

Several cases of undesirable effects caused by methacrylate ultraviolet-curing nail polish for non-professional use

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Summary

Background. Ultraviolet (UV)-curing nail polishes based on acrylates or methacrylates are currently also available for non-professional use. The Swedish Medical Products Agency recently prohibited one brand of UV-curing polish, because several consumers reported undesirable effects after using it.

Objectives. To investigate whether consumers with undesirable effects after using the UV-curing nail polish that was later prohibited were contact allergic to the polish and its individual ingredients.

Materials/Methods. Eight patients who had reported severe skin reactions after the use of the UV-curing polish were patch tested with two coatings of the nail polish and its ingredients at five dermatology departments in Sweden.

Results. All patients tested except one showed contact allergic reactions to one or several of the acrylate-based or methacrylate-based ingredients in the nail polish.

Conclusions. The non-professional use of UV-curing nail polishes poses a risk of sensitization from acrylates and methacrylates.

Key words: 2-HEMA; acrylate; contact allergy; methacrylate; undesirable effect; UV nail polish.

Acrylate-based and methacrylate-based polymers have been used for artificial nails since the 1950s (1, 2). At first, self-curing acrylates containing methyl methacrylate were used, but mixtures cured with ultraviolet (UV) light are now preferred. Several reports have been published regarding contact dermatitis caused by artificial nails. Both nail technicians and their customers

are affected (3–6). A recent report has shown that the frequency of allergic contact dermatitis caused by (meth)acrylates is increasing, both in acrylate nail users and in nail technicians building artificial nails (7).

Recently, a new type of acrylate-based nail cosmetic has been introduced. Nail polishes containing UV-curing methacrylates have been presented as an alternative to common nail polishes. These products are marketed as more durable and long-lasting than conventional nail polishes. The methacrylate-containing nail polishes are applied directly to the nail plate in several layers, with a brush. Between the applications, each layer is cured with UV light. At first, these types of nail polish were only offered by professional nail technicians in beauty salons, but, recently, different kits for home use have appeared on the market. A starter kit typically contains transparent

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base and top coats, a light-emitting diode (LED) lamp emitting UV light, and, sometimes, some coloured coats. The first cases of contact allergy caused by these types of product, which were introduced around 2010, have been reported recently (8, 9). Here, we present the results of patch testing 8 persons reporting undesirable effects when using starter kits of one brand sold on the Swedish market up until July 2014. The starter kit was thereafter prohibited by the Swedish Medical Products Agency (MPA), which is the competent authority for cosmetics. Undesirable effects concerning cosmetics can be reported to the MPA, both by consumers and by healthcare professionals. When the undesirable effects are serious, the MPA is obliged to communicate these reports to the other competent authorities in the EU (10).

Materials and Methods

Consumers who have reported undesirable effects after using UV-curing nail polishes in the starter kit were asked to participate in patch testing for further investigation of possible allergic reactions to the product and its components. Six subjects with the above-described inclusion pathway were patch tested at the dermatology departments in Borås, Karlskrona, Malmö, Stockholm, and Uppsala. Another 2 patients in Malmö (nos. 4 and 5, Table 1) were identified when they were investigated for hand eczema.

Patch testing was performed with a screening series (Table 1) containing the ingredients of the polishes, which were kindly provided by the manufacturer. Colour pigments were not tested. In addition, two complete coatings, one base coat and one coloured coat, were diluted to appropriate test concentrations and patch tested together with the separate ingredients. If a patient showed positive reactions to one or several of the individual ingredients at the first patch test reading, dilution series (five concentrations, decreasing by a factor of square root of 10) of the positive compounds were tested to assess the strength of contact allergy. All patch test preparations in the screening series were diluted in petrolatum (APL, Stockholm, Sweden). For the dilution series, the ingredients were diluted in acetone (Merck, Darmstadt, Germany). Patch test preparations were prepared at the Department of Occupational and Environmental Dermatology in Malmö. All patch testing was performed with IQ Ultra™ chambers (Chemotechnique Diagnostics, Vellinge, Sweden). For pet. preparations, ~25 mg was applied, and for liquid preparations, 20 µl was applied with a micropipette. Reading of the screening series was performed on day (D) 3 or D4 and on D7. For practical reasons, dilutions were, in most cases, read only on D3/D4.

