

# Occupational respiratory disease caused by acrylates

B. SAVONIUS, H. KESKINEN, M. TUPPURAINEN and L. KANERVA

*Institute of Occupational Health, Helsinki, Finland*

## Summary

Acrylates are compounds used in a variety of industrial fields and their use is increasing. They have many features which make them superior to formerly used chemicals, regarding both their industrial use and their possible health effects. Contact sensitization is, however, one of their well known adverse health effects but they may also cause respiratory symptoms. We report on 18 cases of respiratory disease, mainly asthma, caused by different acrylates, 10 cases caused by cyanoacrylates, four by methacrylates and two cases by other acrylates.

*Clinical and Experimental Allergy*, Vol. 23, pp. 416–424. Submitted 10 February 1992; revised 6 November 1992; accepted 7 November 1992.

## Introduction

Acrylic compounds are widely used in industry because of their reactive and cross-binding properties. They have many features which make them near ideal in a polymerization process. The polymerization can be initiated in different ways, e.g. by light, electrons and water. The drying process is energy-saving compared to solvent or water evaporation, and the use of classic solvents can be reduced. Acrylates can be bound to different compounds, and different acrylates can be mixed to obtain polymers with varying properties of strength, viscosity, etc.

The main acrylic compounds in current use are acrylates, cyanoacrylates and methacrylates (Fig. 1). All have adverse health effects, of which the sensitizing properties are best known. Contact hypersensitivity to acrylic compounds has been known since the 1940s [1–3]. Recently it has been demonstrated that acrylates may also cause respiratory symptoms [4–12].

We detected the first case of respiratory disease caused by acrylates in 1985, and report here a total of 18 cases of respiratory symptoms so far diagnosed at our Institute. Three of these cases have been reported earlier in a Finnish paper published in 1985 [12] and one is about to be reported elsewhere [13].

## Subjects and methods

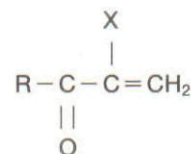
### Patients

Between January 1985 and October 1991 a total of 3152 patients were examined at the Institute of Occupational

Health in Helsinki because of a suspected occupational respiratory disease (pneumoconioses not included). Of these patients, 880 were diagnosed as having an occupational asthma/respiratory disease. Eighteen were caused by acrylates, 12 by cyanoacrylates, four by methacrylates and two by other acrylates (Tables 1–4).

### Skin-prick tests and patch tests

All patients were tested for immediate allergy. Skin-prick tests with 15–20 common allergens, including animal epithelia, pollens, house dust mite and moulds were carried out according to the method of Aas and Belin [14]. Prick tests with methyl methacrylate and polyethyleneglycoldiethyl methacrylate were performed on two patients, and tests with cyanoacrylate on three patients. Weals, at least 3 mm in diameter, and at least half the size of histamine hydrochloride (10 mg/ml) weals, were considered positive. Patch tests were performed, if allergic contact dermatitis was suspected, using the Finn-



X = H; acrylates  
X = CN; cyanoacrylates  
X = CH<sub>3</sub>; methacrylates

Fig. 1. Structure of acrylate compounds.

Correspondence: Dr B. Savonius, Institute of Occupational Health, Topeliuksenkatu 41aA, SF-00250, Helsinki, Finland.

Table 1. Characteristics of six patients suffering from respiratory symptoms probably caused by cyanoacrylates

