Acrylates as a significant cause of allergic contact dermatitis: new sources of exposure

Monika Kucharczyk1, Małgorzata Słowik-Rylska1,2, Sylwia Cyran-Stemplewska1, Monika Gierő2, Grażyna Nowak-Starz1, Beata Kręcisz1,2

1Collegium Medicum, Jan Kochanowski University, Kielce, Poland
2Dermatology Department, Provincial Integrated Hospital, Kielce, Poland

Abstract

Acrylate monomers have a wide range of applications. Since the 1950s, many reports of occupational origin allergic contact dermatitis due to (meth)acrylate monomers have been published. During last decades, (meth)acrylate allergy has undergone an occupational shift from dentistry toward beauty industry and medical devices. The aim of the study was to conduct a literature review on acrylates as a cause of allergic contact dermatitis, current sources of exposure as well as identification of professional groups with an increased risk of this allergy and methods of effective prevention. Database review: Medline search (PubMed), Wiley Online Library and Web of Science base in years 1956–2019 using the following keywords: acrylates, manicurists, dentists, dental technicians, medical devices, occupational exposure, and allergic contact dermatitis. 204 346 articles containing the term ‘acrylates’ have been found. They include 2 042 articles with the word ‘manicurists’, 169 919 – ‘dentists’, 218 236 – ‘dental technicians’, 2 427 418 – ‘medical devices’. Fifty-nine articles were chosen based on analysis of abstracts and full texts. In the past allergy to acrylates was mainly of occupational origin and dental technicians were the most often affected professional group. Since the long-lasting manicure has become popular, this problem concerns both manicurists and their customers. Moreover, the new significant trend is non-occupational allergic contact dermatitis caused by medical devices especially dedicated to diabetes patients.

Key words: acrylates, allergic contact dermatitis, manicurists, medical devices.

Introduction

Acrylate monomers, which contain an acryl group derived from acrylic and methacrylic acid, have a wide range of applications [1–3]. Owing to their reactive double bonds, acrylates easily form polymer plastic structures spontaneously or on ultraviolet (UV) light exposure. The products containing acrylic polymers are relatively inert [4, 5]. However, sometimes active monomer particles are still released from polymer structures and are thought to act as haptens. They trigger allergic responses while high allergenic capacity have their monomeric and dimeric forms [6, 7]. The development of the methacrylate and acrylate compounds started in the 1930s. In a short time they found application in the manufacture of plastic glass used in aircrafts, paints, coatings, and printing inks [8]. Since the 1950s, many reports of occupational origin allergic contact dermatitis due to acrylate monomers have been published [3, 8]. Finally, isobornyl acrylate has been named a contact allergen of the year for 2020 [9].

