AMERICAN JOURNAL OF INDUSTRIAL MEDICINE 38:164–218 (2000)

Occupational Airway Sensitizers: An Overview on The Respective Literature

V. van Kampen, PhD, R. Merget, MD, and X. Baur, MD*

Background *Worldwide, there is rigorous scientific activity concerning the further development of work safety regulations involving airway-sensitizing substances. Technical directives on hazardous substances are enforced in several countries and are being continuously updated. The European Union has established a code for several occupational substances, now labeled R 42 (''may cause sensitization by inhalation'').*
Methods *We present an overview of the literature dealing with allergic occupational asthma. The literature was selected according to criteria of study design and diagnostic test methods. Approximately 300 publications were reviewed including both epidemiological studies and individual case reports.*
Results *Airway sensitizers are systematically arranged and separately listed according to chemicals and their origin from animals, plants, and microorganisms. The clinical data as well as threshold limit values (TLV) and R 42 labeling of 250 airway-sensitizing substances are presented.*
Conclusions *The most common sensitizing substances causing occupational asthma were dust of cereal flours, enzymes, natural rubber latex, laboratory animals as well as low molecular substances such as isocyanates and acid anhydrides.* Am. J. Ind. Med. 38:164–218, 2000. *© 2000 Wiley-Liss, Inc.*

KEY WORDS: airway sensitizers; occupational allergens; occupational asthma; epidemiological studies; case reports; clinical data

INTRODUCTION

Occupational asthma has become one of the most common occupational diseases in many industrialized countries [Chan-Yeung and Malo, 1994]. Many high-molecular-weight occupational agents and additionally some low-molecular-weight compounds induce asthma or rhinitis through an IgE-mediated mechanism. The directives for airway sensitizers are being continuously updated, and the European Union has labeled several substances with the R-phrase R 42 (''may cause sensitization by inhalation'') [Ordinance on Hazardous Substances, 1996].

The medical literature was searched for all identified airway-sensitizing occupational agents. In general, the term ''airway sensitizers'' refers to substances which cause bronchial asthma in human beings. We have included rhinitis, conjunctivitis and/or other diseases induced by airborne substances in the workplace if immunological mechanisms (in contrast to irritative mechanisms) are ensured or are at least probable.

It should be mentioned that the information in Table I deviates from the German *MAK and BAT value list* (**M**aximale **A**rbeitsplatz**k**onzentration und **B**iologische **A**rbeitsstoff**t**oleranzwerte—Maximum Concentrations and Biological Tolerance Values at the Workplace)[1] elaborated

Research Institute for Occupational Medicine (BGFA), Institute at the Ruhr-University of Bochum, Bochum, Germany
*Correspondence to: Xaver Baur, MD, BGFA, Bürkle-de-la-Camp-Platz 1, 44789 Bochum, Germany. E-mail: kampen@bgfa.ruhr-uni-bochum.de

Accepted 28th January 2000

[1] The MAK value is defined as the maximum concentration of a chemical substance in the workplace air which generally does not have known adverse effects on the health of the employee nor cause unreasonable annoyance even when the person is repeatedly exposed during long periods, given a 40-hour working week. The BAT value is defined as the maximum permissible quantity of a chemical substance or its metabolites or the maximum permissible deviation from the norm of biological parameters induced by the substances in exposed humans.

by the Commission for the Investigation of Health Hazards of Chemical Compounds in the Work Area of the "Deutsche Forschungsgemeinschaft." In contrast to the MAK evaluations, Table I also considers agents whose airway-sensitizing potential was established in single cases, and thus is much more comprehensive. It was beyond the scope of this study to evaluate frequency of reported cases and frequency of exposure in workplaces. Further, the relative risk of individual substances, i.e., the frequency of adverse effects in relation to cumulated doses, was not estimated because concrete figures on the number of exposed subjects and exposure degree and duration are not available.

METHODS

Literature Selection and Evaluation

Abstracts were selected from the MEDLINE databank which contains about 9 million medical citations. The keywords "occupational," "asthma" as well as "allergy" were used to search.

The criteria used for article selection were: (1) Cross-sectional or longitudinal studies completed using established epidemiological methods. (2) Sequential investigations on a large number of subjects, preferably including controls. (3) If epidemiological studies on the respective agent were not available case reports were chosen which included comprehensive diagnostic testing. If several studies were available for a given substance, we chose up to three publications which best corresponded to the above criteria and clearly verified the sensitizing potential of the substance. As specific bronchial challenge tests are considered the gold standard, studies with these data were preferred.

About 300 original publications, the Ordinance on Hazardous Substances (1996), and the *MAK and BAT value list* were the major sources of Table I. All R 42 labeled substances (EU category) were included. The label R 42 indicates that these substances "may cause sensitization by inhalation." Frequently, R 42 is combined with R 43 ("may cause sensitization by skin contact"). These cases are indicated in the table. In addition, substances without the R 42 label are included which, according to international publications, have proven to be sensitizing.

Subjective influences due to literature selection cannot be excluded. Our aim was not to get a comprehensive list of all published studies or to summarize information from several studies but to denote airway sensitizers which, according to peer-reviewed publications (exceptions are labeled in Table I), have proven to be sensitizing.

Arrangement of Substances

Airway sensitizers are systematically arranged in four general categories: chemicals, and their origin in animals, plants or microorganisms. The authors endeavored to group the multitude of chemicals. According to corresponding botanical and zoological systems, substances from these origins were arranged. Those clearly originating from plants (e.g., abietic acid, 3-carene) or animals (casein, egg protein) were assigned accordingly. Enzymes were grouped independently of their original organisms while indicating their origin in brackets.

Other Data Presented

USA TLV-TWA. The USA TLV-TWA (threshold limit value-time weighted average) refers to the concentration (weight and volume proportion) of a hazardous substance in workplace atmospheres. If not otherwise indicated, TLV-TWA values are shift mean values of an 8-hour exposure/day and of an average 40-hour working period/week.

European label (EU label). This column shows whether the respective substance is classified as airway-sensitizing pertaining to category R 42 or R 42/43.

German TLV-TWA. The German TLVs-TWAs in this column are published in the Technical Directive on Hazardous Substances 900 (TRGS 900) "Limit values in workplace atmospheres." In 1996 and 1997, 155 foreign (international) exposure limit values were incorporated into the TRGS 900. Nonstatutory categorizations that deviate from mentioned limit values are indicated in brackets; these MAK values are health-based and recommended. So far, they have not been included in the TRGS 900.

Sa or Sah (atemwegssensibilisierender Stoff or atemwegs- und hautsensibilisierender Stoff). "Sa" is used in the *MAK and BAT value list* to designate substances which can cause allergic symptoms of the airway and also of the conjunctiva (substances causing airway sensitization). Substances which have sensitizing effects on the airway and the skin are designated with "Sah."

Symptoms: This column shows work-related symptoms reported by the exposed workers (usually in a questionnaire). If indicated in published longitudinal or cross-sectional studies, prevalences, and incidences of individual symptoms were incorporated. If not differentiated in detail, the indicated total prevalence refers to the total of work-related symptoms.

Methods.

LFT. Lung function tests were performed.

Skin prick test (SPT). It was noted if skin prick tests with the respective substance were performed and how many subjects showed a reaction. If other types of skin test (patch, scratch or intradermal) were performed, it is indicated in the table.

Specific challenge. If specific challenge tests with the respective substance were performed, the number of subjects who showed a positive response is indicated. If not otherwise indicated, bronchial challenge was performed. A decline of FEV1 $\geq$ 20% was regarded as positive.

Antibodies. It was remarked if allergen-specific antibodies were measured in the serum and, if yes, which antibody classes were investigated. In case of positive findings, the percentage of patients with antibodies is indicated.

RESULTS AND DISCUSSION

The clinical data of about 250 occupational airway sensitizers were evaluated on the basis of approximately 300 scientific publications. Sensitizers were classified into four groups: chemicals and agents originating from animals, plants or microorganisms. Within these groups the substances (in alphabetical order) were arranged in subgroups such as isocyanates, anhydrides or amines in the group of chemicals and mites, insects or fish (Table I).

Not only pure substances but also product mixtures used in workplaces were considered. In case of cyanoacrylates for instance, clinical tests (bronchial challenge tests etc.) were generally performed with adhesives which contained components of other materials up to 5%. Due to the probability that the symptoms of subjects were induced by cyanoacrylates and not by additives, these agents were also included in the table with a corresponding note.

Instead of itemizing each individual substance, groups of substances with the same effect were listed (e.g., chloroplatinates, chromates). Wood for instance was even evaluated when only the genus (e.g., oak) and not the species (e.g., silver oak) had been reported. Thus, our procedure differs from that of the *MAK Commission* whose list almost uniformly evaluates individual substances. Even if identical mechanisms are assumed and/or the European labeling R 42 of a whole group exists, we did not include structural analogues in the table when substance-specific investigations in humans are lacking. Phenyl isocyanate for instance was not listed since human investigations have not been performed.

It can be assumed that many workers described in individual studies were exposed to a mixture of materials. The individual substances in Table I are the components with which the subjects were tested (skin test, specific bronchial challenge test and antibody determination).

Table I includes the clinical data on airway-sensitizers described in international investigations that fulfil our quality requirements. Since these original data are heterogeneous due to different study designs and applied test methods, a comparative assessment of individual substances, e.g., the potency of sensitization, was not performed.

However, the listed data show that some substances or substance groups are of major importance:

1. The list of airway-sensitizing agents includes 16 enzymes. Their strongly sensitizing potential was demonstrated in almost every study by skin prick test (prevalences of positive results were 5.2–41%) and detection of specific IgE antibodies (prevalences 16–52%) as well as additionally in about 50% of investigations by specific bronchial challenge tests. Enzymes at air concentrations of approximately 1 ng/m^3 were shown to be important occupational allergens.
2. Among plant allergens, cereal flour dust is particularly relevant due to its wide distribution. In Germany, currently 15–20 million tons of wheat flour are annually produced, and the number of exposed people in bakeries amount to about 100,000. Obstructive airway diseases due to airway sensitizations to wheat/rye flour in this trade were reported with an annual incidence rate of approximately 800 per 100,000 employees.
3. The worldwide consumption of natural rubber latex was about 6 million tons in 1997 and is calculated to increase to 11 million tons up to the year 2020. Regarding the risk of sensitization, the use of natural rubber latex gloves in health care work is of great importance. The yearly consumption in the USA amounts to about 10 billion pairs and in Germany to about 1 billion pairs. In 1997, 365 (35.6%) of a total of 1025 reports of occupational diseases due to suspected allergic obstructive airway diseases that were registered by the German "Berufsgenossenschaft für Gesundheit und Wohlfahrtspflege" (Statutory Accident Insurance Institute for Health Care) were attributed to natural rubber latex exposure. Accident insurance carriers in the public sector registered a comparable number (Report by the German Federal Ministry of Labor and Social Affairs, 1998).
4. The prevalence of airway diseases due to dust originating from laboratory animals approaches 15% of exposed employees. No definite data on the number of exposed employees in Germany are available. For example, it has been estimated that approximately 90,000 workers in the USA and more than 30,000 in the United Kingdom handle laboratory animals (Fisher et al., 1998).
5. Among chemicals, isocyanates are of special relevance. The worldwide production is in the range of 5 million tons, and the number of exposed subjects is estimated to be about 500,000. The detection of specific IgE antibodies as well as specific bronchial challenge tests in several studies revealed average prevalences of immediate-type allergy of approximately 1%. The prevalence of airway diseases induced by isocyanates is about 5%.
6. The absolute number of subjects with platinum salt allergy are low, but in some occupational settings, e.g., precious metal refineries and catalyst productions those developing chronic airway diseases number 50%.

Although the yearly production amounts to only a few tons and worldwide only few workers (2,000–3,000 are exposed) the hazard is significant.

It should be mentioned that a direct comparison of prevalences or incidences given in different epidemiological studies seems not to be feasible here because the frequency of disorders may be modified by various parameters; e.g., in crosssectional studies the ''healthy worker effect'' can bias observed results while in longitudinal studies the duration of the observation period or the exposure time can influence the incidence.

It should also be noted that the information in Table I differs from hitherto published lists of allergens (e.g., Chan-Yeung and Malo, 1994) in that additional materials and aspects were included, and a greater number and more recent publications were considered.

In conclusion, we would like to mention that in spite of our efforts to select suitable and comprehensive references, this list does not claim to be complete. By definition, the list may contain some biases of perspective. Therefore, we caution non-scientists in its use when applying its conclusions to complex work-related problems. We have taken great care to correctly represent the data; however, we realize that some important publications may be missing or that errors in evaluating the material may have occurred.

Characteristics for exact identification of substances
Abbreviation
Formula
MW: molecular weight
CAS-number: chemical abstract service number
Threshold limit values and marking
TLV-TWA (USA): Threshold Limit Value-Time Weighted Average in the USA
EU-Label: R 42: may cause sensitization by inhalation
R 43: may cause sensitization by skin contact
TLV-TWA (Germany): Threshold Limit Value-Time Weighted Average in Germany
Sa: airway sensitizer according to the German *MAK and BAT value list*
Sah: airway and skin sensitizer according to the German *MAK and BAT value list*
( ): proposed of threshold limit value
Type of study
Reference: first two authors and year of publication
#: peer review: not ascertained
L: longitudinal study
C: cross-sectional study
S: investigation of symptomatic people
CR: case reports ($n > 1$)
I: individual case reports ($n = 1$)
n: number of examined exposed workers
Diagnoses/Symptoms
R: rhinitis
Con: conjunctivitis
A: asthmatic symptoms
Cou: cough
S: skin
Tot: total of work-related symptoms
nd: not done
Test methods
LFT: lung function test
SPT: skin prick test
Spec. challenge: specific bronchial challenge test
Antibodies: Antibody determination
$\times$: done, $+$: positive, $-$: negative, nd: not done
If the whole collective was not investigated by skin prick test, challenge, or antibody determination this is indicated in the column, e.g. the entry ''9% of 53'' means that fifty-three people were tested; 9% of them with positive results.