|                                                        | Patient                    |                            |                           |                        |                        |                            |
|--------------------------------------------------------|----------------------------|----------------------------|---------------------------|------------------------|------------------------|----------------------------|
|                                                        | C-1                        | C-2                        | C-3                       | C-4                    | C-5                    | C-6                        |
| <i>Personal</i>                                        |                            |                            |                           |                        |                        |                            |
| Age                                                    | 39                         | 38                         | 29                        | 42                     | 58                     | 49                         |
| Gender                                                 | Female                     | Female                     | Female                    | Female                 | Female                 | Female                     |
| Work                                                   | Manufacture of lamp shades | Manufacture of lamp shades | Manufacture of ski-sticks | Assembling electronics | Assembling electronics | Manufacture of projectiles |
| Smoker                                                 | Yes                        | Yes                        | No                        | Yes                    | Former                 | No                         |
| Atopy own/family                                       | No/no                      | No/no                      | No/no                     | No/no                  | No/no                  | No/no                      |
| Prick positivity (standard series)                     | No                         | No                         | No                        | No                     | No                     | No                         |
| IgE (kU/l)                                             | 160                        | 52                         | 90                        | 160                    | 42                     | 90                         |
| <i>Agent</i>                                           |                            |                            |                           |                        |                        |                            |
| Chemical                                               | Alkyl-cyanoacrylate        | Alkyl-cyanoacrylate        | Alkyl-cyanoacrylate       | Alkyl-cyanoacrylate    | Alkyl-cyanoacrylate    | Alkyl-cyanoacrylate        |
| Use                                                    | Glue                       | Glue                       | Glue                      | Glue                   | Glue                   | Glue                       |
| Time from first exposure to onset of symptoms (months) | 1                          | 0.25                       | 6                         | 7                      | 18                     | 4                          |
| Duration of exposure before diagnosis (months)         | 4                          | 1                          | 10                        | 4                      | 21                     | 7                          |
| <i>Disease</i>                                         |                            |                            |                           |                        |                        |                            |
| Diagnosis/year                                         | Asthma/1985                | Asthma/1985                | Asthma/1986               | Asthma/1986            | Asthma/1988            | Asthma/1988                |
| Reaction                                               | Immediate                  | Late                       | Late                      | Dual                   | Dual                   | Late                       |
| Max. PEF drop                                          | 64%                        | 24%                        | 19%                       | 57%                    | 47%                    | 30%                        |

**Table 2.** Characteristics of six patients suffering from respiratory symptoms probably caused by cyanoacrylates

|                                                        | Patient                  |                        |                    |                     |                         |                                     |
|--------------------------------------------------------|--------------------------|------------------------|--------------------|---------------------|-------------------------|-------------------------------------|
|                                                        | C-7                      | C-8                    | C-9                | C-10                | C-11                    | C-12                                |
| <i>Personal</i>                                        |                          |                        |                    |                     |                         |                                     |
| Age                                                    | 42                       | 59                     | 51                 | 22                  | 44                      | 56                                  |
| Gender                                                 | Male                     | Female                 | Female             | Female              | Female                  | Female                              |
| Work                                                   | Repair of lab. equipment | Assembling electronics | Assembling stoves  | Assembling phones   | Assembling radiophones  | Assembling electronics              |
| Smoker                                                 | No                       | No                     | No                 | No                  | Former                  | No                                  |
| Atopy own/family                                       | Yes/no                   | No/yes                 | No/no              | No                  | Yes/no                  | No/no                               |
| Prick positivity (standard series)                     | No                       | No                     | No                 | No/no               | Yes                     | No                                  |
| IgE (kU/l)                                             | 35                       | 8                      | 6                  | 25                  | 140                     | 5                                   |
| <i>Agent</i>                                           |                          |                        |                    |                     |                         |                                     |
| Chemical                                               | Alkylcyanoacrylate       | Alkylcyanoacrylate     | Alkylcyanoacrylate | Methylcyanoacrylate | Alkylcyanoacrylate      | Alkylcyanoacrylate and methacrylate |
| Use                                                    | Glue                     | Glue                   | Glue               | Glue                | Glue                    | Glue                                |
| Time from first exposure to onset of symptoms (months) | 166                      | 16                     | 1                  | 11                  | 144                     | 6                                   |
| Duration of exposure before diagnosis (months)         | 172                      | 26                     | 18                 | 15                  | 150                     | 24                                  |
| <i>Disease</i>                                         |                          |                        |                    |                     |                         |                                     |
| Diagnosis/year                                         | Asthma/1989              | Asthma/1989            | Asthma/1989        | Rhinitis/1989       | Pharyngolaryngitis/1989 | Asthma/1991                         |
| Reaction                                               | Late                     | Late                   | Late               | Immediate           | Immediate               | Dual                                |
| Max. PEF drop                                          | 23%                      | 24%                    | 21%                | No                  | No                      | 19%                                 |

