Mean value of three measurements.

spent on different tasks when she was building nails on a customer. The protective measures used by the nail technician in her work were also studied, as was possible unintentional exposure or contamination of her skin.

The tested gloves, manufactured by Ansell Healthcare (Iselin, NJ, USA), were made from nitrile and neoprene, and obtained from Procurator (Malmö, Sweden). They were selected because they were delicate enough for performance of a nail technician's work while being worn and still offered sufficient protection (Table 2). For each glove, the thickness at the palm was measured with a micrometer screw-gauge.

An open chamber system has been developed at the Department of Occupational and Environmental Dermatology in Malmö (2–5) for testing the protective efficacies of different glove materials against chemicals. In the present case report, the open chamber model was used to investigate the *in vivo* protection of three gloves against (meth)acrylate-containing nail cosmetics used in nail building. Two gels that the patient used most often and that caused the strongest patch test reactivity at the regular patch testing were chosen for the penetration test, namely Acrylate Crystal Nails® builder clear gel (B) and Acrylate Crystal Nails® xtreme white gel (D).

A group of three circular chambers (12 mm in height; 12 mm in inner diameter) made of chemical-resistant stainless steel were fitted in a 1-mm thick flexible support made from polymethyl methacrylate. Rectangular pieces of each glove, cut from the palm, were fixed to the chambers with a nickel-free metal clip, thus constituting the bottom of the chamber. The glove material thus acted as a membrane between the chamber and the skin. The patient lay horizontally on a bed, and the testing system was taped onto the skin of the back with Scanpor® tape. The bottom of the chamber was filled with either one of the two patient's own (meth)acrylate products 'as is', that is, undiluted (Fig. 1).

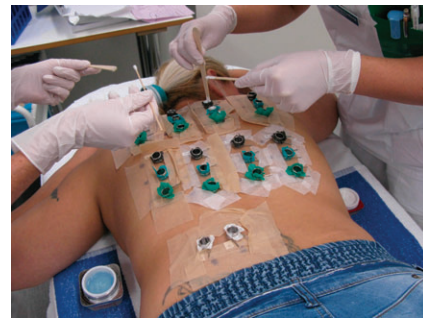


Fig. 1. The chambers applied to the back with tape and with the gloves attached as a membrane between the gel and the skin. Each glove material was tested at four exposure times (15, 30, 45 and 60 min). The negative control was tested for 60 min. Gel A was tested on the left side and gel B on the right side. Left side: row 1 – glove a (Ansell Touch N Tuff Nitrile black®); row 2 – glove b (Ansell Touch N Tuff Nitrile green®); row 3 – glove c (Ansell Touch N Tuff Dermashield Neoprene green®). Right side: row 1 – glove a (Ansell Touch N Tuff Nitrile black®); row 2 – glove b (Ansell Touch N Tuff Nitrile green®); row 3 – glove c (Ansell Touch N Tuff Dermashield Neoprene green®). Left side lower: negative control (Ansell Barrier White) gel A and gel B.

Four exposure times were used. Fifteen, 30, 45 and 60 min were chosen to mimic the range of time that ordinary nail building procedures can take. Three different gloves were tested at the same time on the back of the patient at four exposure times. The Ansell Barrier white, corresponding to the 4H® glove (North Safety Products by Honeywell, Smithfield, RI, USA), is made of layers of polyethylene and ethylene-vinyl alcohol, and was used as a negative control for a period of 60 min because of its known resistance against many chemicals (3).

After removal of the testing devices at four different exposure times, a clinical examination of the skin corresponding to the glove test application area was performed to detect the presence of shining gel as a sign of penetration of the acrylic gel through the gloves. The integrity of the pieces of glove tested and the possible presence of

breakage were checked by cleaning of the glove material and visual examination.

Readings of the areas were performed on D3 and D6.