TABLE I. Sensitizing Substances Which have been Shown to Cause Occupational Asthma[a]

Substances	Abbreviation	Formula	MW	CAS-Number	TLV-TWA (USA)	EU Label	TLV-TWA (Germany)	Sa Sah	Reference	Study	n	Symptoms R	Con.	A	Cou.	S	Tot.	Methods LFT	Skin test	Spec. challenge		Antibodies		Remarks
Chemicals																								
Isocyanates																								
1,3-bis-(isocyanatomethyl)-cyclohexane, prepolymer		$C_6H_{10}(CH_2NCO)_2$	194.24	38661-72-2					Simpson, Garabrant et al. [1996]	S	23	–	–	+	+	–	nd	×	nd	nd		nd		Number of symptomatic subjects; n = 34 (68%)
Diphenylmethane diisocyanate	MDI	$C_{15}H_{10}N_2O_2$	250.26	Total MDI: 9016-87-9, 4,4′: 101-68-8, 2,4′: 5873-54-1, 2,2′: 2536-05-2	0.005 ppm; 0.051 mg/m^3	R 42	0.005 ppm; 0.05 mg/m^3	Sah	Zammit-Tabona, Sherkin et al. [1983]	S	11	–	–	+	–	–	nd	×	nd	×	64%	×	IgE IgG	18% 36%	
Diphenylmethane diisocyanate, prepolymer	PMDI	2-6 × MDI		9016-87-9		R 42		Sah	Vandenplas, Malo et al. [1993b]	S	9	–	–	+	+	–	nd	×	nd	×	89%	×	IgE IgG	100% 100%	Diagnosis in 8 subjects = hypersensitivity pneumonitis (BALF in 2 subjects)
Hexamethylene diisocyanate	HDI	$C_6H_{12}N_2O_2$	168.2	822-06-0	0.005 ppm; 0.034 mg/m^3	R 42/43	0.01 ppm; 0.07 mg/m^3 (0.035 mg/m^3)	Sa	Welinder, Nielsen et al. [1988]	C	30	43%	43%	33%	–	–	nd	nd	nd	nd		×	IgE IgG	not elevated; elevated	Comparison of median antibody values between exposed subjects and 22 controls
Hexamethylene diisocyanate, prepolymer									Vandenplas, Cartier et al. [1993a]	S	20	–	–	+	–	–	nd	×	nd	×	45%	×	IgE IgG	15% 30%	Challenge: 4 out of 9 positive subjects reacted to polymers but not to monomers
Isophorone diisocyanate	IPDI	$C_{12}H_{18}N_2O_2$	222.29	4098-71-9	0.005 ppm; 0.045 mg/m^3	R 42/43	0.01 ppm; 0.09 mg/m^3	Sah	Clarke, Aldons [1981]	I	1	–	–	+	–	–	nd	×	nd	×	+	nd			
Methylisocyanate	MIC			624-83-9	0.02 ppm; 0.047 mg/m^3	R 42	0.01 ppm; 0.024 mg/m^3		Avashia, Battigelli et al. [1996]	C	308	–	–	4,5%	–	–	nd	×	nd	nd		nd			Long-term exposure with low MIC concentrations: no LFT deterioration (may be concentration too low)
Naphthalene diisocyanate	NDI			3173-72-6		R 42	0.01 ppm; 0.09 mg/m^3	Sa	Fuortes, Kiken et al. [1995]	C	26	–	–	+	–	–	54%	×	nd	nd		nd			
”									Harries, Burge et al. [1979a]	CR	3	–	–	+	+	–	nd	nd	nd	×	100%	nd			Challenge: 1 dual reaction, 2 late bronchial ones
Toluene diisocyanate	TDI	$C_9H_6N_2O_2$	174.15	2,4: 584-84-9 2,6: 91-08-7	0.005 ppm; 0.036 mg/m^3	R 42	0.01 ppm; 0.07 mg/m^3	Sa	Baur, Fruhmann [1981]	C	195	–	–	+	–	–	28%	nd	nd	×	70.6% of 17	×	IgE	4.6%	Cross-reactivity between different isocyanate-HSA conjugates
”									Moscato, Dellabianca et al. [1991]	S	113	–	–	+	+	–	nd	×	nd	×	40%	nd			Methacholine challenge test does not indicate isocyanate asthma
”									Mapp, Corona et al. [1988]	S*	35	–	–	+	+	–	nd	×	nd	×	77%	nd			*Follow-up examination after 11 months; 8 out of 30 (27%) not exposed subjects during this period were without symptoms
Toluene diisocyanate, prepolymer					0.5 mg/m^3				Vandenplas, Cartier et al. [1992]	CR	2	+	–	–	+	–	nd	nd	nd	×	100%	×	IgE IgG	– –	

TABLE I. (*Continued*)

Substances	Abbreviation	Formula	MW	CAS-Number	TLV-TWA (USA)	EU Label	TLV-TWA (Germany)	Sa Sah	Reference	Study	n	Symptoms R	Con.	A	Cou.	S	Tot.	Methods LFT	Skin test	Spec. challenge	Antibodies		Remarks
Toluene diisocyanate, hexamethylene diisocyanate, diphenylmethane diisocyanate									Baur [1986]	C	621	+	+	+	−	+	40%	nd	× 9% of 53	× 100% of 2	×	IgE 5.8%	
”									Baur [1995]	S	14	−	−	+	+	−	nd	×	nd	× 100% of 5	×	IgE IgG − 71%	Total group = 1780 subjects; Diagnosis = hypersensitvity pneumonitis (BALF in 6 subjects)
Anhydrides																							
Hexahydrophthalic anhydride	HHPA	$C_8H_{10}O_3$	154.17	85-42-7				Sa	Drexler, Weber et al. [1994]	C	110	+	+	+	−	−	nd	nd	× 54% of 13	× 75% of 8	×	IgE 14.7%	Mixed exposure: HHPA+MTHPA
”									Moller, Gallagher et al. [1985]	C*	27	+	+	+	−	−	81%	×	nd	nd	×	IgE 44% IgG 41%	*:Examination of voluntary subjects (majority presumably symptomatic)
Himic anhydride		$C_9H_8O_3$	164.16	2746-19-2					Rosenman, Bernstein et al. [1987]	C	20	−	−	35%	−	−	nd	nd	nd	nd	×	IgE 43% of 7	Cross-reactivity between himic anhydride and HHPA
Maleic anhydride	MA	$C_4H_2O_3$	98.06	108-31-6	0.25 ppm; 1 mg/m^3	R 42	0.1 ppm; 0.4 mg/m^3	Sah	Lee, Wang et al. [1991]	I	1	+	−	+	+	−	nd	×	nd	× 100%	nd		Additional exposure to PA; but negative challenge with PA
Methylhexahydrophthalic anhydride	MHHPA		169.19	19438-60-9					Tarvainen, Jolanki et al. [1995]	I	1	+	−	−	−	−	nd	nd	×	+ nd	×	IgE +	Cross-reactivity with MTHPA
Methyltetrahydrophthalic anhydride	MTHPA	$C_9H_{12}O_4$	184	3-MTHPA: 88335 93-7; 4-MTHPA: 26590-20-5				Sa	Drexler, Weber et al. [1994]	C	110	+	+	+	−	−	nd	nd	×	+ ×	75% of 8	× IgE 13.8%	Mixed exposure: HHPA+MTHPA
”									Nielsen, Welinder et al. [1989]	I	1	+	−	+	+	−	nd	nd	×	+ nd	×	IgE + IgG −	When on vacation and in another workplace had fewer complaints
”									Welinder, Nielsen et al. [1990]	C	145	?	?	?	?	?	nd	nd	×	16% nd	×	IgE 18% IgG 12%	Compared to controls, specific IgE in exposed subjects significantly elevated
Phthalic anhydride	PA	$C_8H_4O_3$	148.12	85-44-9	1 ppm; 6.1 mg/m^3		1 mg/m^3	Sa	Nielsen, Bensryd et al. [1991]	C	23	39%	48%	9%	17%	−	nd	×	×	− nd	×	IgE Not elevated; IgG signif. elevated	Antibodies compared to controls (n = 19). Symptoms in exposed subjects distinctly more frequent
”									Wernfors, Neilsen et al. [1986]	C	118	24%	−	28%	−	−	nd	×	×	27% of 11*	×	100% of 2 × IgE 100% of 2	*Skin test: scratch Determination of allergen-specific IgE by Prausnitz-küstner test
Pyromellitic dianhydride	PMDA	$C_{10}H_2O_6$	218.13	89-32-7					Meadway [1980]#	C	7	+	−	+	−	+	57%	×	nd	×	29%*	nd	*Challenge: FEV1 decrease of 15% or 18% regarded as positive
Tetrachlorophthalic anhydride	TPCA	$C_8Cl_4O_3$	285.9	117-08-8					Liss, Bernstein et al. [1993]	C	52	−	−	+	−	−	27% 36%	×	nd	nd	×	IgE 31% of 49 IgG 39% of 49	

TABLE I. (*Continued*)

Substances	Abbreviation	Formula	MW	CAS-Number	TLV-TWA (USA)	EU Label	TLV-TWA (Germany)	Sa	Sah	Reference	Study	n	Symptoms R	Con.	A	Cou.	S	Tot.	Methods LFT		Skin test		Spec. challenge		Antibodies		Remarks
Tetrachlorophthalic anhydride										Barker, Harris et al. [1998a]	S*	6	−	−	+	−	−	nd	×	×	60% of 5	nd		×	IgE	100%	*Examination: 12 years after activity termination. SPT at the beginning: 100% out of 6, IgE decreased in 100% during 12 year
Trimellitic anhydride	TMA	$C_9H_4O_5$	192.13	552-30-7		R 42	0.04 mg/m^3	Sa		Zeiss, Mitchell et al. [1992]	C	474	+	−	+	−	−	nd	nd	nd		nd		×	IgE	6.8%	Sensitivity probability increases together with activity duration
Pyromellitic dianhydride, phthalic anhydride, maleic anhydride										Baur, Czuppon et al. [1995b]	C	92	+	+	+	−	+	61%	×	×	+	nd		×	IgE	16.3%	
Phthalic anhydride, trimellitic anhydride, maleic anhydride										Barker, van Tongeren et al. [1998b]	C	401	+	−	+	−	−	9%	×	×	3.2% of 378	nd		nd			Positive SPT correlates with symptoms
Amines																											
Amino ethyl ethanolamine		$C_4H_{12}N_2O$	104.15	111-41-1						Pepys, Pickering [1972]	S	3	−	−	+	+	−	nd	×	nd		×	100%	nd			
Aliphatic amines	EDA, DETA, TETA									Ng, Lee et al. [1995]	C	12	+	+	33%	58%	−	nd	×	nd		×	50% of 2*	nd			*Challenge.: EDA
2-Dimethyl ethanolamine		$C_4H_{11}NO$	89.14	108-01-0						Vallieres, Cockcroft et al. [1977]	I	1	+	−	+	−	−	nd	×	×	+*	×	100%	nd			SPT in non-exposed controls positive −>irritative effect
3-Dimethylamino propylamine	3-DMAPA	$C_5H_{14}N_2$	102.18	109-55-7						Sargent, Brubaker et al. [1976]	C	25	−	24%	44%	−	−	nd	×	nd		nd		nd			
"										Brubaker, Muranko et al. [1979]	C	28	18%	−	−	−	−	nd	×	nd		nd		nd			Same enterprise as in Sargent, Brubaker et al. [1976] but after ventilation installation; ambient air load reduced to 1/7
2-Ethanolamine		C_2H_7NO	61.08	141-43-5	3 ppm; 7.5 mg/m^3		3 ppm; 8 mg/m^3 (5 mg/m^3)			Savonius, Keskinen et al. [1994]	I	1	+	−	+	+	−	nd	×	nd		×	+	nd			Fever indicated hypersensitivity pneumonitis, could not be confirmed by LFT
Ethylenediamine		$C_2H_8N_2$	60.1	107-15-3	10 ppm; 25 mg/m^3	R 42/43	10 ppm 25 mg/m^3			Nakazawa, Matsui [1990]#	CR	2	−	−	+	+	−	nd	×	×	+	×	+	×	IgE IgG	100% −	Skin test: patch negative; intradermal positive
Hexamethylenetetramine	HTMA	$C_6H_{12}N_4$	140.19	100-97-0		R 42/43				Gamble, McMichael et al. [1976]	C	52	+	−	+	+	−	nd	×	nd		nd		nd			HMTA was available as HMTA resorcinol. LFT: comparison to 50 non-exposed controls −> values of exposed subjects significantly lower
4-Methylmorpholine	NNM	$C_5H_{11}NO$	101.15	109-02-4			20 mg/m^3			Belin, Wass et al. [1983]	C	48	−	+	27%	−	−	nd	×	nd		nd		nd			Also exposure to isocyanates but concentrations below MAK; NMM concentration 10,000 times higher
Piperazine		$C_4H_{10}N_2$	86.14	110-85-0	5 mg/m^3	R 42/43			Sah	Hagmar, Welinder [1986]	C	72	−	−	31%	−	−	nd	×	nd		nd		×	IgE	7%	IgE specifity confirmed by RAST inhibition
Piperazine dihydrochloride		$C_4H_{10}N_2(2HCl)$	159.05	142-64-3						Welinder, Hagmar et al. [1986]	CR	2	−	−	+	−	−	nd	×	×	50%	nd		×	IgE	100%	IgE antibodies to piperazin and N-methyl piperazin; RAST inhibition

TABLE I. (*Continued*)