**Table 3.** Characteristics of four patients suffering from respiratory symptoms probably caused by methacrylates

|                                                        | Patient             |                            |                               |                                      |
|--------------------------------------------------------|---------------------|----------------------------|-------------------------------|--------------------------------------|
|                                                        | M-1                 | M-2                        | M-3                           | M-4                                  |
| <i>Personal</i>                                        |                     |                            |                               |                                      |
| Age                                                    | 48                  | 32                         | 46                            | 45                                   |
| Gender                                                 | Female              | Male                       | Female                        | Female                               |
| Work                                                   | Plate engraver      | Assembling hearing devices | Dental technician             | Dentist                              |
| Smoker                                                 | No                  | Yes                        | No                            | No                                   |
| Atopy own/family                                       | Yes/no              | No/no                      | No/no                         | No/not known                         |
| Prick positivity (standard series)                     | No                  | No                         | No                            | No                                   |
| IgE (kU/l)                                             | 88                  | 9                          | Nd                            | 40                                   |
| <i>Agent</i>                                           |                     |                            |                               |                                      |
| Chemical                                               | Methylcyanoacrylate | Methylcyanoacrylate        | Methylcyanoacrylate           | Triethylen-di & isobutylmethacrylate |
| Use                                                    | Glue                | Manufacture of earplugs    | Preparation of dental filling | Dentin primer                        |
| Time from first exposure to onset of symptoms (months) | 92                  | 1                          | Over 150                      | Over 100                             |
| Duration of exposure before diagnosis (months)         | 110                 | 3                          | Over 150                      | Over 100                             |
| <i>Disease</i>                                         |                     |                            |                               |                                      |
| Diagnosis/year                                         | Asthma/1989         | Asthma/1990                | Asthma/1991                   | Pharyngitis/1991                     |
| Reaction                                               | Late                | Late                       | Dual                          | Immediate (dual?)                    |
| Max. PEF drop                                          | 24%                 | 15%                        | 26%                           | 3%                                   |

Chamber method. The tests were scored and evaluated as previously described [15]. Acrylate patch tests were negative in all of the patients studied, except patient M-4.

#### *Lung function and provocation tests*

Non-specific bronchial reactivity was tested according to a modified protocol of Laitinen [16]. In all cases, the specific asthma diagnosis was based on a provocation test in an inhalation challenge chamber with the suspected agent. The physical status and symptoms of the patient and Peak Expiratory Flow (PEF) were followed up according to Newman Taylor and Venables [17]. The schedule of the challenging was as follows. One challenge was performed per day with a 24 hr follow up. If there were evident changes in the PEF surveillance, the patient was followed up until his/her diurnal PEF surveillance was stable, at least until the next day. The placebo tests were performed first with polyol, and frequently with some other inert compound from the workplace, and the

other challenges thereafter. All tests were performed blind, but often the patient recognized his/her own chemicals.

Glue challenges (patients C-1-C-2 and M-1) were done as follows: the examinee spread 1 or 4 ml of glue on a 10 cm × 10 cm tray, and remained for 30 min in the chamber. The acrylate challenges (patients A-1 and A-2) were done with the examinee stirring 200 ml of the ink or paste in a shallow dish in the chamber for 30 min. The dental technician (patient M-3) prepared a dental prosthesis consisting of 10 g of methacrylate powder and 10 ml of methacrylate liquid for 30 min. The dentist (patient M-4) smeared three drops of the dentin primer on a microscope slide and remained for 30 min in the chamber. The examinee assembling hearing devices (patient M-2) ground a piece of methacrylate in the chamber.

The test was considered positive if there was a fall of over 15% in the PEF values within one hour from the challenge (immediate reaction) or a fall of over 20% later (late reaction) compared to both values on the morning before the challenge and to the concurrent values of the

**Table 4.** Characteristics of two patients suffering from respiratory symptoms probably caused by other acrylates

|                                                        | Patient      |                                                                  |
|--------------------------------------------------------|--------------|------------------------------------------------------------------|
|                                                        | A-1          | A-2                                                              |
| <i>Personal</i>                                        |              |                                                                  |
| Age                                                    | 35           | 37                                                               |
| Gender                                                 | Female       | Male                                                             |
| Work                                                   | Machinist    | Glassworker                                                      |
| Smoker                                                 | No           | Yes                                                              |
| Atopy own/family                                       | No/yes       | No/yes                                                           |
| Prick positivity (standard series)                     | Yes          | No                                                               |
| IgE (kU/l)                                             | Not tested   | 259                                                              |
| <i>Agent</i>                                           |              |                                                                  |
| Chemical                                               | Acrylic acid | Trihydroxy-methyl-propyl-triacrylate and hydroxy-propyl-acrylate |
| Use                                                    | Printing ink | UV-hardening paste                                               |
| Time from first exposure to onset of symptoms (months) | 9            | 30                                                               |
| Duration of exposure before diagnosis (months)         | 9            | 36                                                               |
| <i>Disease</i>                                         |              |                                                                  |
| Diagnosis/year                                         | Asthma/1986  | Asthma/1991                                                      |
| Reaction                                               | Immediate    | Immediate                                                        |
| Max. PEF drop                                          | 32%          | 20%                                                              |

placebo challenge. Usually we tested the same patient with several agents, and these negative challenges can also be regarded as placebo tests. In case C-12 the diagnosis was based on a workplace PEF surveillance, as well as a positive chamber challenge and a negative placebo test.

