

CPD

Acrylates: new sources and new allergens

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Summary

Acrylates are synthetic thermoplastic resins used in a multitude of products, ranging from bone cement to artificial nails. They represent an important and increasing cause of both occupational and nonoccupational allergic contact dermatitis. Isobornyl acrylate, an acrylic monomer found within ultraviolet-cured inks, adhesives and various medical devices for diabetes, has emerged as an important sensitizer. In addition, long-lasting nail products have played a significant role in the increased prevalence of acrylate allergy. Sensitized individuals classically present with facial or eyelid dermatitis, and some patients experience associated fingertip and nail changes. This manuscript reviews these two important sources of acrylate allergy and summarizes other potential new exposures, including surgical glues and wound-care products.

Introduction

Acrylates, methacrylates and cyanoacrylates constitute a large group of synthetic thermoplastic resins with well-known potential for causing allergic contact dermatitis (ACD).¹ Contact allergy secondary to acrylates may occur following exposure to a variety of products, and emerging sources and novel nail techniques have created an upsurge of nonoccupational acrylate allergy.² This review presents an overview of acrylates, with a focus on relevant new sources and related new allergens.

Brief history

German chemists first described the process of acrylate polymerization in 1877.³ Polymerization occurs through the combination of chemically reactive monomers – acrylic acid, methacrylic acid, or cyanoacrylic

acid (Fig. 1) – with their corresponding esters, either spontaneously or following exposure to ultraviolet (UV) light.^{4,5} The products of this reaction are thermoplastic resins that are mouldable at high temperatures and solidify once cooled. Rohm and Haas began production of the commercial acrylate, polymethylmethacrylate (PMMA), in 1931, and officially trademarked Plexiglas®, a lightweight, shatter-resistant, glass alternative, in 1933.^{3,6} Today, acrylates are ubiquitous (Table 1). Sources arise from varying chemical forms (Table 2).

Acrylate allergy

Stevenson reported the first case of acrylate allergy in 1941, in a patient with allergy to methyl methacrylate (MMA).⁷ Acrylate allergy has since been well-documented. In 2012, the American Contact Dermatitis Society (ACDS) named acrylates 'Contact Allergen of the Year' owing to their pervasive presence and potent sensitization potential.⁸

New acrylates: isobornyl acrylate

Isobornyl acrylate (IBOA) is a low molecular weight acrylic monomer used in various products, including UV- and electron beam-cured coatings, inks, plastics

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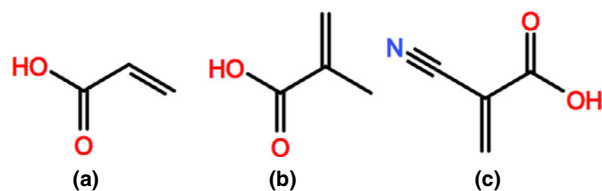


Figure 1 (a–c). Chemical structures of (a) acrylic acid, (b) methacrylic acid and (c) cyanoacrylic acid.

Table 1 Common sources of acrylate exposures.^{4,5,8}

Industrial products	Consumer products	Medical products
Adhesives	Intraocular contact lenses	Adhesives
Coatings	Cosmetics	Bone cement
Fibreglass	Eyelash glues	ECG leads
Glues	Disposable diapers	Epoxy resins
Insulators	Nail products	Dental prostheses, fillings
Lacquers	Sanitary pads	Glucose sensors
Paints	Spectacle frames	Hearing aids
Plastics		Insulin pumps
Printing inks		Surgical glues
Windshields, windowpanes		Wound dressings

Table 2 Examples of monofunctional, polyfunctional and cyanoacrylates.⁴

Monofunctional acrylates	Polyfunctional acrylates	Cyanoacrylates
Ethyl acrylate	Ethyleneglycol dimethacrylate	Ethyl-2-cyanoacrylate
Ethyl methacrylate	Diethyleneglycol dimethacrylate	Methyl-2-cyanoacrylate
Methyl methacrylate	Triethyleneglycol diacrylate	n-butyl-cyanoacrylate
2-hydroxyethyl acrylate	Triethyleneglycol dimethacrylate	2-octyl-cyanoacrylate
2-hydroxyethyl methacrylate	Trimethylol propane trimethacrylate	
2-hydroxypropyl acrylate	1,4-butanediol dimethacrylate	
2-hydroxypropyl methacrylate	1,6-hexanediol diacrylate	

and adhesives. Busschots *et al.* described the first cases of IBOA allergy in 1995, reporting patients with contact dermatitis and abscesses located around the injection site of two insulin pumps, where the UV-cured glue had diffused into the plastic of the infusion sets.⁹ Additional cases have demonstrated IBOA allergy secondary to various medical devices, such as continuous glucose monitoring devices and insulin pumps.¹⁰

These mounting reports have earned IBOA the title of ACDS 2020 'Contact Allergen of the Year'.¹¹ As of June 2019, IBOA 0.1% petrolatum was made available for commercial testing; irritant reactions have been demonstrated at higher concentrations of up to 0.3%.¹² Crossreactivity with other acrylates has not yet been reported.¹²

New sources of acrylate allergy: nail products

A number of nail products can cause acrylate allergy (Table 3).