Results

The results from patch testing with the screening series, dilutions of individual ingredients and the products are shown in Table 1. All positive patch test reactions were caused by acrylate-based ingredients (Fig. 1).

Discussion

During 2014, 65 reports concerning undesirable effects from the use of UV-curing nail polish of the same brand were received by the MPA. One case was reported by the manufacturer, the others by consumers who had been alerted by mass media about the possibility of reporting undesirable effects to the MPA. The most commonly reported problem was eczema starting around the nails (Fig. 2), combined with itching and pain in the fingers. Several customers also reported onycholysis, lesions under the nail plate, or paronychia. Permanent nail damage with thin, brittle nails was also described. In some cases, eczema on other parts of the body, for example on the lips, on the throat, and around the eyes, were reported, indicating that the nail polish had not been completely cured by the provided UV LED lamp. Eight cases were assessed as involving serious undesirable effects (11), as the consumers were on sick leave, and 1 of them was hospitalized. A nail technician was, after a long period of sick leave, forced to close down her business and change profession. The time between the first application of the product and the onset of symptoms varied between 2 and 12 months (average ~5.5 months) in the consumer reports. According to the producer, the nail polish should last for approximately 2–3 weeks, meaning that the average consumer has applied the nail polish ~10 times, provided that the product has been used continuously.

On patch testing, it was found that all tested patients except 1 (patient no. 8, Table 1) had contact allergy to one or several of the acrylate or methacrylate ingredients of the nail polish. Six patients reacted to the product (base coat and top coat). Patient no. 8 did not react to any of the tested ingredients or the UV-curing nail polish. She had also used conventional, non-acrylate nail polish from the same manufacturer intermittently, and might be allergic to some ingredient in that polish. However, she was not patch tested with her own conventional nail polish. As the onset of her hand eczema coincided with the use of the UV-curing nail polish in the starter kit described here, she was patch tested only with individual ingredients of that kit.

Both acrylates and methacrylates are well-known contact allergens. Six patients reacted to the small monomer 2-hydroxyethylmethacrylate (2-HEMA), but reactions were also obtained for the larger and more

Table 1. Results of patch testing with screening series and dilutions

	City		Borås		Malmö				Karlskrona		Stockholm			
	Patient no		2		3				6		7			
	D3/D4	D7	D3/D4	D7	D3/D4	D7 ^a	D3/D4	D7	D3/D4	D7	D3/D4	D7	D3	D7
Sex and age	Female, 15 years		Female, 24 years		Female, 41 years				Female, 25 years		Female, 31 years			
Reading day	D3/D4	D7	D3/D4	D7	D3/D4	D7 ^a	D3/D4	D7	D3/D4	D7	D3/D4	D7	D3	D7
Screening series														
Di-HEMA trimethylhexylcarbamate, 2% pet. (CAS no. 72869-86-4/41137-60-4)	++	IR	+	+	+	+	+	+	?	+	+++	++	?	+
Bis-trimethylbenzoyl phenylphosphine oxide, 1% pet. (CAS no. 162881-26-7)	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Urethane acrylates, 0.1% pet. (CAS no. 152187-46-7)	++	++	-	-	+	+	+	+	?	+	+++	+++	-	-
2-HEMA, 2% pet. (CAS no. 868-77-9)	++	++	-	-	+	++	++	++	?	+	+++	+++	-	-
Hydroxycyclohexyl phenyl ketone, 5% pet. (CAS no. 947-19-3)	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Base coat, 1% pet.	+++	++	-	-	++	++	++	++	++	+	+++	+++	-	-
Coloured coat, 1% pet	+++	++	-	-	++	++	++	++	++	+	+++	+++	-	-
Dilution series														
Di-HEMA-trimethylhexyl dicarbamate, 0.63% acetone	-	?	-	ND	-	+	NT	NT	-	-	-	ND	NT	NT
Di-HEMA-trimethylhexyl dicarbamate, 0.2% acetone	-	-	-	ND	-	-	NT	NT	-	-	-	ND	NT	NT
Di-HEMA-trimethylhexyl dicarbamate, 0.063% acetone	-	-	-	ND	-	-	NT	NT	-	-	-	ND	NT	NT
Di-HEMA-trimethylhexyl dicarbamate, 0.02% acetone	-	-	-	ND	-	-	NT	NT	-	-	-	ND	NT	NT
Di-HEMA-trimethylhexyl dicarbamate, 0.0063% acetone	-	-	-	ND	-	-	NT	NT	-	-	-	ND	NT	NT
Urethane acrylates, 0.031% acetone	+	?	NT	NT	?	++	NT	NT	-	-	+	ND	NT	NT
Urethane acrylates, 0.01% acetone	+	?	NT	NT	-	?	NT	NT	-	-	-	ND	NT	NT
Urethane acrylates, 0.0031% acetone	?	-	NT	NT	-	?	NT	NT	-	-	-	ND	NT	NT
Urethane acrylates, 0.001% acetone	-	-	NT	NT	-	-	NT	NT	-	-	-	ND	NT	NT
Urethane acrylates, 0.00031% acetone	-	-	NT	NT	-	-	NT	NT	-	-	-	ND	NT	NT
2-HEMA, 0.63% acetone	++	+	NT	NT	++	++	NT	NT	?	+	?	ND	NT	NT
2-HEMA, 0.2% acetone	+	+	NT	NT	++	++	NT	NT	-	-	-	ND	NT	NT
2-HEMA, 0.063% acetone	+	?	NT	NT	?	+	NT	NT	-	-	-	ND	NT	NT
2-HEMA, 0.02% acetone	?	?	NT	NT	-	?	NT	NT	-	-	-	ND	NT	NT
2-HEMA, 0.0063% acetone	-	-	NT	NT	-	-	NT	NT	-	-	-	ND	NT	NT