Sources of exposure

In the past most common exposures were associated with manufacturing, particularly in printing, painting, coating, metallurgical industries and dentistry [1, 10]. Among the common sources of these compounds there are floor waxes, floor coatings, surface treatments of leather, textiles and paper products [8]. Well-known examples of occupational allergy to (meth)acrylates most frequently occur among dental personnel. In the 1990s, sensitization increased considerably in this profession [11, 12]. Dental staff is exposed to a large number of materials being potential contact allergens like uncured plastic resins, mainly acrylic monomers – acrylates, methacrylates, urethane acrylates, and epoxy acrylates – used in dentistry in prostheses, dentin bonding materials, and
A retrospective analysis of the German Information Network of Departments of Dermatology patch test data from the years 2001–2015 stated that dental technicians (DTs), which constituted the study group with occupational contact dermatitis (OCD), are significantly more often diagnosed with allergic contact dermatitis than the dental technicians with contact dermatitis of non-occupational origin. In the study group, patch tests were most frequently positive to methacrylates and/or acrylates [13]. According to Aalto-Korte et al., there is a varying frequency of allergy to particular acrylate hapten among dental staff. 2-hydroxyethyl methacrylate (2-HEMA) and methyl methacrylate (MMA) are reported to be the most important allergens among dentists and dental nurses, whereas ethyleneglycol dimethacrylate (EGDMA) has a negative influence on dental technicians mostly [15]. The typical clinical features of (meth)acrylate allergy in those occupational groups is hand eczema and pulpitis of the fingertips, especially of the first three fingers, although wide-spread dermatitis is also reported [8, 15, 16]. Sometimes there is involvement of the face and eyelids caused by airborne particles of acrylates or by allergen transport by contaminated tools or hands [17, 18]. Respiratory hypersensitivity may also be provoked by acrylates, e.g. wheezing, asthma or rhinoconjunctivitis [19]. Awareness of the sensitizing properties of acrylates has increased during last years. As a result of adequate personal protection as well as popularity of non-touch techniques, the number of methacrylate allergic dental personnel seems to decrease [15]. Another issue is allergic contact stomatitis, which was observed in some dental patients. The reason was inadequate polymerization and release of residual monomers from acrylate-based dental fillings [20]. The oral symptoms include subjective sensations like burning or soreness in the mouth, loss of taste, nummous, mucous membrane inflammation, vesiculations, erosions, lichenoid reaction confined to the area in contact with dental materials [21]. During last decades, (meth)acrylate allergy has undergone an occupational shift from dentistry toward beauty industry, and this change seems to be constantly trending upwards in many countries [22]. The most important sources of sensitisation are eyelash, hair extensions and primarily artificial nails [18, 23]. It is worth mentioning that false nail products are not a new source of acrylate allergy. The first description of such a case was published by Canizes in 1956 [24]. Currently wide availability of techniques based on acrylates, methacrylates or cyanoacrylates has resulted in increasing popularity of artificial nails among women and consequently frequency of sensitization [25, 26]. Acrylic nails were the most popular technique in the past. They are created from powder and liquid-based substance, containing acrylates, which is applied to the nail plate. The procedure does not require photocuring, however, it is rarely used because it is time consuming [23]. Today, the most common fashion trend is the so-called permanent nail polish containing photo-bonded acrylates. This product is also known as ‘semi-permanent’, ‘long-lasting nail polish’ or ‘gel nail’ polish. It consists of a mixture of acrylate monomers, which are applied to the nail plate. Either fluorescent UV lamps or light-emitting diode (LED) lights are used for polymerization. Both the low cost and ease of application have been the factors of the aforementioned nail procedure [2, 27–29]. All types of artificial nails contain acrylates and can cause sensitization. Not only does it refer to the beauticians who apply them but also to the customers [23, 29]. It should be emphasized that the current commercialized home use kits could cause even higher degrees of allergy. ACD triggered by domestic-administered nail manicure has already been described in Australia, Sweden and Spain [18, 29, 30]. Additionally, sensitization may develop after months or even years of using false nails [31]. The clinical presentation of skin allergy includes pulpitis, finger dermatitis, acquired leukoderma in the fingertips, periungual eczematous lesions, nail dystrophy, sometimes with coexisting atypical locations like face- or neck-dermatitis [32]. Nail abnormalities can imitate psoriasis because of the presence of onycholysis and severe subungual hyperkeratosis. Nail lesions can exist without dermatitis of the digit [27, 28]. Allergic contact dermatitis induced by different types of acrylate stylisation techniques is often misdiagnosed. The patients usually do not realize the association between the use of manicure and abnormalities of nails [1, 2]. Involvement of all nails and the absence of specific signs of nail psoriasis, such as salmon patches, can be helpful in establishing the correct diagnosis. A nail biopsy is usually not necessary [31]. According to Gatica-Ortega et al., the typical acrylate-allergy patient is a young, woman working as a beautician and suffering from hand and, occasionally, face dermatitis [18]. A retrospective study in 11 European Environmental Contact Dermatitis Research Group (ECCDRG) showed that 67% of cases of acrylate-ACD were caused by materials used in nail stylisation. 43% of patients were exposed as consumers and 56% occupationally. Furthermore, 65% of cases with occupational ACD was revealed during the first year at work. This feature shows the high sensitising potency of these chemicals [23, 33]. Most patients showed positive reaction to two or more acrylates. 2-hydroxyethyl methacrylate (HEMA), 2-hydroxypropyl methacrylate, ethylene glycol dimethacrylate and ethyl cyanoacrylate were identified as the most common positive allergens [23]. The literature contains descriptions of mucosal symptoms (ocular, nasal and respiratory) due to exposure to acrylates among beauticians. They include cases of induced asthma or exacerbations of pre-existing asthma, conjunctivitis and rhinitis [34–39]. Reutman et al. pilot findings suggested that among nail salon workers lung function and airway inflammation may be adversely influenced by working environment, possibly by contact with (meth)acrylates.
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New sources