Substances	Abbreviation	Formula	MW	CAS-Number	TLV-TWA (USA)	EU Label	TLV-TWA (Germany)	Sa	Sah	Reference	Study	n	Symptoms R	Con.	A	Cou.	S	Tot.	Methods LFT	Skin test	Spec. challenge		Antibodies		Remarks
Triethylene tetramine		$C_6H_{18}N_4$	146.24	112-24-3						Fawcett, Taylor et al. [1977]	I	1	+	+	+	−	−	nd	nd	×	−*	×	100%	nd		*Skin test: patch
”										Savonius, Keskinen et al. [1994]	CR	2	+	+	+	+	−	nd	×	nd		×	100%	nd		
Metals and their compounds																										
Chromium																										
Chromium (VI) salts		Cr	52	7440-47-3	0.01–0.5 mg/m^3		*0.05–0.1 mg/m^3																		*:Dependent on processing
Chromium sulphate		$Cr_2(SO_4)_3$	374	15244-38-9						Park, Yu et al. [1994]	CR	4	+	−	+	−	−	nd	×	×	+	×	100%	nd		SPT: 2 out of 4 positive; patch: 2 different subjects positive
Chromium sulphate and nickel sulphate		$Cr_2(SO_4)_3$ and $NiSO_4$								Novey, Habib et al. [1983]	I	1	−	−	+	+	−	nd	×	×	−	×	+	×	IgE	100%	Challenge: Cr: immediate bronchial reaction, Ni: dual bronchial reaction
Cobalt		Co	58.93	7440-48-4	0.02 mg/m^3	R 42/43	*0.1–0.5 mg/m^3		Sah	Gheysens, Auwerx et al. [1985]	CR	3	+	+	+	+	+	nd	×	nd		×	100%	nd			*: Dependent on processing. Challenge with cobalt powder: 2 late bronchial reactions, 1 immediate reaction
”										Shirakawa, Morimoto [1997]	C	281	−	−	14%*	−	−	nd	nd	nd		nd		×	IgE	2.5%	*: Asthma IgE to Co-HSA. Significantly elevated IgE level of exposed compared to non-exposed subjects
Cobalt sulphate		$CoSO_4$	137	60459-08-7						Pisati, Zedda [1994]	S	9	−	−	+	−	−	nd	×	×	44%	×	100%	nd			After 1 year: 8 workers quit job: 2 healthy, 5 improved, 1 stable
Cobalt and nickel sulphate										Shirakawa, Kusaka et al. [1990]	CR	8	−	−	+*	−	−	nd	×	×	Co 75% Ni 63%	×	Co 100% Ni 88%	×	IgE	Co 63% Ni 50%	*: Hard metal asthma; IgE in comparison to controls. According to authors, tungsten inert, does not induce asthma
Iridium																										
Iridium Chloride		$IrCl_3$	298.56	10025-83-9						Bergman, Svedberg et al. [1995]	I	1	+	+	+	−	−	nd	nd	×	+	nd		nd			SPT with hexachloroplatinate negative
Nickel		Ni	58.69	7440-02-0	(1 mg/m^3)		0.5 mg/m^3																			
Nickel sulphate		$NiSO_4$	154.86	7786-81-4		R 42/43			Sah	Estlander, Kanerva et al. [1993]	I	1	−	−	+	+	+	nd	nd	×	+	×	+	×	IgE	Elevated	Patch also positive
”										Malo, Cartier et al. [1982]	I	1	−	−	+	−	−	nd	×	×	+	×	+	×	IgE	Elevated	
Platinum		Pt	195.08	04.06.7440	1 mg/m^3		1 mg/m^3		Sah																	
Chloroplatinates					0.002 mg/m^3 (salt)		0.002 mg/m^3		Sah	Baker, Gann et al. [1990]	C	107	43%	−	26%	−	12%	nd	×	×	14%	nd		nd			Positive SPT with elevated total IgE and positive challenge associated with cold air
Hexachloroplatinate		H_2PtCl_6							Sah	Merget, Schultze-Werninghaus et al. [1988]	C	30	−	−	+	−	−	27%	nd	×	38% of 26	nd		×	IgE	Elevated	SPT of highly exposed subjects positive. Elevated specific IgE in symptomatic

TABLE I. (*Continued*)

Substances	Abbreviation	Formula	MW	CAS-Number	TLV-TWA (USA)	EU Label	TLV-TWA (Germany)	Sa	Sah	Reference	Study	n	Symptoms R	Con.	A	Cou.	S	Tot.	Methods LFT	Skin test	Spec. challenge		Antibodies		Remarks
																									subjects. Correlation with high total IgE—> non-specific binding
Ammonium hexachloroplatinate		$Cl_6H_8N_2Pt$	443.89	16919-58-7					Sah	Murdoch, Pepys et al. [1986]	C	306	–	–	–	–	–	nd	nd	×	12%	nd	×	IgE	Elevated (in 7.5%)	Elevated specific IgE in 61% of SPT positive subjects, but only in 6% of SPT negative subjects
Potassium																									
Potassium dichromate		$K_2Cr_2O_7$	294.19	7778-50-9						Keskinen, Kalliomaki et al. [1980]	CR	2	–	–	+	–	–	nd	nd	×	50%*	×	100%	nd			*Skin test: patch patients are welders
Potassium dichromate and nickel chloride		$K_2Cr_2O_7$ and $NiCl_2$								Bright, Burge et al. [1997]	CR	7	–	–	+	–	–	nd	×	×	Cr 29% Ni 57%	×	Cr: 100% of 7; Ni: 40% of 5	nd			Challenge: Cr: 5 immediate, 3 late bronchial reactions; Ni: 2 late bronchial reactions
Potassium hexachloroplatinate		K_2Cl_6Pt	486.01	16921-30-5					Sah	Bolm-Audorff, Bienfait et al. [1992]	C	65	+	+	+	–	–	23%	×	×	19% of 64	nd	×	IgE	Elevated	Elevated specific and total IgE in symptomatic subjects. No increase in histamine release
Tungsten		W	183.85	7440-33-7	1–5 mg/m^3		*1–5 mg/m^3																		*: According to solubility
Tungsten carbide		W_2C	379.71	11130-73-7	1–5 mg/m^3		*1–5 mg/m^3			Bruckner [1967]	I	1	–	–	+	+	–	nd	nd	nd		nd		nd			*: According to solubility; workplace observations: mask (∅ 0,6 μm; symptoms remain
Zinc (fume, steam)		Zn	65.39	7440-66-6						Malo, Cartier et al. [1993]	I	1	+	–	+	–	–	nd	×	×	+	×	+	×	IgE	Not elevated	
Zinc chloride and ammonium chloride										Weir, Robertson et al. [1989]	CR	2	–	–	+	+	–	nd	×	nd		×	+	nd			Challenge: pure substances: weak bronchial reactions
Medicaments																									
Aminophylline		$C_{16}H_{24}N_{10}O_4$	420.4	317-34-0						Rosenberg, Aaronson et al. [1984]	CR	2	–	–	+	+	–	nd	×	×	50%	×	100%	nd			Challenge: bronchial reaction after 8 h
Ampicillin		$C_{16}H_{19}N_3O_4S$	349.4	69-53-4						see Davies, Hendrick et al. [1974]															
Amprolium hydrochloride				121-25-5						Greene, Freedman [1976]	I	1	+	–	+	–	–	nd	×	nd		×	+	nd			
Cephalosporin C zinc salt		$C_{16}H_{19}N_3O_8S\,Zn$	478.79	59143-60-1						Stenton, Dennis et al. [1995]	I	1	+	–	+	–	–	nd	×	nd		×	+	nd			Tests with ceftazidim (cephalosporin of the third generation)
”										Coutts, Dally et al. [1981]	CR	2	–	–	+	+	–	nd	nd	×	100%	×	100%	nd			7-Aminocephalosporin acid (7ACA)+tylosilate dihydrate derivate (7CTD)
Chlorhexidine		$C_{22}H_{30}Cl_2N_{10}$	505.46	55-56-1						Waclawski, McAlpine et al. [1989]	CR	2	–	–	+	+	–	nd	×	nd		×	100%*	nd			*Challenge: FEV1 decline 13 or 22%
Cimetidine		$C_{10}H_{16}N_6S$	252.34	51481-61-9						Coutts, Lozewicz et al. [1984]	C	55	–	–	+	–	–	36%	nd	×	–	×	25% of 4	nd			Challenge: Additionally to1 late bronchial reaction 2 nasal reactions

TABLE I. (*Continued*)

Substances	Abbreviation	Formula	MW	CAS-Number	TLV-TWA (USA)	EU Label	TLV-TWA (Germany)	Sa	Sah	Reference	Study	n	Symptoms R	Con.	A	Cou.	S	Tot.	Methods LFT	Skin test		Spec. challenge		Antibodies		Remarks
Ciprofloxacin										Broding, Chen et al. [1996]	CR	2	−	−	+	−	−	nd	×	×	50%	×	100%	×	IgE	−	
Hydralazine		$C_8H_4N_4$	160.18	304-20-1						Perrin, Malo et al. [1990]	I	1	−	−	+	+	−	nd	nd	×	−	×	+	×	IgE IgG	− −	
Ipecacuanha										Luczynska, Marshall et al. [1984]	C	42	+	+	+	−	−	48%	nd	×	33%	nd		×	IgE	44% of 32	12 out of 18 SPT-pos. subjects and 2 out of 14 SPT-neg. subjects had spec. IgE
Isonicotinic acid hydrazine	INH	$C_6H_7N_3O$	137.15	54-85-3						Asai, Shimoda et al. [1987]	I	1	+	−	+	−	−	nd	nd	×	+	×	+	×	IgE*	+	*IgE detection: Prausnitz-Küstner
”										Shimoda [1990]	C	8	−	−	+	−	−	25%	nd	×	25%	×	100% of 2	×	IgE	63%	Cross-reactivity between INH and metabolite isonicotin acid (INA)
Methyldopa		$C_{10}H_{13}NO_4$	211.12	555-30-6						Harries, Taylor et al. [1979b]	I	1	−	−	+	−	−	nd	nd	×	−	×	+	×	IgG	−	Challenge: late bronchial reaction (Max. FEV1 decline after 11 h)
Opiate compounds										Biagini, Bernstein et al. [1992]	C	39	−	−	+	−	+	54%	×	×*		nd		nd			*SPT: M-6-HS-HSA, dihydrocodein,hydrocodon, codein significant elevated compared to controls
Penicillamine		$C_5H_{11}NO_2S$	149.21	52-67-5 (D-form)						Lagier, Cartier et al. [1989]	I	1	−	−	+	−	−	nd	×	×	−	×	+	nd			Reaction probably not IgE-mediated
Penicillin and penicillin derivatives				1404-05-9						Davies, Hendrick et al. [1974]	CR	4	+	−	+	−	+	nd	×	×	−	×	75%	nd			Challenge: late bronchial reactions
”										Stejskal, Forsbeck et al. [1987]	CR	8	+	−	+	−	+	nd	nd	×	63%	nd		nd			Lymphocyte transfer test: all subjects positive; penicillin sidechain important to reaction
”										Shmunes, Taylor et al. [1976]	C	169	−	+	+	−	+	40%	nd	×	11% of 9	nd		×	IgG IgM	43% and/or	
Piperacillin		$C_{23}H_{26}N_5NaO_7S$	539.5	59703-84-3						Moscato, Galdi et al. [1995]	I	1	+	−	+	−	+	nd	×	×	+	×	+	nd			IgE to other antibiotics negative
Phenylglycine acid chloride										Kammermeyer, Mathews [1973]	C	24	−	−	+	−	−	29%	×	×	38%	×	100% of 2	×	IgE*	100% of 3	*IgE detection: Prausnitz-Küstner reaction
Psyllium				8063-16-9						Vaswani, Hamilton et al. [1996]	I	1	−	−	+	−	−	nd	nd	×	+	nd		×	IgE	+	ELISA inhibition positive
”										Marks, Salome et al. [1991]	C	125	−	+	6%*	−	+	52%	×	×	8% of 118	nd		nd			*:Asthma
Salbutamol (including prestages)		$C_{13}H_{21}NO_3$	239.31	18559-94-9						Agius, Davison et al. [1994]	CR	2	+	−	+	+	−	nd	×	×	−	×	100% of 1	nd			
Senna										Helin, Makinen-Kiljunen [1996]	I	1	+	+	+	−	−	nd	×	×	+	×	+	×	IgE	+	Immunoblot: strong IgE binding 16 kDA
”										Marks, Salome et al. [1991]	C	125	−	+	6%*	−	+	52%	×	×	15% of 118	nd		nd			*:Asthma
Spiramycin				8025-81-8						Moscato, Naldi et al. [1984]	CR	2	−	−	+	+	−	nd	×	×	−	×	100%	nd			

TABLE I. (*Continued*)