Allergic contact dermatitis to nail acrylate

Classically, acrylate allergy due to nail exposure presents with a facial and/or eyelid rash, eczematous finger pulp fissuring (pulpitis), nail dystrophy and/or periungual dermatitis (Fig. 2).^{13,14} Pain and paraesthesia of the fingertips may occur, as acrylic monomers penetrate the nail plate and may damage sensory nerve fibres.¹⁵ Nail technicians may need to discontinue working, and sensitized patients may have complications with dental work.¹⁶

Acrylic nails

Acrylic nails consist of a liquid methacrylate monomer drawn through a powder methacrylate polymer, which is then sculpted onto the nail plate.¹⁷ Around 95% of polymerization occurs within the first 5–10 min and takes up to 48 h to complete.¹⁸ Allergy is caused primarily by acrylic monomers, as the fully cured polymers have little allergenic potential.⁸ In 1974, the US Food and Drug Administration banned the use of 100% MMA in cosmetic products.¹⁹ Most products now contain ethyl methacrylate, isobutyl methacrylate and/or tetrahydrofurfuryl methacrylate (THFMA).²⁰ MMA has been similarly restricted in the European Union, but is still widely available worldwide due to lack of enforcement and availability online.²¹

Gel nails

Gel nails have become popular in recent years. The application process entails using a primer coat and two to three coats of gel nail polish plus top coat, all cured under light [either UV or light-emitting diode (LED) source].¹⁸ Each layer consists of acrylic monomers that are polymerized via the curing process. Monomeric acrylates are similar to those used in

Table 3 Comparison of long-lasting nail products.

Nail product	Synonyms	Process	Duration, weeks	Light source
Acrylic nails	Porcelain nails	Liquid acrylic monomers are mixed with powder polymers and sculpted onto the nail plate	2–3	No
Gel nails	Gel nail polish Long-lasting nail polish Semipermanent nail polish	Gel polish consisting of acrylic monomers is painted onto the nail plate and cured with light	2	LED or UV
Nail wraps	Preformed nails	Decorative sheets are warmed and applied to the nail plate with cyanoacrylate-based adhesive backing or nail glue	1–2	No
Powder nails	Dipped nails	Cyanoacrylate-based nail glue is applied to the nail plate, dipped into polymer powder and hardened with a water-based activator	3–4	No
Press-on nails	Fake nails False nails Stick-on nails	False plastic nails are applied to the nail plate with cyanoacrylate-based nail glue	1–2	No

LED, light-emitting diode; UV, ultraviolet.

acrylic nails, with the exception of 2-hydroxyethyl methacrylate (2-HEMA), which is present only in gel nails.²² These nails last approximately 2 weeks, and removal involves soaking the fingertips in acetone for 20 min or using mechanical removal by a nail milling machine.²³ Shellac[®] (tradename for a synthetic product, not a natural resin) nails are a blend of gel and lacquer, which has a similar application and removal process.²⁴

Reports of allergy to gel and Shellac[®] nails have emerged, with the primary described allergens being 2-HEMA, 2-hydroxypropyl methacrylate (2-HPMA) and ethylene glycol dimethacrylate (EGDMA).²⁰ Patients may also rarely develop allergy to photoinitiators, including hydroxycyclohexyl phenylketone.²⁰ Home gel nail kits are now widely available and come with either a UV or LED light source. Consumers using these kits are at high risk of sensitization and light-related damage, owing to frequent reapplication rates and lack of

proper training (Fig. 3). Current recommendations include pretreatment application of a broad-spectrum sunscreen in conjunction with wearing an opaque cloth¹⁸ or UV-protective gloves. However, these gloves may become contaminated with acrylic monomers and increase exposure. Risk of sensitization and relapsing dermatitis may be mitigated by using appropriate light sources, completely curing the acrylic monomers and avoiding cutaneous contact with uncured polish.