There was only a 15% fall in the PEF values of patient M-2 but a change was noted in the reactivity of the airways in the histamine test, indicating that the test was positive.

In cases of pharyngitis, the status of the pharynx was assessed immediately before and after the challenge by an otorhino-laryngologist normally unaware of the challenge substance. The redness and swelling of the mucosa was rated on a 4-point scale: no, mild, moderate or abundant. The test was interpreted as positive if both signs (redness and swelling) were increased by at least one point [13].

The nasal reaction was followed as previously described [18]. The patient was considered atopic if there was a history of asthma, allergic rhinitis or atopic eczema in his/her own parents or siblings. Total IgE values were

determined by the enzyme immunoassay technique (Phadezym PRIST kit, Pharmacia Diagnostics, Uppsala, Sweden).

## Case reports

### *Cyanoacrylates*

Twelve patients had occupational respiratory disease caused by cyanoacrylates. All, except one, were women. Cyanoacrylate-based glue was the cause in all cases. Ten of the patients had been exposed daily and two only occasionally. Only two patients had a history of atopy. The exposure time before onset of the symptoms ranged from 1 week to 14 years.

The main characteristics of the 12 patients are summarized in Tables 1 and 2.

Three cases representing typical histories but different reaction patterns, diagnosis and outcome are presented below. The number of the cases corresponds to the numbering in Tables 1 and 2.

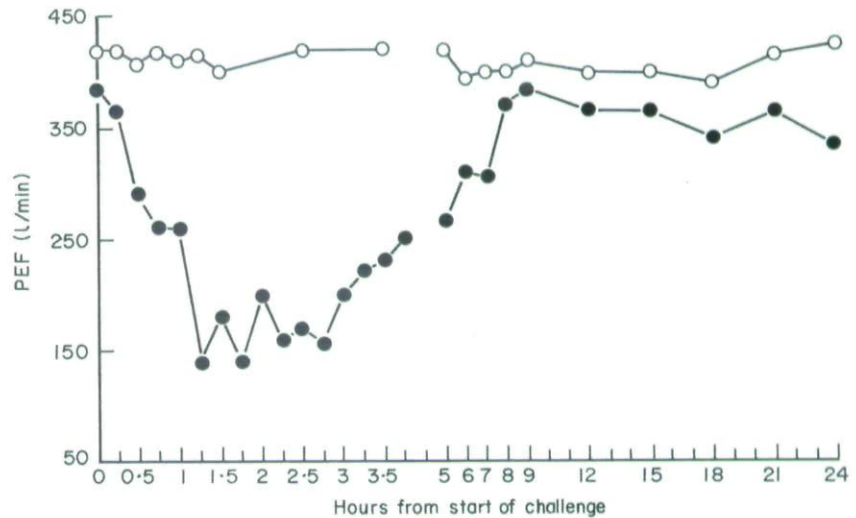


Fig. 2. Response to cyanoacrylate glue (●) and placebo (○) chamber challenge in patient C-1, showing a maximal PEF drop of 64% (\*, rimiterol inhalation, 0.2 mg).

**Patient C-1.** A 39-year-old woman had previously made cloth lampshades by sewing, but then started to use cyanoacrylate glue instead. After one month of glueing she developed symptoms of rhinorrhoea and sore throat, and later chest tightness, dyspnoea and wheezing in the evening and at night. The respiratory symptoms were so severe that she had difficulties in walking home from work. Glue challenge caused a 64% drop in PEF values (Fig. 2). After the cause was diagnosed she changed her job, but her asthma still needs medication.

**Patient C-7.** A 42-year-old male laboratory technician performing various maintenance tasks occasionally used cyanoacrylate glues in his work. During the previous 4 years he had been building a model of a human body of different plastic materials, and used glue frequently. He experienced worsening cough, rhinorrhoea and stuffiness at work. Currently he is not exposed to acrylates; he is continuing his former work without medication, and is symptomless and healthy.