Substances	Abbreviation	Formula	MW	CAS-Number	TLV-TWA (USA)	EU Label	TLV-TWA (Germany)	Sa Sah	Reference	Study	n	Symptoms R	Con.	A	Cou.	S	Tot.	Methods LFT	Skin test	Spec. challenge		Antibodies		Remarks
Spiramycin									Malo, Cartier [1988]	C	51	–	–	8%*	+	–	nd	×	× **		×	25% of 12	nd		*:Asthma; **SPT result not interpretable: reactions to 0.1 but not to1 mg/ml
Tetrachloroisophthalonitrile				1897-45-6					Honda, Kohrogi et al. [1992]	I	1	–	–	+	–	–	nd	×	×	+*	×	+	×	IgE –	*Skin test: patch
Tetracycline		$C_{22}H_{24}N_2O_8$	444.4	60-54-8					Menon, Das [1997]	I	1	–	–	+	+	–	nd	×	×	+	×	+	nd		Oral challenge also positive
Tributyl tin oxide		$C_{24}H_{54}OSn_2$	596.08	56-35-9			0.002 ppm; 0.05 mg/m^3		Shelton, Urch et al. [1992]	I	1	+	–	+	–	–	nd	×	×	–	×	+*	nd		*Challenge: FEV1 decline by 19%
Tylosin tartrate		$C_{46}H_{77}NO_{17}.C_4H_6O_6$	1066.2	74610-55-2					Lee, Wang et al. [1989a]	I	1	–	–	+	–	–	nd	nd	nd		×	+*	nd		*Challenge: FEV1 decline begins after 2 h, after 5 h, decline more than 50%
Plastics (incl. their monomers)																								
95% alkyl aryl polyether alcohol and 5% polypropylene glycol				Polypropylene glycol: 25322-69-4					Stevens [1976]	I	1	–	–	–	+	–	nd	×	nd		×	+	nd		
Alkylcyanoacrylate	ECA	$C_6H_7NO_2$	125.1	7085-85-0					Savonius, Keskinen et al. [1993]	CR	11	+	–	+	–	–	nd	×	nd		×	91%*	nd		Alcylcyanacrylate *:Challenge with adhesive
Cyanoacrylates (general)									Lozewicz, Davison et al. [1985]	S	5	+	–	+	+	–	nd	×	nd		×	100%	nd		See methylmethacrylate
Methylcyanoacrylate	MCA	$C_5H_5NO_2$	111	137-05-3			2 ppm; 8 mg/m^3		Savonius, Keskinen et al. [1993]	CR	3	–	–	+	–	–	nd	×	nd		×	100%*	nd		*:Challenge with adhesive
Methyl methacrylates	MMA	$C_5H_8O_2$	100.12	80-62-6	100 ppm; 410 mg/m^3		50 ppm; 210 mg/m^3		Lozewicz, Davison et al. [1985]	S	2	–	–	+	–	–	nd	×	nd		×	50%	nd		See cyanacrylate in general
Plexiglas (dust)									Kennes, Garcia-Herreros et al. [1981]	I	1	+	–	+	+	–	nd	×	nd		×	+	nd		
Polyethylene		$(–CH_2–CH_2–)_n$	polymer	9002-88-4					Gannon, Burge et al. [1992]	I	1	–	–	+	–	–	nd	×	nd		×	+	nd		
"									Stenton, Kelly et al. [1989]	I	1	–	–	+	+	–	nd	×	nd		×	+	nd		Challenge: late bronchial reaction
Polypropylene		$(–CH_2CH(CH_3)–)_n$	polymer	25085-53-4					Malo, Cartier et al. [1994b]	I	1	–	–	+	+	–	nd	×	nd		×	+	nd		Challenge with heated polypropylene. Challenge with formaldehyde negative
Polyvinylchloride	PVC	$(–CH_2–CHCl–)_n$	polymer	9002-86-2			5 mg/m^3		Lee, Yap et al. [1989b]	I	1	–	–	+	+	–	nd	×	nd		×	+	nd		
Styrene		C_8H_8	104.15	100-42-5	(50 ppm; 213 mg/m^3)		20 ppm; 85 mg/m^3		Hayes, Lambourn et al. [1991]	I	1	–	–	+	–	–	nd	×	nd		×	+	nd		Challenge: dual bronchial reaction at 12 ppm
"									Moscato, Biscaldi et al. [1987]	CR	2	–	–	+	+	+	nd	×	×	–	×	100%	nd		Challenge in 1 case: after immediate bronchial reaction late cutaneous reaction
Synthetic textile fibres (rayon, nylon = polyamide, orlon = acryl, terylen = polyester)									Muittari, Veneskoski [1978]	C	136	–	–	+	–	–	nd	nd	×	61% of 76	×	20% of 79	nd		Mixed exposure to natural fibres; type 1 allergy assumed; fibres may function as haptens

TABLE I. (*Continued*)

Substances	Abbreviation	Formula	MW	CAS-Number	TLV-TWA (USA)	EU Label	TLV-TWA (Germany)	Sa Sah	Reference	Study	n	Symptoms R	Con.	A	Cou.	S	Tot.	Methods LFT	Skin test	Spec. challenge	Antibodies		Remarks
Dyes																							
Basic Blue 99 (hair dye)									Wigger-Alberti, Elsner et al. [1996]	I	1	+	+	−	+	−	nd	nd	×	+	nd	nd			SPT positive, patch negative
Carmine	E120								Stücker, Roggenbuck et al. [1996]	I	1	+	−	+	−	−	nd	nd	×	+	nd	×	IgE	+	IgE antibodies to coloring components of carmine acid
Dyes (dyeing of textile fibres)									Zuskin, Mustajbegovic et al. [1997]	C	135	−	−	6%*	38%	−	nd	×	nd		nd	nd			*: Asthma; in 103 controls occupational asthma prelavance = 0%; exposed subjects: worse LFT
Henna, black (from *Indigofera argentea*)									Scibilia, Galdi et al. [1997]	I	1	+	+	+	+	−	nd	×	×	+	nd	×	IgE	+	SPT+IgE: red henna negative
Lanasol Yellow 4G									Romano, Sulotto et al. [1992]	I	1	−	−	+	−	−	nd	×	×	+	× +	nd			Challenge: other colors negative
Remazol black B (dyeing of textile fibres)									Nilsson, Nordlinder et al. [1993]	C	162	−	−	+	−	+	11%	×	×	36% of 14	nd	×	IgE	2.5%	IgE: cross-reactivity with many other colors
Other chemicals																							
Ammonium chloride		NH_4Cl	53.49	12125-02-9					see Weir, Robertson et al. [1989]								nd						
Azodicarbonamide		$C_2H_4N_4O_2$	116.08	123-77-3					Normand, Grange et al. [1989]	CR	4	−	−	+	−	+	nd	×	nd		×	100% of 2	nd			Challenge: 1 immediate and 1 late bronchial reaction
"									Slovak [1981]	C	151	29%	25%	19%*	39%	−	nd	×	×	−	nd		nd			Azodicarbonamide is hardly soluble, therefore problems with production of SPT solutions; SPT might be false-negative
1,2-benzisothiazolin-3-one		C_7H_5NOS	151.19	2634-33-5					Moscato, Omodeo et al. [1997]	I	1	+	−	+	+	−	nd	×	nd		×	+	nd			Challenge: immediate bronchial reaction
Captafol		$C_{10}H_9Cl_4NO_2S$	349.1	2425-06-1	0.1 mg/m^3				Royce, Wald et al. [1993]	I	1	−	−	+	−	−	nd	×	nd		×	+	nd			IgE to maleic acid anhydrice (captafol pre-stage not available)
Chloramine T		$C_7H_7ClNNaO_2S$	227.67	127-65-1					Dijkman, Vooren et al. [1981]	S	5	+	−	+	+	−	nd	nd	×	100% of 4	×	100% of 3	nd			Challenge: 1 dual, 2 late bronchial reactions (4 h after challenge)
"									Kramps, van Toorenenbergen et al. [1981]	S	4	−	−	+	−	−	nd	nd	nd		nd		×	IgE IgG	+ −	Antibody comparison with 4 asymptomatic subjects: also IgE to chloramine T-HSA conjugates
"									Kujala, Reijula et al. [1995]	I	1	−	−	+	+	−	nd	×	×	+	×	+	×	IgE	+	
Diazonium tetrafluoroborate									Luczynska, Hutchcroff et al. [1990]	C	45	−	−	+	+	−	78%	nd	nd		×	100% of 2	×	IgE	20%	Correlation between asthmatic symptoms and IgE
"									Graham, Coe et al. [1981]	I	1	−	−	+	−	−	nd	×	nd		×	+	nd			

TABLE I. (*Continued*)

Substances	Abbreviation	Formula	MW	CAS-Number	TLV-TWA (USA)	EU Label	TLV-TWA (Germany)	Sa Sah	Reference	Study	n	Symptoms R	Con.	A	Cou.	S	Tot.	Methods LFT	Skin test	Spec. challenge		Antibodies		Remarks
EPO 60									Lambouen, Hayes et al. [1992]	I	1	−	−	+	−	−	nd	×	nd		×	+	nd		Challenge: late bronchial reaction
Ethylcyanoacrylate									Kopp, McKay et al. [1985]	I	1	+	−	+	+	−	nd	×	nd		×	+	nd		Challenge: maximal bronchial reaction after 11 h
Ethyleneimine		C_2H_5N	43.1	151-56-4			0.5 ppm; 0.9 mg/m^3		Kanerva, Estlander et al. [1995]	CR	9	−	−	+	−	+	nd	×	×	80% of 5	×	88% of 8	×	IgE	−(in 5)	Challenge: 1 immediate, 1 dual, 5 late bronchial reactions. patch: 83% positive
Ethylene oxide		C_2H_4O	44.05	75-21-8	1 ppm; 2 mg/m^3		1 ppm; 2 mg/m^3		Verraes, Michel [1995]	I	1	−	−	+	−	+	nd	nd	nd		nd		×	IgE	+	Ethylene oxide binds to powder (similar to latex allergens)
Formaldehyde		CH_2O	30. Mrz	50-00-0			0.5 ppm; 0.6 mg/m^3		Lemiere, Desjardins et al. [1995]	CR	3	+	−	+	+	−	nd	×	nd		×	100%	nd			Challenge: 2 subjects reacted only to dust, 1 to dust and gas
"									Burge, Harries et al. [1985]	S	15	+	−	+	+	−	nd	×	nd		×	47%	nd			Non-specific challenge with histamine correlates with specific challenge
Freon®									Malo, Gagnon et al. [1984]	I	1	−	−	+	−	−	nd	×	nd		×	+	nd			Challenge: only bronchial reaction to heated Freon
Furfuryl alcohol		$C_5H_6O_2$	98.1	98-00-0	10 ppm; 40 mg/m^3		10 ppm; 40 mg/m^3		Cockcroft, Cartier et al. [1980]	I	1	−	−	+	−	−	nd	×	nd		×	+	×	IgE	−	
Glutaraldehyde		$C_5H_8O_2$	100.12	111-30-8		R 42/43	0.1 ppm; 0.4 mg/m^3		Curran, Burge et al. [1996]	S	20	+	−	65%*	−	−	nd	nd	nd		×	88% of 8	×	IgE	28% of 18	*Asthma IgE: comparison to controls. High total IgE interferes
"									Gannon, Bright et al. [1995]	S	8	−	−	+	−	−	nd	×	nd		×	88%	nd			Challenge: mostly late bronchial reactions; 3 subjects reacted to formaldehyde
Hexachlorophene		$C_{13}H_6Cl_6O_2$	406.92	70-30-4					Nagy, Orosz [1984]	I	1	+	−	+	−	−	nd	nd	×	−	×	+	nd			
Isothiazolinone									Bourke, Convery et al. [1997]	I	1	−	−	+	+	−	nd	×	nd		×	+	nd			Challenge: in the workplace
Metabisulphite		$O_5S_2^{2-}$		16731-55-8 7681-57-4					Malo, Cartier et al. [1995]	I	1	−	+	+	−	−	nd	×	×	−	×	+	nd			Challenge: immediate bronchial reaction to low dose (no irritative reaction)
Ninhydrin		$C_9H_6O_4$	178.14	485-47-2					Hytonen, Martimo et al. [1996]	I	1	+	−	−	−	−	nd	nd	×	+	×	+	×	IgE	+	Challenge: no lung function parameters; blocked nose
"									Piirila, Estlander et al. [1997a]	I	1	+	−	(+)	−	−	nd	×	×	−	×	+	×	IgE	+	
Sodium iso-nonanoyl-oxibenzene-sulphonate				123354-92-7					Stenton, Dennis et al. [1990]	CR	3	+	+	+	−	−	nd	×	nd		×	100%	nd			Challenge: late reaction (>2 h)
"									Hendrick, Connolly et al. [1988]	I	1	+	−	+	+	−	nd	×	nd		×	+	×	IgE	−	Challenge: late bronchial reaction; antibody test difficult since positive controls not available
Tetrazene		$C_2H_8N_{10}O$	188.2	31330-63-9					Burge, Hendy et al. [1984]	I	1	+	−	+	+	+	nd	×	nd		×	+	nd			Challenge: late bronchial reaction

TABLE I. (*Continued*)

Substances	Abbreviation	Formula	MW	CAS-Number	TLV-TWA (USA)	EU Label	TLV-TWA (Germany)	Sa	Sah	Reference
Triglycidyl isocyanurate	TGIC	$C_{12}H_{15}N_3O_6$	297.3	2541-62-9						Piirila, Estlander et al. [1997b]
Persulphate salts										
Potassium persulphate, sodium persulphate		$K_2O_8S_2$ $Na_2O_8S_2$	270.33 238.09	7727-21-1 7775-27-1						Parra, Igea et al. [1992]
”										Pankow, Hein et al. [1989]
ANIMALS										
Mites										
Grain mites (*Tyrophagus longior, T. putrescentiae, Glycyphagus destructor, G. domesticus, Acarus siro*)										Musk, Venables et al. [1989]
Grain mites (*G. destructor, G. domesticus, T. putrescentiae, A. siro, A. farris*)										Blainey, Topping et al. [1989]
Grain mites (*Lepidoglyphus destructor*)										van Hage-Hamsten, Ihre et al. [1988]
House dust mites (*Dermatophagoides pteronyssinus, D. farinae*)										Oertmann, Müsken et al. [1995]
Poultry mites (*Ornithonyssus sylviarum*)										Lustsky, Teichtahl et al. [1984]
Red spider mites (*Tetranychus urticae*)										Burches, Pelaez et al. [1996]
”										Delgado, Orta et al. [1997]
Insects										Dyne, Campion et al. [1996]
Bee moth (*Galleria mellonella*; fish bait)										Siracusa, Bettini et al. [1994]
Cockroach (*Blatella germanica*)										Steinberg, Bernstein et al. [1987]
Cricket, locust										Bagenstose, Mathews et al. [1980]