At patch testing, the patient reacted to several (meth)acrylates and to five of her own seven gels (Table 1). She also reacted to one component of gel D, that is, hydroxypropyl methacrylate. We did not see any signs of shining gel on the back after the chambers were taken off, and nor did we detect any breakage of any of the gloves. We observed no positive skin reactions either on D3 or on D6 in the open chamber test on any of the test sites when we used (i) Acrylate Crystal Nails® builder clear gel (B) and Acrylate Crystal Nails® xtreme white gel (D), employing the four gloves (Table 2), and (ii) after 15, 30, 45 and 60 min of exposure.

Discussion

This patient was allergic to several (meth)acrylates, and also to five of her seven tested commercial nail building gels containing (meth)acrylates, even diluted to 0.1% in pet. ACD is an occupational hazard for nail technicians. Their lesions tend to be more widespread than in customers, involving the fingers, hands, and wrists, and often the face, eyelids, and neck (6). Once a nail technician is sensitized and has developed ACD because of exposure to (meth)acrylates, it is difficult to achieve satisfactory protection from these monomers in the occupational setting, especially as protective gloves have previously been shown to offer insufficient protection, as acrylic monomers can penetrate delicate rubber gloves. Thicker gloves could offer the desired protection, but are often difficult to wear during performance of the fine work that building nails requires (7).

To diminish the risk of occupational sensitization, protective measures must be taken. One such measure is to always use protective gloves. Which type of protective glove to choose depends on the types of chemical used and the exposure time. The protective glove should not only offer protection but should also enable work tasks to be performed in a convenient way (8). The protective efficacy of gloves can be influenced by factors such as occlusion, sweating, stretching, and skin temperature.

The open chamber test has been used previously to examine the protective efficacy of gloves against dental acrylates (3, 4). It has also been used to investigate which gloves protect from *p*-phenylenediamine-based hair dyes (5). One drawback is that only a few gloves and only one or two products can be tested at one time, owing to the area that the devices cover on the back (Fig. 1). Moreover,

a session of testing with the open chamber system takes ~2.5 h, including the time needed to prepare and to clean the chambers. Furthermore, one might argue that the back is not as sensitive as the fingertips or fingers of a patient. However, for practical reasons, the back is used, as using the chambers on the fingertips would be impossible. We tested the two gels that the patient used at the time of the test and that had given the strongest patch test reactions at the initial patch testing. Consideration could be given to comparing the open chamber test with an open application test, with a glove between the product to be investigated and the skin.

Another way to examine the protective efficacy of gloves is by using permeation tests with the single (meth)acrylate. One such standard test is the American Society for Testing and Materials standard ASTM F 739-96 ANSI 105-200, a standard test method for determining the resistance of protective clothing materials to permeation by liquids or gases under conditions of continuous contact. The results from these tests may differ from those of an open test, such as we have used, with a commercial product containing all of the ingredients that the patient is exposed to and at the same time.

The open chamber system used for testing the protective efficacies *in vivo* of three different gloves with four exposure times, that is, 15, 30, 45 and 60 min, in this patient provided useful information on which gloves she could use without risking any adverse reactions from her acrylic nail cosmetics. In this test, good protection was achieved with all gloves, and the protection was comparable to that achieved with the Ansell Barrier White glove used as a negative control. As there were no differences in the protective efficacy of the gloves tested, she could have used any of them. However, she was advised to use one of the thinnest gloves, Ansell Touch N Tuff Nitrile green (0.09 mm in thickness), because we thought that this would be the most versatile glove for use in nail building work. She was also informed about the risk of contaminating her skin when changing gloves. Her working desk also constitutes a potential hazard, as this area is easily contaminated by fine dust when the acrylic nails are being sanded, or by the acrylic gel. She was advised to change her workplace pad frequently, and always when she suspected contamination. An effective exhaust in her working area would also be beneficial.

We tried to contact the patient several times by sending letters and making telephone calls to determine whether the proposed gloves were sufficient in real work procedures, but unfortunately she was lost to follow-up.

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