**Patient C-11.** After several years of work, a 44-year-old atopic woman whose work involved the glueing and soldering of parts to radiophones began to have difficulties in swallowing, and developed a sore throat, a dry irritating cough, chest tightness and hoarseness at work. She was an ex-smoker but had stopped at the age of 34. No asthmatic reactions developed after work and chamber challenges, but she developed pharyngolaryngitis after the cyanoacrylate challenge. Chamber challenge with soldering flux and polyol were negative. Her symptoms disappeared when her exposure to cyanoacrylate ceased.

All these cases, as also with the other acrylates, have been

acknowledged as occupational diseases by the insurance companies.

After the diagnosis of occupational respiratory disease, all of these patients were removed from exposure to cyanoacrylates. The present status of their respiratory disease is known in 10 cases. Three of them (patients C-4, C-5, C-9) could not continue working because of persistent asthma; they still have symptoms and need medication. One (C-1) has changed occupation, but needs regular medication. The others (C-3, C-6, C-7, C-8, C-10, C-11) are now healthy and symptomless.

#### Methacrylates

Four patients with respiratory disease caused by methacrylates have been found (Table 3). They represent different occupations in which the use of methacrylates differs. None of them were atopic. Three patients used methacrylates daily and one only occasionally.

Two cases representing typical histories but different occupations and reaction patterns are presented below. The number of the cases corresponds to the numbering in Table 3. Case M-4 has been presented elsewhere in detail [13].

**Patient M-1.** A 48-year-old atopic woman working as a plate engraver used glues occasionally in her work; she developed respiratory distress at work, and strain, sneezing, rhinorrhoea and stuffiness. Methacrylate glue challenge caused a 24% fall in PEF values (Fig. 3). Her methacrylate glue was replaced by cyanoacrylate, but when her symptoms persisted she had to quit her work. Her symptoms have now reduced, but she still needs regular medication.

**Patient M-3.** A 46-year-old woman who had worked for about 20 years as a dental technician developed paresthe-

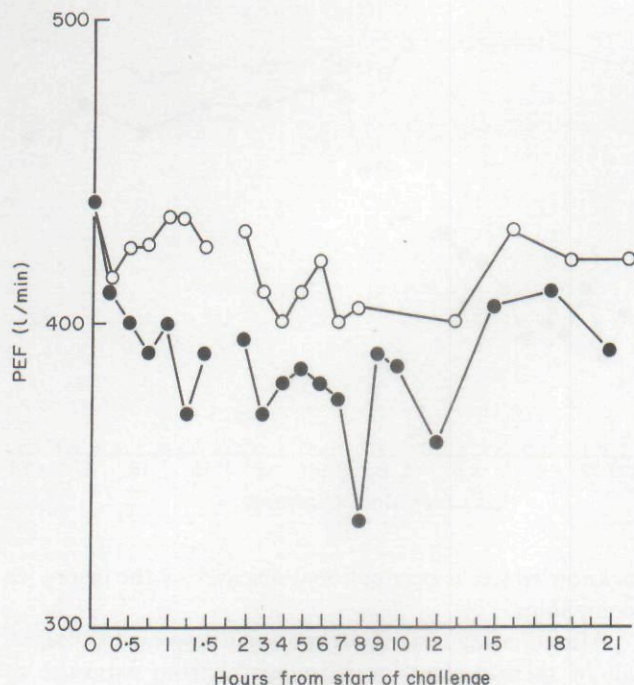


Fig. 3. Response to methacrylate glue (●) and placebo (O) chamber challenge in patient M-1, showing a maximal PEF drop of 24%.

siae on the ulnar side of both hands but no dermatitis. Subsequently, she experienced a feeling of tickling in her throat, yawning, cough, tiredness and chest tightness. The symptoms subsided on sick-leave and vacations but recurred within a week at work. The responses to methacrylate and placebo challenge are shown in Fig. 3. Prick tests with methacrylate and polyethyleneglycoldimethacrylate were negative. The patient is able to continue her work with steroid/sympathomimetic inhalation medication. When not exposed to methacrylate she needs only sympathomimetics occasionally.

#### Other acrylates

Two patients developed asthma from other acrylates (Table 4). Their work represented different industrial fields, where the acrylates are used as part of a coating material. One of the patients had a family history of atopy and also an elevated total IgE level. Both had been continuously exposed to acrylates at work.