		Symptoms						Methods									
Study	n	R	Con.	A	Cou.	S	Tot.	LFT		Skin test	Spec. challenge			Antibodies		Remarks
I	1	−	−	+	−	+	nd	×	×	−(Prick) +(Patch)	×	+	×	IgE	−	Skin test: patch positive due to contact dermatitis; SPT and IgE negative, perhaps due to bad HSA conjugates
I	1	−	−	+	+	+	nd	×	×	+	×	+	×	IgE, G, M, A	−(all)	Challenge: bronchial reaction after 2 h; pathomechanism unclear
I	1	+	+	+	+	−	nd	×	×	+	×	+	nd			Irritative reaction excluded
C	279	+	−	+	−	−	25%	×	×	33% of 259	nd		nd			See moulds, *Saccharomyces cerevisiae*
C	133	−	−	+	+	−	33%	×	×	25% of 130	×	100% of 1	×	IgE	23% of 128	Various degrees of cross-reactivity with house dust mites
S	12	−	−	+	−	−	nd	nd	×	100%	×	100%	×	IgE	100%	Healthy exposed farmers (n = 4) in all tests negative
I	1	+	+	+	−	−	nd	nd	×	+	×	+	×	IgE	+	*Challenge: nasal; mites in hen houses but not in house dust
S	16	+	−	+	−	−	nd	nd	×	63%	×	100% of 1	×	IgE	93% of 14	SPT: all 12 exposed asymtomatic controls negative
S	150	+	+	+	−	+	nd	nd	×	36%	×	89% of 54*	×	IgE	100% of 54	*Challenge: conjunctival; cross-reactivity with house dust mite. Sensitization to house dust mite might be a risk factor
S	24	+	−	+	−	+	nd	nd	×	66%	×	86% of 14	×	IgE	100% of 16	No cross-reactivity between spider mite and house dust mite
C	26	−	−	+	−	−	50%	nd	nd		nd		×	IgE	46% of 13	Partial cross-reactivity with different insects
S	14	+	+	+	−	−	nd	×	×	15% of 13	×	100% of 1	×	IgE	25% of 12	See also *T. molitor* and *L. caesar*
C	6	+	+	−	−	−	50%	nd	×	67%	×	100% of 1*	×	IgE	50% of 4	*Challenge: nasal
CR	2	+	+	+	+	−	nd	×	×	100%	×	100%	×	IgE	100%	Prausnitz-Küstner (n = 1); positive

TABLE I. (*Continued*)

Substances	Abbreviation	Formula	MW	CAS-Number	TLV-TWA (USA)	EU Label	TLV-TWA (Germany)	Sa Sah	Reference	Study	n	Symptoms R	Con.	A	Cou.	S	Tot.	Methods LFT		Skin test		Spec. challenge		Antibodies		Remarks
Cricket, locust									Tee, Gordon et al. [1988]	C	15	+	−	+	−	+	60%	nd	×	67%	nd		×	IgE	73%	Immunoblot with IgE: 7 allergen bands [18-68 kDa]
”									Soparkar, Patel et al. [1993]	C	17	+	−	+	−	+	59%	nd	×	41% of 16	×	100% of 1	nd			A single case was the reason for this study
Echinodorus plamosus larvae									Resta, Foschino-Barbaro et al. [1982]#	I	1	+	+	+	−	−	nd	nd	×	+	×	+*	×	IgE	+	*Challenge: FEV1 decrease of about 15%
Fruit flies (*Drosophila melanogaster*)									Spieksma, Vooren et al. [1986]	C	22	−	−	+	−	−	32%	nd	×	41%	×	21% of 14*	×	IgE	45%	*Challenge: simultaneously nasal and bronchial; 9 pos. nasal reactions (64%), out of them 3 pos. bronchial reactions
Greenbottle (*Lucilia caesar*; fish bait)									Siracusa, Bettini et al. [1994]	S	14	+	+	+	−	−	nd	×	×	92% of 13	×	67% of 6	×	IgE	50% of 12	See also *T. molitor* and *G. Mellonella*
Ground bugs (family *Lygaeidae*)									Garcia Lazaro, Abengozar Muela et al. [1997]	I	1	+	+	+	−	−	nd	×	×	+	×	+*	×	IgE	+	*Challenge: conjunctival
Gypsy moth (*Lymantria dispar*)									Etking, Odell et al. [1982]	C	17	−	+	+	−	+	59%	nd	×	88%*	nd		nd			*Skin test: scratch
Honeybee (*Apis mellifera*)									Ostrom, Swanson et al. [1986]	I	1	−	−	+	+	−	nd	nd	×	+	×	+	×	IgE	+	RAST inhibition
Mealworm (larva of flour worm *Tenebrio molitor*)									Friedrich [1986]	I	1						nd	nd	×	+	×	+	×	IgE	+	
”									Schroeckenstein, Meier-Davis et al. [1990]	I	1	+	+	−	−	−	nd	nd	×	+	nd		×	IgE	+	Cross-reactivity with *Alphitobius diaperinus* in SPT and RAST
”									Siracusa, Bettini et al. [1994]	S	14	+	+	+	−	−	nd	×	×	23% of 13	×	100% of 1	×	IgE	8% of 12	See also *L. caesar* and *G. mellonella*
Non-biting midges (*Chironomus thummi thummi*)									Liebers, Hoernstein et al. [1993]	C	225	62%	63%	45%	−	37%	nd	nd	×	54% of 94	nd		×	IgE IgG	34% 20%	Association between symptoms and degree of exposure
Sheep blowfly (*Lucilia cuprina*)									Kaufman, Gandevia et al. [1989]	C	53	+	+	+	−	+	28%	nd	nd		nd		×	IgE	37%	
Sewer flies (*Psychoda alternata*)									Gold, Mathews et al. [1985]	I	1	+	+	+	−	−	nd	×	×	+	×	+	×	IgE	+	Prausnitz-Küstner: positive
Silkworm									Harindranath, Prakasth et al. [1985]	C	243	−	−	17%	−	−	nd	nd	×	22%	nd		×	IgE	87%; 80% of 15*	*IgE: 87% to cocoon allergens, 80% to pupal allergens
“Seafood”																										
Clam									Desjardins, Malo et al. [1995]	C	57	7%	−	4%	−	−	nd	nd	×	7%	×	100% of 2	×	IgE	7% of 55	See also crabs
Lobster									Lemiere, Desjardins et al. [1996b]	I	1	+	+	+	−	+	nd	×	nd		×	+	×	IgE	+	See also crabs

TABLE I. (*Continued*)

Substances	Abbreviation	Formula	MW	CAS-Number	TLV-TWA (USA)	EU Label	TLV-TWA (Germany)	Sa Sah	Reference
Shrimp									Lemiere, Desjardins et al. [1996b]
”									Desjardins, Malo et al. [1995]
Snow crab									Cartier, Malo et al. [1986b]
Water-flea (*Daphnia*)									Meister [1978]#
Fish									
Plaice, salmon, tuna, sardine, trout etc.									Rodriguez, Reano et al. [1997]
Salmon									Douglas, McSharry et al. [1995]
Trout									Sherson, Hansen et al. [1989]
Dander, hair, and urine of animals								Sah	
Cow hair									Hinze, Bergmann [1995]
Deer dander									Nahm, Park et al. [1996]
Laboratory animals									
Dust of laboratory animals (guinea pigs, rats, mice, rabbits, hamsters)									Krakowiak, Szulc et al. [1997]
Urine of laboratory animals (guinea pigs, rats, mice, rabbits)									Venables, Tee et al. [1988
Pig urine									Haries, Cromwell [1982]
Mice									Hollander, Doekes et al. [1996]
Mink urine									Jimenez Gomez, Anton et al. [1996]
Rats									Hollander, Doekes et al. [1996]
Other animals and their products									
Casein (main milk protein)									Rossi, Corsico et al. [1994]
”									Olaguibel, Hernandez et al. [1990]

		Symptoms						Methods								
Study	n	R	Con.	A	Cou.	S	Tot.	LFT	Skin test		Spec. challenge		Antibodies		Remarks
I	1	+	+	+	–	+	nd	×	nd		×	+	×	IgE	+	See also lobster
C	57	5%	–	4%	–	–	nd	nd	×	16%	×	50% of 2	×	IgE	14% of 55	See also clam
C	303	?	?	?	?	?	?	nd	×	55% of 119	nd		×	IgE	54% of 115	Data collection over several years; no information about symptoms
CR	2	–	–	+	–	+	nd	nd	×	100%	×	100% of 1	nd			
CR	2	+	+	+	+	–	nd	×	×	100%	×	100%	×	IgE	100%	Oral challenge: negative
C	291	–	–	+	+	–	42%	×	nd		nd		×	IgE IgG	8.6% 33%	
S	8	+	–	+	+	–	nd	×	nd		× *	67% of 6	×	IgE	100%	*PEFR measurement in the workplace; high concentrations of endotoxins
S	67	+	+	+	+	+	nd	×	×	97% of 61	×	84% of 37	×	IgE	82.5% of 40	
I	1	+	–	+	–	–	nd	nd	×	+	×	+	×	IgE	+	Immunoblot: 5 IgE binding components
C	60	7%	–	13%	–	–	nd	×	×	54% of 26*	nd		×	IgE	15%	*SPT: all tested subjects (n = 26) were atopics
C	138	+	+	+	–	+	44%	nd	×	13% of 133	nd		×	IgE	38% of 130	
I	1	–	–	+	–	+	nd	nd	×	+	×	+	×	IgE	+	
C	540	–	–	3%	–	4%	10%	nd	×	9.8%	nd		×	IgE	6.1%	See also rats
I	1	+	+	+	+	–	nd	×	×	+	×	+	×	IgE	–	SPT: mink pelt negative
C	540	–	–	6%	–	11%	nd	nd	×	18%	nd		×	IgE	11%	See also mice
I	1	+	–	+	+	–	nd	nd	×	+	×	+	×	IgE	+	
I	1	+	–	+	+	–	nd	nd	×	+	×	+	×	IgE	+	Oral challenge: patient tolerated cow milk

TABLE I. (*Continued*)

Substances	Abbreviation	Formula	MW	CAS-Number	TLV-TWA (USA)	EU Label	TLV-TWA (Germany)	Sa	Sah	Reference	Study	n	Symptoms R	Con.	A	Cou.	S	Tot.	Methods LFT		Skin test		Spec. challenge		Antibodies		Remarks
Egg powder (egg white, ovalbumin, ovomucoid, lysozyme, conalbumin)										Bernstein, Smith et al. [1987]	C	25	−	−	+	−	−	?	×	×	32%	×	24%*	×	IgE	16%	*PEFR measurement in the workplace. Number of symptomatic subjects not given
”										Smith, Bernstein et al. [1990]	C	188	−	−	+	−	−	31%	nd	×	34% of 86	×	22%*	×	IgE	26% of 87	*PEFR measurement in the workplace
Frogs										Armentia, Martin-Santos et al. [1988]	I	1	+	+	+	−	−	nd	nd	×	+	nd		×	IgE IgG	+ −	Venom of frog skin glands was identified to be the allergen. Prausnitz-küstner: pos.
Ivory										Armstrong, Neill et al. [1988]	I	1	−	−	+	−	−	nd	×	×	−	×	+	×	IgE	−	Although IgE and SPT were negative a type I reaction is suspected
Lactoalbumin										Rossi, Corsico et al. [1994]	I	1	+	−	+	+	−	nd	nd	×	+	nd		×	IgE	+	See also casein
Poultry (feather extract)										Perfetti, Cartier et al. [1997]	CR	4	+	+	+	−	−	nd	×	×	100%	×	100%*	nd			*FEV1 measurement in the workplace: decrease 20%
Plants																											
Amaryllis (family *Amaryllidaceae*, order *Hippeastrum*)										Jansen, Visser et al. [1996]	I	1	+	−	+	−	−	nd	×	×	+	×	+	×	IgE	+	
Anis seed (*Pimpinella anisum*)										Fraj, Lezaun et al. [1996]	I	1	−	−	+	+	−	nd	×	×	+	×	+	×	IgE	+	SPT: 12 other spices neg.
Asparagus (*Asparagus officinalis*)										Lopez-Rubio, Rodriguez et al. [1998]	I	1	+	+	+	+	−	nd	×	×	+	×	+	×	IgE	+	SPT, challenge, IgE test with raw asparagus pos.; neg. with cooked aspar.
“Baby’s breath” (*Gypsophila paniculata*)										Antepara, Jauregui et al. [1994]	I	1	+	−	+	+	−	nd	×	×	+	×	+	×	IgE	+	Immunoblot: 3 IgE binding regions (20–40 kDa)
Buckwheat flour										Park, Nahm [1996]	I	1	+	−	+	−	−	nd	nd	×	+	×	+	×	IgE IgG4	+ +	Immunoblot: 8 IgE binding regions
Cacao beans										Perfetti, Lehrer et al. [1997]	I	1	+	−	+	+	−	nd	×	×	+	×	+	×	IgE	+*	*IgE: weak binding
3-Carene (terpene)										Eriksson, Levin et al. [1997]	C	38	−	+	+	−	−	21%	×	nd		nd		nd			
Castor beans									Sa	Merget, Heger et al. [1994]	I	1	+	−	+	−	−	nd	×	×	+	×	+	×	IgE	+	
”										Baur, Chen et al. [1998]	I	1	+	+	+	−	−	nd	×	×	+	nd		×	IgE	+	
Chicory (*Cichorium intybus*)										Nemery, Demedts [1989]	I	1	+	−	+	+	+	nd	×	×	+*	nd		nd			*Skin test: patch
Decorative flowers (freesias, chrysanthemums, tulips)										Piirila, Keskinen et al. [1994]	CR	4	+	+	+	−	+	nd	×	×	50%	×	100% of 3	×	IgE	100% of 3	
Dried flowers (*Limonium tataricum*)										Quirce, Garcia-Figueroa et al. [1993]	I	1	+	+	+	−	+	nd	×	×	+	×	+	×	IgE	+	SPT also positive with grass
Entada gigas seed										Rubin, Duke [1974]#	I	1	+	+	+	−	−	nd	nd	×	+	nd		nd			
Garlic dust										Falleroni, Zeiss et al. [1981]	I	1	+	−	+	−	−	nd	×	×	+	×	+	×	IgE	+	Additional reaction to onion dust

TABLE I. (*Continued*)