Wraps and press-on nails

Nail wraps and press-on nails offer an inexpensive alternative to acrylic or gel nails. Nail wraps are decorative sheets of silk, linen, or fibreglass that are applied to the nail plate using an adhesive typically composed of cyanoacrylates.¹⁸ Templates are warmed and trimmed to accommodate the size and shape of the nail. As cyanoacrylates do not typically crossreact

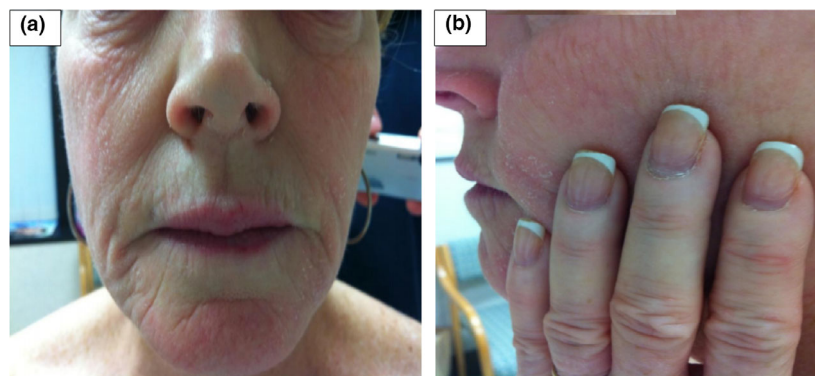


Figure 2 (a,b) Classic presentation of an acrylate allergy due to nail acrylate exposure: (a) facial dermatitis and (b) associated nail dystrophy.

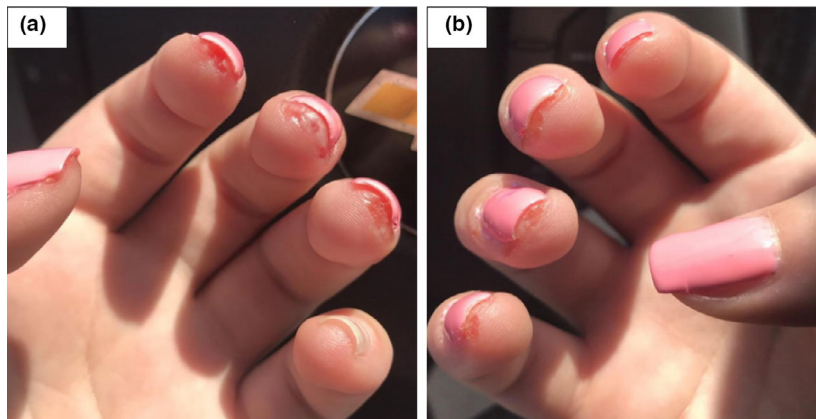


Figure 3 (a,b) Allergic contact dermatitis seen around the nail bed, following use of a home nail acrylate kit by the patient.

with acrylates or methacrylates,¹⁵ these products may represent a safer substitute for individuals with acrylate allergy. It should be noted, however, that cyanoacrylates may also lead to sensitization.²⁵ The prevalence of acrylate allergy associated with these products is not well-documented at this time.

Powder/dipped nails

Another acrylic-based nail technique is powder or dipped nails. The process involves applying a modified cyanoacrylate glue solution to the nail plate, then dipping the nails into clear or coloured acrylic polymer powder and hardening with a water-based activator.²⁴

Other new sources of acrylate allergy

Cyanoacrylates

Acrylate sensitization has been demonstrated secondary to ethyl cyanoacrylate glues for false eyelashes, Super Glue[®], Krazy[®] Glue (Fig. 4),⁴ industrial glues, anaerobic sealants and instant adhesives.²⁶ In the medical industry, 2-octyl and 2-butyl cyanoacrylate are used as wound sealants and do not reliably cross-react with ethyl cyanoacrylate. Multiple reports have documented contact sensitization secondary to Dermabond[®] (Ethicon[®], Edinburgh, UK) surgical glue containing 2-octyl cyanoacrylate (Fig. 5).^{27–29}

Dressings and wound-care products

Acrylates are also used in wound-care products for their absorptive properties and ability to preserve wound bed dryness.³⁰ A 13-year retrospective review identified multiple cases of acrylate allergy associated

with wound-care products.⁵ Mestach *et al.* reported two cases of ACD secondary to acrylate-based adhesives applied to secure a chemotherapeutic catheter; the composition of the adhesive was withheld by the manufacturers.³⁰

Patch testing with acrylates

Screening series

Multiple studies have investigated the possibility of implementing a set of screening monomers to detect acrylate allergy. The North American Contact Dermatitis Group currently includes ethyl acrylate (EA), MMA and 2-HEMA in its baseline series, and the European Society for Contact Dermatitis includes 2-HEMA. However, sensitivity and crossreactivity of these allergens are inconsistent between studies, and no specific set of screening monomers invariably detects every case of acrylate allergy.

Patch-test considerations

Acrylates are labile molecules. They should be prepared freshly at the time of testing and stored frozen to preserve sample stability.⁴ Petrolatum is the preferred vehicle. Testing with IQTM chambers (Chemotechnique Diagnostics, Vellinge, Sweden) is often favoured, as the aluminium content of Finn Chambers[®] (SmartPractice, Phoenix, AZ, USA) may act as a catalyst for acrylate polymerization and consequently lead to false-negative results.³¹ The initial extrusion from a syringe should be discarded, as the concentration may be decreased at the syringe tip due to sample volatility.³² Expiration dates must be adhered to because sample concentration may decrease over time.