**Patient A-1.** A 35-year-old woman working as a machinist in a paper mill manufacturing coloured paper serviettes developed prolonged rhinorrhoea, sinusitis, and at a later date, asthmatic symptoms. She experienced coughing when mixing printing inks in the afternoon and

shortness of breath the same night. The diagnosis was based on a challenge with the ink containing acrylic acid (30%), white spirit (4%), ethanol (10%), hydroxy-propionic acid (30%) and bronze powder (25%). The challenge was done twice with a two week interval. Placebo challenges performed with other inks, with polyols, with a 1-1-1 trichlor-ethane glue and with isopropanol were negative. The responses are shown in Fig. 4. The patient was transferred from these tasks but the disease is still somewhat labile and she needs medication occasionally.

**Patient A-2.** A 37-year-old man was working in a factory making windscreens for cars. He worked next to an UV-stove where a paste containing acrylates applied at the edges of the screens was hardened. After 2-3 years of working, he developed a cough, rales, chest tightness and wheezing at work and especially at night after workdays. He has not worked in the factory for some months now and has less symptoms but still needs medication.

#### Discussion

A total of 314 cases of occupational asthma were diagnosed at our Institute during the period 1987-1990. By far the most common causes of occupational asthma caused by low molecular weight chemicals were the isocyanates (76 cases) [19] followed by formaldehyde (18 cases) [20], epoxy resin and epoxy resin hardeners (17 cases) [21] and cyanoacrylates (six cases). Acrylates, however, are compounds which are used increasingly and they cause both contact and respiratory allergy. While methacrylates are well known contact sensitizers [22-27], cyanoacrylates have caused only few cases of contact allergy [28]. Acrylates may also have other harmful health effects.

Hand and finger symptoms and paraesthesiae have been reported among dental personnel preparing acrylates with their bare hands [29,30].

The domestic use of acrylates is very limited and the sensitizing problem is mainly occupational, but possibly occurs in many different industries.

Cyanoacrylates are used mostly as a component of a high strength glue used for joining different materials. Our cases represent different industrial branches, of which the electronics industry is the largest. The subjects sensitized to cyanoacrylates have usually used at most 50-200 ml of glue per week.

Methacrylates are used as adhesives, as dental and orthopaedic fillings, as material for prostheses and as an embedding material for different purposes, including histological preparations. Our cases represent a variety of occupations, including dental personnel who are currently daily exposed to methacrylates. Unfortunately,

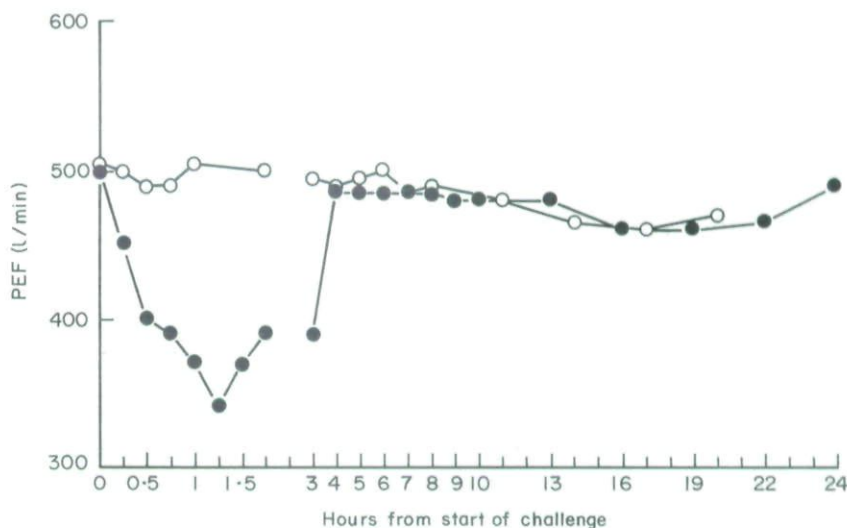


Fig. 4. Response to acrylate ink (●) and placebo (○) chamber challenge in patient A-1, showing a maximal PEF drop of 32%.

methacrylates very quickly penetrate most protective gloves [21,26,27].

Other acrylates are used in different industrial processes. Our cases represent occupations in which acrylates are used as part of a polymerization process producing a coating material. The exposure to acrylates in these cases has been relatively strong, the acrylate vapours have been present in the workplace air, and the patients may have been continuously exposed to relatively high concentrations.