Substances	Abbreviation	Formula	MW	CAS-Number	TLV-TWA (USA)	EU Label	TLV-TWA (Germany)	Sa Sah	Reference	Study	n	Symptoms R	Con.	A	Cou.	S	Tot.	Methods LFT		Skin test		Spec. challenge		Antibodies		Remarks
Ginseng (brazil; *Pfaffia paniculata*)									Subiza, Subiza et al. [1991]	I	1	+	+	+	−	−	nd	×	×	+	×	+	×	IgE IgG	+ −	No hypersensitivity reaction to Korean ginseng (Panax ginseng)
Gluten derivative (AHGD: alkaline hydrolysis wheat glutene derivative)									Lachance, Cartier et al. [1988]	I	1	+	+	+	−	−	nd	×	×	+	×	+	×	IgE	+	
Grain dust									Massin, Bohadana et al. [1995]	C	118	−	−	5%	30%	−	nd	×	nd		nd		nd			Significantly more symptoms in exposed subjects than in controls (n = 164). LFT in controls better than in exposed subjects
Green bean									Igea, Fernandez et al. [1994]	I	1	+	+	+	−	+	nd	×	×	+	×	+	×	IgE	+	SPT: cooked beans: neg. No problems after bean consumption
Green (raw) coffee beans (dust)									Larese, Fiorito et al. [1998]	C	31	+	+	+	−	−	19.4%	×	×	26%	nd		nd			
”									Zuskin, Kanceljak et al. [1985]	S	9	+	−	+	+	−	nd	×	×	78%*	×	45%	nd			*Skin test: intradermal
”									Jones, Hughes et al. [1982]	C	372	−	−	+	+	−	nd	×	×	10% of 362	nd		×	IgE	7% of 341	The average FEV1 decreased with the duration of occupation
Herbs (thyme, rosemary, bay leaf, garlic)									Lemiere, Cartier et al. [1996a]	I	1	−	−	+	+	−	nd	×	×	+	×	+	×	IgE	+	No problems after herb consumption
Hops									Newmark [1978]	I	1	+	+	+	−	+	nd	nd	×	+*	nd		nd			*Skin test: scratch
Mushrooms									Symington, Kerr et al. [1981]	S	8	+	−	+	−	−	nd	×	×	63%	×	50%	nd			
Natural textile fibres (cotton, flax, jute)									Muittari, Veneskoski [197	C	136	−	−	+	−	−	nd	nd	×	54% of 104	×	19% of 108	nd			Mixed exposure to synthetic fibres as well as to wool and silk
Pea (*Lathyrus odoratus*)									Jansen, Vermeulen et al. [1995]	I	1	+	+	+	−	−	nd	×	×	+	×	+*	×	IgE	+	*Challenge: PEFR measurement before and after work: FEV1 decrease >20%
Pea flour									Bhagat, Swystun et al. [1995]	I	1	−	−	+	+	−	nd	×	×	+	nd		nd			Non-specific challenge with histamine: positive
Pectin (carbohydrate of plant cells)									Cohen, Forse et al. [1993]	I	1	+	−	+	−	−	nd	×	×	+	×	+*	nd			*Challenge: PEFR measurement before and after work: FEV1 decrease of 16%
Poppy (*Papaver somniferum*)									Moneo, Alday et al. [1993]#	C	28	?	?	?	?	?	21%	nd	×	21%	×	100% of 4	×	IgE IgG	21% −	Immunoblot: IgE binding in the region of 52 kDa. Allergens may be polyphenols
Roasted coffee beans									Lemiere, Malo et al. [1996c]	I	1	+	+	+	−	−	nd	×	×	+	×	+	×	IgE	+	

TABLE I. (*Continued*)

Substances	Abbreviation	Formula	MW	CAS-Number	TLV-TWA (USA)	EU Label	TLV-TWA (Germany)	Sa	Sah	Reference	Study	n	Symptoms R	Con.	A	Cou.	S	Tot.	Methods LFT		Skin test		Spec. challenge		Antibodies		Remarks
Rose hips										Kwaselow, Rowe et al. [1990]	CR	13	+	−	+	−	+	nd	nd	×	62%	×	50% of 4	×	IgE	64%	
Ryegrass juice (*Lolium perenne*)										Subiza, Subiza et al. [1995]	I	1	+	+	+	+	−	nd	×	×	+	×	+	×	IgE	+	SPT with moulds: negative
Saffron (*Crocus sativus*)										Feo, Martinez et al. [1997]	C	50	16%	−	6%	−	8%	nd	nd	×	6%	×	100% of 3	×	IgE	6%	Challenge: 2 conjunctival, 1 bronchial; 4.2% out of 237 controls showed positive SPT (cross reactivity with pollen)
Sarsaparilla root dust (family *Liliacea*, order *Smila*)										Vandenplas, Depelchin et al. [1996]	I	1	+	−	+	−	−	nd	×	×	+	×	+	×	IgE	+	Component of herbal tea
Sesame seeds (*Sesame indicum*)										Keskinen, Ostman et al. [1991]	I	1	+	−	+	+	+	nd	×	×	+	×	+	×	IgE	+	
Sisal										Zuskin, Kanceljak et al. [1994]	C	20	75%	−	10%*	65%	−	nd	×	×	10%	nd		×	IgE	10%	*Asthma
Spices (paprika, coriander, mace)										Sastre, Olmo et al. [1996]	I	1	+	−	+	−	−	nd	nd	×	+	×	+	×	IgE	+	
Sunflower pollen (*Helianthemum annuus*)										Bousquet, Dhivert et al. [1985]	I	1	+	+	+	−	−	nd	×	×	+	×	+	×	IgE	+	SPT with sunflower seed: negative
Sunflower seeds										Vandenplas, Vander Borght et al. [1998]	I	1	+	+	+	−	−	nd	×	×	+	×	+	×	IgE	+	SPT with sunflower pollen: negative
Tea										Cartier, Malo [1990]	S	3	+	−	+	+	−	nd	×	×	− (100%)	×	67%	×	IgE	− (100%)	
Tobacco dust										Baur [1993]	I	1	+	+	+	−	−	nd	×	×	+	×	+*	×	IgE	+	Challenge: nasal
”										Lander, Gravesen [1988]	C	16	−	−	+	−	−	nd	×	nd		× *		nd			*PEFR measurement before and after work: FEV1 variation in exposed subjects significantly greater than in 32 controls
Vetch (*Vicia sativa*)										Picon, Blanco Carmona et al. [1991]	I	1	−	−	+	+	−	nd	×	×	+	×	+	×	IgG	+	Challenge: late bronchial reaction Prausnitz-Küstner: pos.
Weeping fig (*Ficus benjamina*)										Axelsson, Johansson et al. [1987]	C	84	+	+	+	−	+	17%	nd	×	21%	×	100% of 6	×	IgE	21%	Rhinoconjunctival challenge (n = 9): all positive
Vegetable gums																											
Gaur gum (of *Cypamopsis tetragonolobus*)										Malo, Cartier et al. [1990]	C	162	20%	12%	23%	+	11%	nd	nd	×	5%	×	50% of 4	×	IgE IgG	8% 14% of 133	
Karaya gum										Wagner [1980]	I	1	+	−	+	−	−	nd	×	×	+*	×	+	nd			*Skin test: scratch
Latex (natural rubber latex)				9006-04-6					Sah	Grzybowski, Ownby et al. [1996]	C	741	+	+	+	−	+	60%	nd	nd		nd		×	IgE	9%	
”										Baur, Chen et al. [1995a]	C	111	11%	9%	4%	−	23%	nd	nd	nd		nd		×	IgE	15.3%	

TABLE I. (*Continued*)

Substances	Abbreviation	Formula	MW	CAS-Number	TLV-TWA (USA)	EU Label	TLV-TWA (Germany)	Sa Sah	Reference
Latex (natural rubber latex)									Yassin, Lierl et al. [1994]
Soybean compounds								Sa	
Soybean									Alvarez, Tabar et al. [1996]
Soybean flour									Baur, Sauer et al. [1989]#
Soybean lecithin									Lavaud, Perdu et al. [1994]
Grain flour dust				68525-86-0			4 mg/m^3	Sa	
Barley flour									Vidal, Gonzalez-Quintela [1995]
Wheat flour									Baur, Degens et al. [1998]
"									Houba, Heederik et al. [1998]
"									De Zotti, Larese et al. [1994]
Rye flour									Baur, Degens et al. [1998]
Wood and wood compounds									
Abietic acid									Burge, Harries et al. [1980]
Colophonium						R 42/43			Burge, Edge et al. [1981]
"									So, Lam et al. [1981]
"									Burge, Harries et al. [1980]
Plicatic acid									
Tall oil									Tarlo [1992]
Wood dust (TRK value)							2 mg/m^3		
Wood dust									Wilhelmsson, Jernudd et al. [1985]#
Alnus glutinosa (alder)									Ahman, van Hage-Hamsten et al. [1995]

		Symptoms						Methods								
Study	n	R	Con.	A	Cou.	S	Tot.	LFT		Skin test	Spec. challenge		Antibodies		Remarks
C	224	13%	13%	+	5%	10%	49%	nd	×	17%	nd		nd		Symptoms in SPT pos. subjects significant more frequent than in SPT neg. subjects
S	21	+	−	+	−	−	nd	nd	×	43%	×	56% of 9	×	IgE	80% of 5	
S	261	+	+	+	−	−	nd	nd	nd		nd		×	IgE	32%	
CR	2	+	−	+	−	−	nd	×	×	100%	×	100%	×	IgE	100%	
I	1	−	−	+	−	−	nd	×	×	+	×	+	×	IgE	+	Oral challenge with beer: positive
S	193	+	+	+	+	+	nd	×	×	33%	×	55% of 47	×	IgE	58%	Also positive reaction to α-amylase and rye flour
C	393	21%	15%	7%	+	−	nd	nd	nd		nd		×	IgE	10%	
C	226	14%	14%	19%	−	−	nd	nd	×	12%	nd		nd			
S	193	+	+	+	+	+	nd	×	×	25%	×	69% of 64	×	IgE	42%	Also positive reaction to α-amylase and wheat flour
S	51	−	−	+	−	−	nd	×	nd		×	100% of 6	nd			Positive reaction after colophonium challenge
C	45	−	−	4%-21%*	−	−	nd	×	×	−	nd		×	IgE	−(in 30)	*:Asthma; Patients were divided into 3 exposure groups
I	1	−	−	+	+	−	nd	×	nd		×	+	nd			
S	51	−	−	+	−	−	nd	×	nd		×	67%	nd			FEV1 decrease with American colophonium in 83% out of 12 cases lower than with Portuguese colophonium
																see red cedar and white cedar
I	1	+	−	+	−	−	nd	×	×	−*	×	+	nd			*Skin test: patch with abietic acid, colophonium and pine tar
C	268	−	−	+	−	−	16%	nd	×	13% of 23	×	13% of 23*	nd			*Challenge: nasal
C	127	+	+	+	+	−	nd	nd	nd		nd		×	IgE	0.8%	Discussion, whether for wood SPT is more suitable than IgE detection

TABLE I. (*Continued*)

Substances	Abbreviation	Formula	MW	CAS-Number	TLV-TWA (USA)	EU Label	TLV-TWA (Germany)	Sa Sah	Reference	Study	n	Symptoms R	Con.	A	Cou.	S	Tot.	Methods LFT	Skin test	Spec. challenge		Antibodies		Remarks
Aningeria robusta (mukali)									Garces Sotillos, Blanco Carmona et al. [1995]	I	1	−	−	+	−	+	nd	×	×	+	×	+	nd			Challenge and SPT: negative with pine and iroko
Balfourodendron riedelianum (pau marfim)									Basomba, Burches et al. [1991]	I	1	+	−	+	−	−	nd	×	×	+	×	+	×	IgE	+	
Chlorophora excelsa (iroko, kambala)									Kersten, von Wahl [1994]	S*	157	?	?	?	?	?	nd	nd	×	5.3%*	×	7.8%*	nd			*Patients claiming for compensation due to occupational asthma. *SPT: 263 tests with 18 wood types. *Challenge: 90 tests with 14 wood types.
Euonymus europaeus (spindle tree)									Herold, Wahl et al. [1991]	I	1	+	+	+	−	−	nd	nd	×	+*	×	+*	×	IgE	+	*Skin test: scratch; *challenge: nasal
Fagus sylvatica (beech)									Oertmann, Bergmann [1993]	S*	55	−	−	+	−	−	nd	nd	nd		×	50% of 2	nd			*Patients claiming for compensation due to occupational asthma
”									Spiewak, Bozek et al. [1994]	I	1	+	+	+	−	−	nd	×	×	−	×	+	nd			See also ash, oak, pine
”									Kersten, von Wahl [1994]	S*	157	?	?	?	?	?	nd	nd	×	6.1%*	×	6.7%*	nd			*Patients claiming for compensation due to occupational asthma. *SPT: 263 tests with 18 wood types. *Challenge: 90 tests with 14 wood types.
Fraxinus excelsior (ash)									Fernandez-Rivas, Perez-Carral et al. [1997]	I	1	+	+	+	+	−	nd	×	×	+*	×	+*	×	IgE	+	*Skin test: intradermal *Challenge: FEV1 decrease: 18%
”									Oertmann, Bergmann [1993]	S*	55	−	−	+	−	−	nd	nd	nd		×	100% of 2	nd			*Patients claiming for compensation due to occupational asthma
”									Spiewak, Bozek et al. [1994]	I	1	+	+	+	−	−	nd	×	×	−	×	+	nd			See also beech, oak, pine
Gaboon									Kersten, von Wahl [1994]	S*	157	?	?	?	?	?	nd	nd	×	5.3%*	×	4.4%*	nd			*Patients claiming for compensation due to occupational asthma. *SPT: 263 tests with 18 wood types. *Challenge: 90 tests with 14 wood types.
Gonystylus bancanus (ramin)									Hinojosa, Losada et al. [1986]	S	2	−	−	+	−	−	nd	×	×	100%	×	−(100%)	nd			Cross-reactivity with obeche (*Triplochiton scleroxylon*)
Khaya anthoteca (african. mahaghoni)									Oertmann, Bergmann [1993]	S*	55	−	−	+	−	−	nd	nd	nd		×	50% of 4	nd			*Patients claiming for compensation due to occupational asthma
Microberlinia (african. zebrawood)									Bush, Yunginger et al. [1978]	I	1	−	−	+	−	−	nd	×	×	+	×	+	×	IgG IgE	− +	

TABLE I. (*Continued*)