Nowadays new sources of acrylates are constantly appearing. The case of acrylate allergic contact dermatitis triggered by hair prosthesis fixative was described in 2019 by Rodenas-Herranz et al. A 57-year-old male with scarring alopecia 4 weeks after using a capillary prosthesis fixed by an acrylate-based liquid glue (Ghostbond) developed a pruritic eczematous rash on the scalp. Although the patient changed the fixation to double-sided adhesive tapes (unknown composition), no improvement was noticed. The patch test showed positive reaction to hydroxypropyl methacrylate 2% pet. (2+), hydroxyethyl acrylate 2% pet. (2+), butyl acrylate (2+), adhesive tape (2+) and Ghostbond glue (2+) [42].

Recently acrylates have a wide application also in various medical purposes. They are important allergens in bone cement for orthopaedic endoprostheses, soft contact lenses, hearing aids as well as histological preparations [8]. Currently wound dressings are underlined as emerging sources of sensitization to acrylates [1]. The literature contains case descriptions of severe dermatitis from surgical glue containing acrylates which is used by many surgeons. Because of prolonged exposure to those skin adhesives, for weeks or months after application, there is a higher risk of primary sensitization, particularly if the skin is inflamed [43].

Recently there have been several reports indicating medical devices for diabetes patients as an important cause of allergic contact dermatitis. New technologies such as flash glucose monitoring (FGM) measure the interstitial glucose levels [44]. In 2017, Herman et al. published results of a multicentre study that involving 15 patients. They presented a skin reaction to Freestyle Libre, which is the FGM system popular in Europe. The device is fixed on the skin for a 2-week period with an adhesive. Patients had a rash just below the adhesive part of the sensor. Twelve of 15 tested patients had a positive reaction to isobornyl acrylate that is used to combine the different components in this device [45, 46]. In another study, performed by Hyyry et al., seventy type 1 diabetes patients with a suspected contact allergy to glucose sensors were subjected to patch testing. The median exposure time was 6 months before first signs of sensor-associated dermatitis. Positive reactions to isobornyl acrylate were observed in 81% of Freestyle Libre users [46]. Isobornyl acrylate (IBOA) used in the past mainly in coatings, inks, cosmetics or paints was rarely a cause of contact allergy as compared with other (meth)acrylates [46]. While lately IBOA has been identified as a culprit sensitizer in the tubeless insulin pump (OmniPod) [47]. According to the present observations of increased prevalence of acrylate allergy in such devices, it is strongly recommended that manufacturers should eliminate this allergen from those systems [44]. Moreover, other acrylates recently emphasized as a significant sensitizer in devices for insulin infusion and monitoring of glucose levels are N,N-dimethylacrylamide (DMAA) or 2-ethyl cyanoacrylate present in the glue of the CGM Platinum G4 Dexcom sensor [48, 49]. In order to prevent symptoms, patients with ACD to acrylates may insert special hydrocollloid plates between the skin and the adhesive part of the sensor. Thanks to this, the allergic reaction can be limited [50, 51]. Another source of sensitisation to acrylates is transcutaneous electrical nervous stimulation (TENS) electrodes, used in the treatment of chronic back pain, and also in the adhesive layer of electrocardiogram electrodes [52, 53].