We have no estimate of the level of exposure, because atmospheric acrylate concentrations have not been measured in workplace air.

In Finland, occupational exposure limits have been defined as follows: for methyl-methacrylate, 35 mg/m<sup>3</sup> of ambient air, and for methyl-cyanoacrylate, 9 mg/m<sup>3</sup> of ambient air, for 8 hr exposure. The reported cases do not seem to have many features in common, except for the causative agent, acrylate. The duration of exposure, atopic status, type of asthmatic reaction at challenge, and the outcome after diagnosis of occupational disease vary from case to case. The observed asthmatic reactions have been immediate, late or dual.

Very little is known about the mechanism of the respiratory reaction. So far there is no evidence of a specific IgE-mediated reaction [4-12]. HSA (human serum albumin)-low-molecular-weight-chemical conjugates are largely manufactured on a trial and error basis [29,31]. We have tried to perform prick-tests by conjugating different acrylates (cyanoacrylate, methylmethacrylate, polyethyleneglycoldi-methacrylate) with HSA, but it is not clear whether the HSA-acrylate compounds represent true allergens. So far there have been no positive reactions. The mechanism of di-isocyanate asthma has been studied more extensively, and about 15-20% of the

cases are believed to be associated with IgE-mediated mechanisms [19]. The irritating mechanism cannot be excluded. Acrylates are well known contact sensitizers [26], and a delayed type mechanism (type IV allergy) may apply to the cases of pharyngitis and rhinitis [13].

According to our experience, acrylates do not seem to have non-specific irritative effects on the airways at the concentrations we have been using. During 1989 we performed 11 chamber challenges with different acrylates.

Besides the four cases reported here, similar challenge tests were carried out to seven other acrylate exposed patients with negative results; four of them had unspecific bronchial hyperreactivity in the histamine challenge test.

The hallmark of occupational disease is evidence of a causal relationship between the workplace environment and both clinical symptoms and physiological changes. From a medicolegal aspect, however, the mechanism of reaction is not as critical if we define occupational diseases as not needing strict evidence of sensitization.

The risk of occupational disease in industrial fields where different acrylates are used can be reduced by normal measures, i.e. appropriate (point) ventilation and better workplace hygiene. It has been shown that the atmospheric concentration of cyanoacrylate monomers at the workplace can be reduced by maintaining a high level of humidity in the workplace [2,7]. Use of less volatile acrylic compounds also diminishes workplace atmospheric concentrations [32].

Although animal studies have revealed quite a lot about the relationship between the (meth)acrylate structure and the sensitizing capacity of (meth)acrylates as regards delayed (type IV) allergy [22-24,26], no firm conclusions about the structure of acrylates and their sensitizing effect on respiratory disease can be drawn from the present data. Our observations indicate that

both cyanoacrylates and (meth)acrylates may cause respiratory hypersensitivity, but the mechanism is currently not known.