Substances	Abbreviation	Formula	MW	CAS-Number	TLV-TWA (USA)	EU Label	TLV-TWA (Germany)	Sa	Sah	Reference	Study	n	Symptoms R	Con.	A	Cou.	S	Tot.	Methods LFT	Skin test	Spec. challenge		Antibodies		Remarks
Phoebe porosa (imbuia)										Jeebhay, Prescott et al. [1996]	I	1	+	−	+	−	−	nd	×	nd	×	+	×	IgG +	
Picea abis (spruce)										Oertmann, Bergmann [1993]	S*	55	−	−	+	−	−	nd	nd	nd	×	0% of 2	nd		*Patients claiming for compensation due to occupational asthma
”										Kersten, von Wahl [1994]	S*	157	?	?	?	?	?	nd	nd	×	8.4%*	×	2.2%*	nd	*Patients claiming for compensation due to occupational asthma. *SPT: 263 tests with 18 wood types. *Challenge: 90 tests with 14 wood types.
Pinus sylvestris (pine)										Spiewak, Bozek et al. [1994]	I	1	+	+	+	−	−	nd	×	×	−	×	+	nd	See also beech, oak, ash
”										Kersten, von Wahl [1994]	S*	157	?	?	?	?	?	nd	nd	×	5.3%*	×	5.6%*	nd	*Patients claiming for compensation due to occupational asthma. *SPT: 263 tests with 18 wood types. *Challenge: 90 tests with 14 wood types.
Prunus avium (cherry tree)										Abendroth, Kalveram et al. [1992]	C	33	51%	−	−	−	−	nd	×	nd	nd		×	IgE	80% of 10	See also oak
Quillaja saponaria (Soapbark)										Raghuprasad, Brooks et al. [1980]	I	1	+	+	+	−	−	nd	×	nd	×	+	×	IgE	+	Cross-reactivity with gum acacia and gum tragacanth
Quercus (Oak)										Oertmann, Bergmann [1993]	S*	55	−	−	+	−	−	nd	nd	nd	×	33% of 3	nd			*Patients claiming for compensation due to occupational asthma
”										Malo, Cartier et al. [1995]	CR	3	+	−	+	+	−	nd	×	×	− (100%)	×	100%	nd		Challenge: 2 dual and 1 late bronchial reaction
”										Abendroth, Kalveram et al. [1992]	C	33	51%	−	−	−	−	nd	×	nd	nd		×	IgE	80% of 10	See also cherry tree
Swietenia mahagoni (Americ. mahagoni)										Kersten, von Wahl [1994]	S*	157	?	?	?	?	?	nd	nd	×	8%*	nd		nd		*Patients claiming for compensation due to occupational asthma. * SPT: 263 tests with 18 wood types.
Tectona grandis (teak)										Oertmann, Bergmann [1993]	S*	55	−	−	+	−	−	nd	nd	nd		×	50% of 2	nd		*Patients claiming for compensation due to occupational asthma
Terminalia superba (limba)										Oertmann, Bergmann [1993]	S*	55	−	−	+	−	−	nd	nd	nd		×	33% of 3	nd		*Patients claiming for compensation due to occupational asthma
Thuja occidentalis (eastern white cedar)										Cartier, Chan et al. [1986a	I	1	−	−	+	+	−	nd	×	nd		×	+*	×	IgE	+*	*Challenge: FEV1 decrease only 12% *IgE to plicatic acid (see there)
”										Malo, Cartier et al. [1994a]	C	43	−	−	+	+	−	58%	×	nd		×	25% of 12*	nd			*Challenge: with plicatic acid (see there)
Thuja plicata (red cedar)									Sah																See plicatic acid

TABLE I. (*Continued*)

Substances	Abbreviation	Formula	MW	CAS-Number	TLV-TWA (USA)	EU Label	TLV-TWA (Germany)	Sa	Sah	Reference	Study	n	Symptoms R	Con.	A	Cou.	S	Tot.	Methods LFT	Skin test	Spec. challenge		Antibodies		Remarks
Plicatic acid (PA, major allergen or red cedar) white cedar contains half the PA amount of red cedar										Cote, Kennedy et al. [1990]	S	23	–	–	+	+	–	nd	nd	nd	×	61%	nd		See red cedar and white cedar
”										Lam, Tan et al. [1983]	S*	206	–	–	+	–	–	nd	×	nd	×	100% of 8	×	IgE IgG	30%* —	*S: Patients with diagnosed red cedar asthma; *IgE to red cedar dust: 25%
”										Chan-Yeung, Desjardins [1992]	S	4	+	–	+	–	–	nd	×	nd	×	100%	×	IgE	75%	
Tieghemella heckeli (macrore)										Oertmann, Bergmann [1993]	S*	55	–	–	+	–	–	nd	nd	nd	×	80% of 5	nd			*Patients claiming for compensation due to occupational asthma
”										Kersten, von Wahl [1994]	S*	157	?	?	?	?	?	nd	nd	×	11.4%*	×	15.6%*	nd		*Patients claiming for compensation due to occupational asthma. *SPT: 263 tests with 18 wood types. *Challenge: 90 tests with 14 wood types.
Triplochiton scleroxylon (obeche)									Sah	Hinojosa, Losada et al. [1986]	S	4	–	–	+	–	–	nd	×	×	100%	×	100%	×	IgE	100%	Cross-reactivity with ramin (*Gonystylus bancanus*)
”										Oertmann, Bergmann [1993]	S*	55	–	–	+	–	–	nd	nd	nd		×	75% of 8	nd			*Patients claiming for compensation due to occupational asthma.
”										Kersten, von Wahl [1994]	S*	157	?	?	?	?	?	nd	nd	×	11.8%*	×	22.2%	nd		*Patients claiming for compensation due to occupational asthma. *SPT: 263 tests with 18 wood types. *Challenge: 90 tests with 14 wood types.
Microorganisms																									
Fungi																									
Aspergillus niger										Seaton, Wales [1994]	C	261	–	–	+	+	–	30%	nd	×	9.6%	nd		nd			After 7 years: 14% of sympt. and 49% of non-symptomatic subjects remained
Aspergillus fumigatus										Allmers, Huber et al. [1997]	I	1	–	–	+	+	–	nd	×	×	+	×	+	×	IgE	+	Diagnosis: ABPA (allergic bronchopulmonary aspergillosis)
Chrysonila sitophila										Tarlo, Wai et al. [1996]	I	1	+	+	+	+	–	nd	×	×	+	×	+*	×	IgE	+	*PEFR measurement in the workplace
Dictyostelium discoideum (slime mould)										Gottlieb, Garibaldi et al. [1993]	I	1	+	+	+	–	–	nd	×*	×	+	nd		×	IgE	+	*LFT before and after working with the mould —> FEV1 decrease of 14%
Neurospora sp.										Cote, Chan et al. [1991]	I	1	–	–	+	–	–	nd	×	×	+	×	+	×	IgE	+	
Paecilomyces sp.										Wilhelmsson, Jernudd et al. [1985]#	C	268	–	–	+	–	–	16%	nd	×	43% of 23*	×	50% of 10*	×	IgG	32%	*SPT: only in symptomatic subjects; *challenge: nasal

TABLE I. (*Continued*)

Substances	Abbreviation	Formula	MW	CAS-Number	TLV-TWA (USA)	EU Label	TLV-TWA (Germany)	Sa	Sah	Reference
Saccharomyces cerevisiae										Belchi-Hernandez Mora-Gonzalez et al. [1996]
"										Musk, Venables et al. [1989]
"										Baldo, Baker [1988]
Mold-containing dust										Musk, Venables et al. [1989]
Aspergillus, Mucor, Cladosporium										Wallenstein, Bergmann et al. [1980]#
Enzymes										
α-Amylase				9000-90-2		R 42		Sa		
α-Amylase of Aspergillus oryzae										Losada, Hinojosa et al. [1992]
"										Quirce, Cuevas et al. [1992]
"										Baur, Chen et al. [1994]
Bromelain (protease of plant family *Bromeliaceae*)				9001-00-7		R 42				Gailhofer, Teubl et al. [1987]#
Cellulase of *Aspergillus niger*				9012-54-8		R 42				Sander, Raulf-Heimsoth et al. [1998]
"										Tarvainen, Kanerva et al. [1991]
"										Losada, Hinojosa et al. [1986]
Esperase® (protease)						(R 42)				Johnsen, Sorensen et al. [1997]
"										Zachariae, Hoech-Thomsen et al. [1981]
Glucoamylase of *Aspergillus niger* (Amyloglucosidase)										Baur, Sauer et al. [1989]#
"										Sander, Raulf-Heimsoth et al. [1998]
Glucose oxidase of *Aspergillus niger*										Baur [1981]

		Symptoms						Methods								
Study	n	R	Con.	A	Cou.	S	Tot.	LFT		Skin test	Spec. challenge		Antibodies			Remarks
I	1	−	−	+	+	−	nd	×	×	+	×	+	×	IgE	+	
C	279	+	−	+	−	−	25%	×	×	1% of 259	nd		nd			See also grain mites, moulds
S	47	+	−	+	−	+	nd	nd	×	66%	nd		×	IgE	68%	Tests were performed with Enolase of *S. cerevisiae* − > an important allergen
C	279	+	−	+	−	−	25%	×	×	2% of 259	nd		nd			See also grain mites, *Saccharomyces c.*
S	437	?	?	?	?	?	nd	nd	×	95%*	×	4% of 354	nd			*Skin test: intradermal
C	83	59%	−	30%	−	−	nd	nd	×	31%	×	43% of 14	×	IgE	52%	Oral challenge: 1 of 5 subjects (20%) positive
S	5	+	+	+	−	−	nd	×	×	100%	×	100%	×	IgE	100%	
C	89	+	−	+	−	−	48%	nd	×	18%	nd		×	IgE	16%	
CR	2	+	+	+	−	−	nd	nd	×	100%	nd		×	IgE	100%	1 case: anaphylactic shock after ingestion of pineapple
S	171	+	+	+	−	+	nd	nd	nd		nd		×	IgE	13%	Mixed exposure; cross-reactivity with xylanase
S	4	+	−	+	−	+	nd	×	×	75%	nd		×	IgE	100%	RAST-inhibition: cross-reactivity with xylanase
S	2	+	−	+	+	−	nd	×	×	100%	×	100%	×	IgE IgG	100% −	Prausnitz-Küstner: 100% pos. of 1
L	1064	+	−	+	−	+	8.8% (3 J)	×	nd		nd		×	IgE	22% of 653	Mixed exposure; Incidence development 0–15 mon. = 4.9%, 16–27 mon. = 2,8%; 28–39 mon. = 1,1%
L	667	+	−	+	+	−	3.3% (10 J)	×	nd		nd		×	IgE	4.7% in 10 Y	
S	261	+	+	+	−	−	nd	nd	nd		nd		×	IgE	5%	Mixed exposure
S	171	+	+	+	−	+	nd	nd	nd		nd		×	IgE	8%	Mixed exposure
I	1	−	−	+	−	−	nd	nd	×	+	nd		×	IgE	+	

TABLE I. (*Continued*)

Substances	Abbreviation	Formula	MW	CAS-Number	TLV-TWA (USA)	EU Label	TLV-TWA (Germany)	Sa Sah	Reference	Study	n	Symptoms R	Con.	A	Cou.	S	Tot.	Methods LFT		Skin test		Spec. challenge		Antibodies		Remarks
Hemicellulase of *Aspergillus niger*									Baur, Sauer et al. [1989]#	S	261	+	+	+	−	−	nd	nd	nd		nd		×	IgE	10%	Mixed exposure
Lactase									Muir, Verrall et al. [1997]	C	207	+	+	+	−	−	nd	×	×	31%	nd		nd			
Lysozyme (lysozyme chloride)									Park, Nahm [1997]	I	1	+	−	+	−	−	nd	×	×	+	×	+	×	IgE	+	See peptidase; RAST inhibition: no cross-reactivity
Lysozyme (egg)									Anibarro Bausela, Fontela [1996]	I	1	+	+	+	+	−	nd	×	×	+	×	+	×	IgE	−	See pepsin; RAST inibition: no cross-reactivity
”									Bernstein, Kraut et al. [1993]	I	1	−	−	+	−	−	nd	×	×	+	×	+		IgE	+	
Pancreatin (porcine)									Wiessmann, Baur [1985]	S	14	−	−	+	+	−	nd	×	×	93%	×	100% of 8	×	IgE IgG	75% of 4 14%	Reaction to the single substance α-amylase
Pancreatin (α-amylase of porcine pancreatin)									Aiken, Ward et al. [1997]	I	1	−	−	+	−	−	nd	×	nd		×	+	nd			
Papain of *Carica papaya*				9001-73-4		R 42			Merget, Bergmann et al. [1995]	I	1	+	+	+	−	−	nd	×	×	+	nd		×	IgE	+	
”									Baur, Konig et al. [1982]	C	29	+	+	+	−	+	45%	nd	×	41%	×	89% of 9	×	IgE	40%	
Pepsin				9001-75-6		R 42			Drexler, Beyer [1997]	I	1	−	−	+	−	−	nd	×	×	+	×	+	×	IgE	+	
”									Anibarro Bausela, Fontela [1996]	I	1	+	+	+	+	−	nd	×	×	+	×	+	×	IgE	−	See lysozyme; RAST-inhibition: no cross-reactivity
Peptidase of *Serratia ssp.*									Park, Nahm [1997]	I	1	+	−	+	−	−	nd	×	×	+	×	+	×	IgE	+	See lysozyme; RAST-inhibition: no cross-reactivity
Phytase of *Aspergillus niger*									Straßburger, Bossert et al. [1998]#	C	49	+	+	+	−	−	65%	×	×	34% of 32	×	34% of 32*	×	IgE	31% of 32	*Challenge: nasal
”									Doekes, Kamminga et al. [1999]	C	11	−	−	+	+	−	55%	nd	nd		nd		×	IgE	82%	Significantly evelated IgE level of exposed compared to non-exposed subjects (n = 30)
Suparen® (a rennet of *Endothica parasitica*)									Niinimaki, Saari [1978]	I	1	−	−	+	−	−	nd	nd	×	+*	nd		nd			*Skin test: scratch; skin test with rennet from calf: negative
Trypsin of cow pancreatin				9002-07-7		R 42			Johnsen, Sorensen et al. [1997]	L	1064	+	−	+	+	−	8.8% (3J)	×	nd		nd		×	IgE	11% of 288	Mixed exposure; Incidence development: 0–15 mon. = 4,9%; 16–27 mon. = 2,8%; 28–39 mon. = 1,1%
Trypsin (porcine)						R 42			Colten, Polakoff et al. [1975]	C	14	+	+	+	−	−	29%	×	×	29%*	×	75% of 4	×	IgG	−	*Skin test: scratch; Prausnitz-Küstner: 100% pos. of 2
β-Xylanase									Tarvainen, Kanerva et al. [1991]	CR	2	+	−	+	−	+	nd	×	×	100%	nd		×	IgE	100%	RAST inhibition: cross-reactivity with cellulase