HEMA, hydroxyethylmethacrylate; 2-HEMA, 2-hydroxyethylmethacrylate; IR, irritant reaction; ND, not done; NT, not tested; ?+, doubtful reaction.

^aPatch test reading on D7 of dilution series based on photographs sent by the patients.

^bNot read, owing to topical corticosteroid treatment on the site of the test reaction on D3.

^cDiluted to 0.2% pet. Previous testing with 2-HEMA 2% pet. (Chemotechnique Diagnostics, Vellinge, Sweden) resulted in a strong positive reaction (+++).

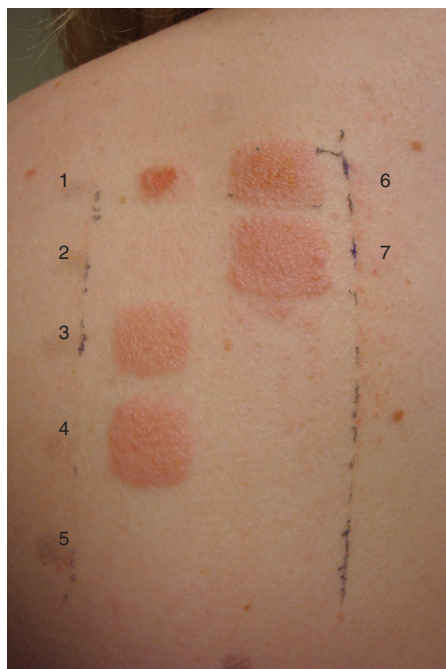


Fig. 1. Patch test with screening series for ultraviolet-curing nail polish; test reactions on D3. 1, di-HEMA-trimethylhexylcarbamate 2% pet., ++; 2, bis-trimethylbenzoyl phenylphosphine oxide 1% pet., –; 3, urethane acrylates 0.1% pet., ++; 4, 2-HEMA 2% pet., ++; 5, hydroxycyclohexyl phenyl ketone 5% pet., –; 6, base coat 1% pet., +++; 7, coloured coat 1% pet., +++.