Figure 4 (a) Erythema and fissuring of the distal thumb associated with ethyl cyanoacrylate present in Krazy[®] Glue, a cyanoacrylate glue. (b) Positive reaction to ethyl cyanoacrylate demonstrated on patch testing.

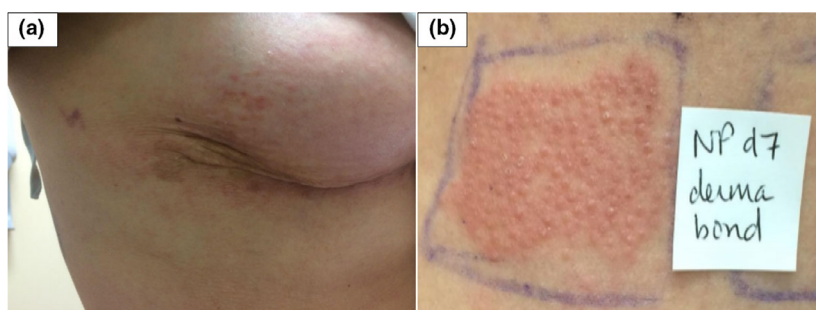


Figure 5 (a) Dermatitis of the breast and inframammary region approximately 4–5 weeks following a breast reduction. (b) Positive reaction demonstrated on patch testing to Dermabond[®] containing 2-octyl cyanoacrylate, which had been used to close the wound.

Management of acrylate allergy

Affected individuals should avoid contact with acrylic monomers, but 'acrylate copolymers' in personal care products are generally safe for use. Protective gloves should be worn by beauticians; nitrile gloves provide up to 60 min of protection,¹⁴ but trilaminated polyethylene gloves provide a longer duration of protection (up to 4 h) and 4H[®] plastic polymer gloves seem to be resistant to methacrylates.^{5,14,17}

Conclusion

Acrylates are widely used synthetic plastics, and sensitizations to these chemicals are increasing. Both consumers and nail technicians can be affected. Widespread use in nail products, medical devices, surgical glues and wound-care products make further allergy likely. Patch testing to a broad array of acrylates is usually necessary to identify the substances responsible.

Learning points

- Acrylates are an important and increasingly common cause of both occupational and non-occupational ACD.
- Long-lasting nail products are primarily responsible for the surge in ACD to acrylates seen in recent years.
- IBOA is an emerging source of acrylate allergy, particularly with regards to diabetic glucose sensors.
- Regulations are needed for companies to disclose full composition lists of products and devices.
- No current consensus exists for an acrylate screening series and clinicians should test with a broad range of acrylate allergens.
- Acrylates are unstable molecules that should be stored in the freezer, prepared at the time of testing and tested on IQTM chambers.

Acknowledgement

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CPD questions

Learning objective

To demonstrate up-to-date knowledge in emerging sources of acrylates and relevant new allergens leading to allergic contact dermatitis.

Question 1

Which of the following is the primary source responsible for the significant increase in acrylate allergy seen in recent years?

- (a) Bone cement.
- (b) Dental prostheses.
- (c) Long-lasting nail products.
- (d) Moisturizing creams.
- (e) Contact lenses.

Question 2

Among individuals who develop allergic contact dermatitis secondary to long-lasting nail products, which of the following displays the greatest allergenic potential?

- (a) Acrylate copolymers.
- (b) Acrylate monomers.
- (c) Cyanoacrylate nail glues.
- (d) Nail wraps.
- (e) Ultraviolet (UV) nail lights.

Question 3

Which acrylate was banned by the US Food and Drug Administration and restricted by European cosmetic regulations due to its strong potency in inducing allergic contact dermatitis?

- (a) 2-hydroxyethyl acrylate (2-HEA).
- (b) 2-hydroxymethyl methacrylate (2-HEMA).
- (c) Ethyl cyanoacrylate (ECA).
- (d) Ethylene glycol dimethacrylate (EGDMA).
- (e) Methyl methacrylate (MMA).

Question 4

Which acrylate is most commonly used in surgical glues, including the product Dermabond®?

- (a) 2-butyl cyanoacrylate (2-BCA).
- (b) 2-hydroxymethyl methacrylate (2-HEMA).
- (c) 2-octyl cyanoacrylate (2-OCA).
- (d) Ethyl acrylate (EA).
- (e) Methyl methacrylate (MMA).

Question 5

Isobornyl acrylate (IBOA) is an emerging acrylate most commonly found in which of the following sources?

- (a) Bone cement.
- (b) Dental products.
- (c) Gel nail polish.
- (d) Glucose sensors.
- (e) Surgical glues.

Instructions for answering questions

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- Reflect on the article
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