Furthermore, cases of ACD to acrylates are also reported in aesthetic medicine. In 2017, Shah et al. reported the case of a 28-year-old patient who developed allergic contact dermatitis caused by polymethyl methacrylate following an intradermal filler injection to correct his nose tip. In the past he had a mucosal reaction to a denture based on polymethyl methacrylate resin. Patch tests showed positive reactions (3+) to methyl methacrylate [41].
**Diagnosis**

Patch testing is a gold standard in confirming the diagnosis of allergy to acrylates. Nowadays, acrylic monomers are included in several different commercial patch test series like dental materials for dental patients, dental staff, artificial nails, and printing [15]. In some cases, acrylate allergy is polyvalent, patients present multiple positive patch tests reactions, although they have probably not been exposed to all of those substances. The reason may be cross-reactions between acrylic monomers and concomitant allergies due to their coexistence in particular products [3, 15]. Heratizadeh *et al.* reported, that among 67 (meth)acrylates allergic patients, 42% reacted to one or two (meth)acrylates, whereas 33% reacted to more than five (meth)acrylates [54]. The study by Raposo *et al.* showed that patch testing with HEMA was positive in more than 90% of cases of the (meth)acrylates tested. It is considered to be a gold screening marker [6]. Recently, It has been proposed to add 2-HEMA and HPMA to the European baseline series [55].

**Occupational prevention**

Nitrile gloves are considered to be a more effective option than latex gloves, but only if exposure is brief (15–20 min), as shown by patch testing over glove fragments. Morgado *et al.* suggest using nitrile gloves for a maximum of 30 min, and then change if the procedure is not completed. They observed that during long-time exposure, (meth)acrylates probably diffuse from the nail gel, and therefore become the cause of dermatitis [56]. If the contact with an allergen is longer than 30 min, it is recommended to use 4H (ethylene–vinyl alcohol–polyethylene) fingerstalls below classic protective gloves or complete 4H Gloves [20, 21, 23, 41]. Unfortunately, 4 H gloves are not comfortable and limit the feeling of touch. Additionally, many mucosal and skin irritant reactions in the case of manicurists could be prevented and avoided by using efficient ventilation systems as well as personal protective equipment such as goggles, masks especially when exposure to volatile substances or dusts (e.g. nail dust) occurs [34]. The risk of sensitisation also depends on proper use of good quality UV-devices and adequate time of gel curing. This problem seems to be especially significant among women who self-apply the product at home. They are not trained enough and educated on the risks associated with handling acrylates. Necessary protective measures are not usually used by ‘home beauticians’. Moreover, they may change artificial nails too often and their skin comes into contact with nail polish more frequently causing a higher risk of sensitisation [29, 57].

Another significant issue is career counselling. Allergy to acrylates can have an important impact on the choice of the future profession and ability to work [23]. The literature contains a description of a manicurist who developed an allergic skin reaction to acrylates after 3 months of work, manifested by bullous lesions on fingertips as well as eczema of the hands and ears. It should be emphasized that she was not correctly advised on retraining and started to work as a dental nurse. Soon after re-exposure to acrylates in dental materials, she experienced recurrence of the skin symptoms. Patch tests showed positive reactions to 2-hydroxyethyl methacrylate, 2-hydroxypropyl methacrylate, ethylene-glycol dimethacrylate, triethylene glycol dimethacrylate, 1,6-hexanediol diacrylate, 2-hydroxyethyl acrylate and triethylene glycol diacrylate. Because of her skin disorder, she had to change her job. In successful retraining and redeployment of individuals allergic to acrylates, the presence of these chemicals in various workplaces (e.g. in dentistry, beauty salons, printing industry and construction industry) should be considered. Otherwise, as in this case, re-exposure to acrylates in a new job may cause recurrence of the skin disorder [58].

**Summary**

In recent years allergy to acrylates has become an increasingly common problem. Nowadays artificial nail products are the most significant source of this allergy. Popularity, development of the beauty industry and improper usage of nail curing lamps have resulted in the epidemic of acrylate allergy. Therefore, policies regulating usage of these highly sensitizing chemicals for aesthetic procedures should be stricter. The awareness of a potential risk of sensitization to acrylates and available preventative measures need to be broadened particularly among workers of beauty industries during their apprenticeship. The new significant trend is allergic contact dermatitis caused by medical devices. Patch tests are considered to be the gold standard in establishing diagnosis. It is required to include both HEMA and HPMA in the baseline series as a good marker of acrylate sensitisation [55].

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**Conflict of interest**

The authors declare no conflict of interest.
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