## References

- Bradford EW. Case of allergy to methylmethacrylate. *Br Dent J* 1948; 84:195.
- Calnan CD. Cyanoacrylate dermatitis. *Con Derm* 1979; 5:165-7.
- Fowler JF. Immediate contact hypersensitivity to acrylic acid. *Dermatol Clin* 1990; 8:193-5.
- Pickering CA, Bainbridge D, Birtwhistle IH, Griffiths DL. Occupational asthma due to methacrylate in an orthopaedic theatre sister. *Lancet* 1986; 292:1362-3.
- Nakazawa T. Occupational asthma due to alkyl cyanoacrylate. *J Occup Med* 1990; 32:709-10.
- Kopp SK, McKay RT, Moller DR, Cassidy K, Brooks SM. Asthma and rhinitis due to ethylcyanoacrylate instant glue. *Ann Int Med* 1985; 102:613-15.
- Lozewicz S, Davison AG, Hopkirk A *et al.* Occupational asthma due to methacrylate and cyanoacrylates. *Thorax* 1985; 40:836-9.
- Roy ML, Siu SR, Wong R. Possible asthma and rhinitis associated with exposure to ethyl-2-cyanoacrylate. *Occupational Health in Ontario* 1989; 10:191-7.
- Basker RM, Hunter AM. A severe asthmatic reaction to poly(methyl methacrylate) denture base resin. *Br Dent J* 1990; 69:250-1.
- De Zotti R, Larese F. Asma da collanti cianoacrilici. *Med Lav* 1990; 81:142-6.
- Reynaud-Gaubert M, Philip-Joet F, Arnaud A. Asthme professionnel au methyl-methacrylate. *La Presse Medicale* 1990; 20:386.
- Poppius E, Antti-Polka M, Keskinen H. Syaaniakrylaattiliima ja astma. *Suom Lääkäril* 1986; 41:834-6.
- Kanerva L, Estlander T, Jolanki R, Pekkarinen E. Occupational pharyngitis associated with allergic patch test reactions from acrylates. *Allergy* 1992; 47:571-3.
- Aas K, Belin L. Standardisation of diagnostic work in allergy. *Int Arch Allergy Appl Immunol* 1973; 45:57-60.
- Estlander T. Occupational skin disease in Finland. Observations made during 1974-1988 at the Institute of Occupational Health, Helsinki. *Acta Derm Venerol (Stockh)* 1991; Suppl. 155:1-85.
- Laitinen LA. Histamine and metacholine challenge in testing of bronchial reactivity. *Scand J Resp Dis* 1974; Suppl. 86:1-48.
- Newman Taylor AJ, Venables KM. Clinical and epidemiological methods in investigating occupational asthma. In: Pepys J, Ed. *Clinics in immunology and allergy: occupational respiratory allergy*; vol 4. Philadelphia: W.B. Saunders, 1984:3-17.
- Kanerva L, Tupasela O, Jolanki R, Vaheri E, Estlander T, Keskinen H. Occupational allergic rhinitis from guar gum. *Clin Allergy* 1988; 18:245-52.
- Keskinen H, Tupasela O, Tiikkainen U, Nordman H. Experiences of specific IgE in asthma due to di-isocyanates. *Clin Allergy* 1988; 18:597-604.
- Nordman H, Keskinen H, Tuppurainen M. Formaldehyde asthma-rare or overlooked? *J Allergy Clin Immunol* 1985; 75:91-9.
- Kanerva L, Jolanki R, Tupasela O, Halmepuro K, Keskinen H, Estlander T, Sysilampi M-L. Immediate and delayed allergy from epoxy resins based on diglycidyl ether of bisphenol A. *Scand J Work Environ Health* 1991; 17:208-15.
- Van Der Walle HB, Klecak G, Geleick H, Bensink T. Sensitizing potential of 14 mono(meth)acrylates in the guinea pig. *Con Derm* 1982; 8:223-35.
- Van Der Valle HB, Bensink T. Cross reaction pattern of 26 acrylic monomers on guinea pig skin. *Con Derm* 1982; 8:376-82.
- Van Der Valle HB, Waegemaekers TH, Bensink T. Sensitizing potential of 12 di(meth)acrylates in the guinea pig. *Con Derm* 1983; 9:10-20.
- Fisher AA. *Contact dermatitis*. 3rd ed. Philadelphia: Lea & Febiger, 1986.
- Björkner B. Kontaktallergi för ultraviolett härdande akrylatprodukter i färger och lacker. *Arbete och Hälsa* 1989; 20:27-34.
- Kanerva L, Estlander T, Jolanki R. Allergic contact dermatitis from dental composite resins due to aromatic epoxy acrylates and aliphatic acrylates. *Con Derm* 1989; 20:201-11.
- Fisher AA, Baran RL. Adverse reactions to acrylate sculptured nails with particular reference to prolonged paresthesia. *Am J Con Derm* 1991; 2:38-42.
- Rajaniemi R, Tola S. Subjective symptoms among dental technicians exposed to the monomer methyl methacrylate. *Scand J Work Environ Health* 1985; 11:281-6.
- Kanerva L, Turjanmaa K, Estlander T, Jolanki R. Occupational allergic contact dermatitis caused by 2-hydroxyethyl methacrylate (2-HEMA) in a new dentin adhesive. *Am J Con Derm* 1991; 2:24-30.
- Wass U. Studies on IgE antibodies induced by low-molecular weight chemicals (Doctoral dissertation). Göteborg (Sweden), University of Göteborg, 1989.
- Burge PS. Single and serial measurements of lung function in the diagnosis of occupational asthma. *Eur J Respir Dis* 1982; 63 (Suppl. 123):47-59.

Copyright of Clinical & Experimental Allergy is the property of Blackwell Publishing Limited and its content may not be copied or emailed to multiple sites or posted to a listserv without the copyright holder's express written permission. However, users may print, download, or email articles for individual use.