polymerized acrylates di-hydroxyethylmethacrylate (HEMA)-trimethylhexylcarbamate and urethane acrylates. Di-HEMA-trimethylhexylcarbamate is defined by the producer as a mixture of two larger methacrylates, both containing the HEMA structure in the molecule. Urethane acrylates is a mixed isocyanate–acrylate polymer, containing hydroxyethyl acrylate. It is possible that 2-HEMA is the main sensitizer, and that the other reactions are cross-reactions resulting from the structural similarities. The purity of the (meth)acrylate-containing ingredients provided by the manufacturer and used for patch testing has not yet been further investigated, but previous studies have shown that acrylate mixtures may contain further acrylates as impurities (12). With yet lacking chemical analyses of the ingredients, another possibility is that the reactions to the other acrylate-containing ingredients were caused by 2-HEMA present as a contaminant. However, 1 patient reacted only to di-HEMA-trimethylhexylcarbamate, with a weak allergic reaction. Bis-trimethylbenzoyl phenylphosphine oxide, added as a photo-initiator for the acrylates, has been classified as a moderate skin sensitizer on the basis of the guinea-pig maximization test (13). None of the patients showed positive reactions to this substance or

to the other photo-initiator, hydroxycyclohexyl phenyl ketone.

The patients presented in this article represent just a few of the individuals who experienced undesirable effects from using this product. When the internet is searched for the specific product in combination with 'allergy', internet forums and personal websites can be found where several individuals describe their negative experiences with the product. It is likely that not all people have been aware of the possibility of reporting to the MPA. Therefore, the true number of affected consumers is unknown, but it is probably much higher than 65. For instance, patients nos. 4 and 5 (Table 1) in this study were referred to the Malmö department for other reasons, but, when their history was scrutinized, adverse reactions to this nail polish were suspected.

The use of acrylates in industry is controlled by work environment legislation in Sweden (14), because of the known risks associated with handling these types of substance. In material safety data sheets for acrylates and methacrylates, which should be provided for chemicals or mixtures used, risk phrases inform about the possibility of the compounds acting as skin sensitizers. Moreover, the Swedish Work Environment Authority obliges employers to offer health control before and during (upon suspicion of a related disease) long-term exposure to acrylates and methacrylates. In cosmetic products, on the other hand, the use of acrylates and methacrylates is currently not restricted (9), and neither has their safety been evaluated at a European level by the Scientific Committee on Consumer Safety (15). The UV-hardening nail polishes contain, more or less, the same types of chemical that are used industrially, but information about the risk of skin sensitization is much less obvious to the user of the nail polish. This specific product was marked with small text, which was not specially highlighted on the box: 'Warning, base coat, top coat. Avoid skin contact due to risk of allergy. Upon skin contact, immediately clean according to instructions in the manual'. In the manual, the customer is informed that nail polish should be removed from the skin with a nail polish remover solution before the polish is hardened with the UV LED lamp. If the nail polish is used according to the instructions, the first and third layers consist of applications of completely transparent coatings (base coat and top coat). It may be difficult to notice if these preparations have come into contact with the skin. Artificially built nails and UV-hardening nail polishes have previously only been available at professional nail salons, and application of acrylate-based products to the nails has been performed by trained nail technicians with (if properly educated) knowledge about the risks of the material used. When these types of product are



Fig. 2. Allergic contact dermatitis caused by ultraviolet-curing nail polish in one consumer that reported undesirable effects. A (left): right hand, B (right): left hand.

available for everyone to use, the risk of them being used more carelessly increases. The products may be bought and applied even by adolescents (such as our patients nos. 1 and 8), who may understand the possible risks even less. Several (meth)acrylates are used in other applications, and sensitization caused by this type of product may affect the future life of the patients, for example concerning choice of career or dental treatment, in which many different (meth)acrylates are used. In general, probably very few people who do not work with acrylate or methacrylate compounds professionally are aware of their very strong sensitizing potential. The concentration of acrylates and methacrylates in UV-curing polishes can be >90%.

In our opinion, consumers are at very high risk of contact sensitization when exposed to such strong sensitizers

as acrylates and methacrylates in cosmetic products. Even though this specific product was prohibited in Sweden, similar products still exist on the market. There will probably be an increase in the number of patients with acrylate or methacrylate contact allergy caused by UV-curing nail polishes in the near future. The Swedish sales ban of this product has been reported to the European Commission and to the other member states within the EU. The Commission has recently asked all member states for all relevant scientific information, and information on the use of acrylates and methacrylates, with the aim of performing a safety evaluation. Hopefully, these proposed measures will decrease the risk in the long term.

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