TABLE I. (*Continued*)

Substances	Abbreviation	Formula	MW	CAS-Number	TLV-TWA (USA)	EU Label	TLV-TWA (Germany)	Sa Sah	Reference	Study	n	Symptoms R	Con.	A	Cou.	S	Tot.	Methods LFT	Skin test	Spec. challenge		Antibodies			Remarks
β-Xylanase (*Aspergillus niger*)									Sander, Raulf-Heimsoth et al. [1998]	S	171	+	+	+	−	+	nd	nd	nd		nd		×	IgE	11%	Mixed exposure; cross-reactivity with cellulase
”									Baur, Sander et al. [1998]	I	1	+	+	+	−	−	nd	×	×	+	×	+	×	IgE	+	
Bacillus subtilis enzymes																									
Alkalase® (Subtilisin A) (protease)						R 42			Johnsen, Sorensen et al. [1997]	L	1064	+	−	+	−	+	8.8% (3 J)	×	nd		nd		×	IgE	16% of 799	Mixed exposure; Incidence development: 0–15 mon. = 4,9%; 16–27 mon. = 2,8%; 28–39 mon. = 1,1%
Proteases (*B.s.*)						R 42			Franz, McMurrain et al. [1971]	S	38	−	−	+	−	+	nd	×	×	66%*	×	90% of 10*	×	IgG	48% of 25	*Skin test: intradermal; *challenge; FEV1 decrease of 14–45% Prausnitz-Küstner: 100% pos. of 5
Mixture (*B.s.*)									Juniper, How et al. [1977]#	L	1642	−	−	3%*	−	−	nd	×	×	18%*	nd		×	IgE	°26% of 248	*:Incidence over 7 years °:Alkalase-spec. IgE
Enzyme dust (mixture)																									
Trypsin, chymotrypsin, bromelain, papain = proteolytic enzymes; α-amylase, lipase									Zentner, Jeep et al. [1997]	S	10	−	+	+	+	−	nd	nd	×	100%	nd		×	IgE	100%	Sensitization to proteolytic enzymes more frequent, SPT: 6 subjects reacted to >3, IgE: 5 subjects reacted to >2 enzymes
α-Amylase, cellulase, xylanase									Vanhanen, Tuomi et al. [1996]	C	365	+	−	+	+	−	16%	nd	×	5.2%	nd		nd			

Occupational agents which, according to international publications, have proven to be airway sensitizers are presented. Substances are systematically arranged into four groups: chemicals, and those originating from animals, plants or microorganisms. Chemicals are subclassified into isocyanates, anhydrides or amines, metals and their compounds, medicaments, plastics including their monomers, dyes, and other chemicals. Animal categories include mites, insects, seafood, fish, dander, hair and urine of animals, and other animals and their products. Plants and microorganisms are arranged alphabetically and include subgroups of vegetable gums, soybean compounds, grain flour dust, wood and its components. Microorganisms (fungi) and enzymes complete the list.

[a]Modified from: van Kampen V, Merget R, Baur X. 1999. Atemwegssensibilisierende Arbeitsstoffe: Eine Übersicht. Arbeitsmedizin Sozialmedizin. Umweltmedizin. Stuttgart, Germany: Gentner Verlag.

ACKNOWLEDGMENTS

We thank Karin Weber for her assistance in improving the English.

REFERENCES

Abendroth RR, Kalveram CM, Kalveram KJ. 1992. Wood dust allergy: clinical findings, diagnosis, prognosis, new trends in protection at work. Allergologie 15:300–303.

Agius RM, Davison AG, Hawkins ER, Newman Taylor AJ. 1994. Occupational asthma in salbutamol process workers. Occup Environ Med 51:397–399.

Ahman M, van Hage-Hamsten M, Johansson SG. 1995. IgE-mediated allergy to wood dusts probably does not explain the high prevalence of respiratory symptoms among Swedish woodwork teachers. Allergy 50:559–562.

Aiken T, Ward R, Peel E, Hendrick D. 1997. Occupational asthma due to porcine pancreatic amylase. Occup Environ Med 54:762–764.

Allmers H, Huber H, Baur X. 1997. Bronchopulmonary mould allergy of a refuse collection worker. Arbeitsmed Sozialmed Umweltmed 32:64–67.

Alvarez MJ, Tabar AI, Quirce S, Olaguibel JM, Lizaso MT, Echechipia S, Rodriguez A, Garcia BE. 1996. Diversity of allergens causing occupational asthma among cereal workers as demonstrated by exposure procedures. Clin Exp Allergy 26:147–153.

Anibarro Bausela B, Fontela JL. 1996. Occupational asthma in a cheese worker. Allergy 51:960–961.

Antepara I, Jauregui I, Urrutia I, Gamboa PM, Gonzalez G, Barber D. 1994. Occupational asthma related to fresh *Gypsophila paniculata*. Allergy 49:478–480.

Armentia A, Martin-Santos J, Subiza J, Pola J, Zapata C, Valdivieso R, Losada E. 1988. Occupational asthma due to frogs. Ann Allergy 60:209–210.

Armstrong RA, Neill P, Mossop RT. 1988. Asthma induced by ivory dust: a new occupational cause. Thorax 43:737–738.

Asai S, Shimoda T, Hara K, Fujiwara K. 1987. Occupational asthma caused by isonicotinic acid hydrazide (INH) inhalation. J Allergy Clin Immunol 80:578–582.

Avashia B, Battigelli MC, Morgan WK, Reger RB. 1996. Effects of prolonged low exposure to methyl isocyanate. J Occup Environ Med 38:625–630.

Axelsson IG, Johansson SG, Zetterstrom O. 1987. Occupational allergy to weeping fig in plant keepers. Allergy 42:161–167.

Bagenstose AH, 3d, Mathews KP, Homburger HA, Saaveard-Delgado AP. 1980. Inhalant allergy due to crickets. J Allergy Clin Immunol 65:71–74.

Baker DB, Gann PH, Brooks SM, Gallagher J, Bernstein IL. 1990. Cross-sectional study of platinum salts sensitization among precious metals refinery workers. Am J Ind Med 18:653–664.

Baldo BA, Baker RS. 1988. Inhalant allergies to fungi: reactions to bakers' yeast (*Saccharomyces cerevisiae*) and identification of bakers' yeast enolase as an important allergen. Int Arch Allergy Appl Immunol 86:201–208.

Barker RD, Harris JM, Welch JA, Venables KM, Newman Taylor AJ. 1998a. Occupational asthma caused by tetrachlorophthalic anhydride: a 12-year follow-up. J Allergy Clin Immunol 101:717–719.

Barker RD, van Tongeren MJA, Harris JM, Gardiner K, Venables KM, Newman Taylor AJ. 1998b. Risk factors for sensitisation and respiratory symptoms among workers exposed to acid anhydrides: a cohort study. Occup Environ Med 55:684–691.

Basomba A, Burches E, Almodovar A, de Rojas DH. 1991. Occupational rhinitis and asthma caused by inhalation of *Balfourodendron riedelianum* (Pau Marfim) wood dust. Allergy 46: 316–318.

Baur X. 1981. Isolated enzymes of bacterial, plant and mould origin as potent inhalent and potential ingestive antigens. Allergologie 4: 87–89.

Baur X. 1986. Asthma caused by isocyanates. Allergologie 9: 487–496.

Baur X. 1993. Occupational hypersensitivity against tobacco dust. Allergologie 16:94–95.

Baur X. 1995. Hypersensitivity pneumonitis (extrinsic allergic alveolitis) induced by isocyanates. J Allergy Clin Immunol 95:1004–1010.

Baur X, Chen Z, Allmers H, Beckmann U, Walther J. 1995a. Relevance of latex aeroallergen for healthcare workers. Allergology International 20:105–111.

Baur X, Chen Z, Hurter T. 1998. Asthma and rhinoconjunctivitis caused by castor bean dust. Pneumologie 52:539–540.

Baur X, Chen Z, Sander I. 1994. Isolation and denomination of an important allergen in baking additives: α-amylase from *Aspergillus oryzae* (*Asp* o II). Clin Exp Allergy 24:465–470.

Baur X, Czuppon AB, Rauluk I, Zimmermann FB, Schmitt B, Egen-Korthaus M, Tenkhoff N, Degens PO. 1995b. A clinical and immunological study on 92 workers occupationally exposed to anhydrides. Int Arch Occup Environ Health 67:395–403.

Baur X, Degens PO, Sander I. 1998. Baker's asthma: still among the most frequent occupational respiratory disorders. J Allergy Clin Immunol 102:984–997.

Baur X, Fruhmann G. 1981. Specific IgE antibodies in patients with isocyanate asthma. Chest 80:73–76.

Baur X, Konig G, Bencze K, Fruhmann G. 1982. Clinical symptoms and results of skin test, RAST and bronchial provocation test in thirty-three papain workers: evidence for strong immunogenic potency and clinically relevant 'proteolytic effects of airborne papain'. Clin Allergy 12:9–17.

Baur X, Sander I, Posch A, Raulf-Heimsoth M. 1998. Baker's asthma due to enzyme xylanase—a new occupational allergen. Clin Exp Allergy 28:1591–1593.

Baur X, Sauer W, Weiss W, Fruhmann G. 1989. Inhalant allergens in modern baking industry. Immunol Allergy Pract 11:13–15.

Belchi-Hernandez J, Mora-Gonzalez A, Iniesta-Perez J. 1996. Baker's asthma caused by Saccharomyces cerevisiae in dry powder form. J Allergy Clin Immunol 97:131–134.

Belin L, Wass U, Audunsson G, Mathiasson L. 1983. Amines: possible causative agents in the development of bronchial hyperreactivity in workers manufacturing polyurethanes from isocyanates. Br J Ind Med 40:251–257.

Bergman A, Svedberg U, Nilsson E. 1995. Contact urticaria with anaphylactic reactions caused by occupational exposure to iridium salt. Contact Dermatitis 32:14–17.

Bernstein DI, Smith AB, Moller DR, Gallagher JS, Aw TC, London M, Kopp S, Carson G. 1987. Clinical and immunologic studies among egg-processing workers with occupational asthma. J Allergy Clin Immunol 80:791–797.

Bernstein JA, Kraut A, Bernstein DI, Warrington R, Bolin T, Warren CP, Bernstein IL. 1993. Occupational asthma induced by inhaled egg lysozyme. Chest 103:532–535.

Bhagat R, Swystun VA, Cockcroft DW. 1995. Occupational asthma caused by pea flour. Chest 107:1772.

Biagini RE, Bernstein DM, Klincewicz SL, Mittman R, Bernstein IL, Henningsen GM. 1992. Evaluation of cutaneous responses and lung function from exposure to opiate compounds among ethical narcotics-manufacturing workers. J Allergy Clin Immunol 89: 108–118.

Blainey AD, Topping MD, Ollier S, Davies RJ. 1989. Allergic respiratory disease in grain workers: the role of storage mites. J Allergy Clin Immunol 84:296–303.

Bolm-Audorff U, Bienfait HG, Burkhard J, Bury AH, Merget R, Pressel G, Schultze-Werninghaus G. 1992. Prevalence of respiratory allergy in a platinum refinery. Int Arch Occup Environ Health 64: 257–260.

Bourke SJ, Convery RP, Stenton SC, Malcolm RM, Hendrick DJ. 1997. Occupational asthma in an isothiazolinone manufacturing plant. Thorax 52:746–748.

Bousquet J, Dhivert H, Clauzel AM, Hewitt B, Michel FB. 1985. Occupational allergy to sunflower pollen. J Allergy Clin Immunol 75:70–74.

Bright P, Burge PS, O'Hickey SP, Gannon PF, Robertson AS, Boran A. 1997. Occupational asthma due to chrome and nickel electroplating. Thorax 52:28–32.

Broding HC, Chen Z, Baur X. 1996. Occupational asthma in a Ciprofloxacin production. Arbeitsmed Sozialmed Umweltmed 31: 156–158.

Brubaker RE, Muranko HJ, Smith DB, Beck GJ, Scovel G. 1979. Evaluation and control of a respiratory exposure to 3-(dimethylamino) propylamine. J Occup Med 21:688–690.

Bruckner HC. 1967. Extrinsic asthma in a tungsten carbide worker. J Occup Med 9:518–519.

Burches E, Pelaez A, Morales C, Braso JV, Rochina A, Lopez S, Benito M. 1996. Occupational allergy due to spider mites: *Tetranychus urticae* (Koch) and *Panonychus citri* (Koch). Clin Exp Allergy 26:1262–1267.

Burge PS, Harries MG, O'Brien I, Pepys J. 1980. Bronchial provocation studies in workers exposed to the fumes of electronic soldering fluxes. Clin Allergy 10:137–149.

Burge PS, Edge G, Hawkins R, White V, Taylor AJ. 1981. Occupational asthma in a factory making flux-cored solder containing colophony. Thorax 36:828–834.

Burge PS, Harries MG, Lam WK, O'Brien IM, Patchett PA. 1985. Occupational asthma due to formaldehyde. Thorax 40:255–260.

Burge PS, Hendy M, Hodgson ES. 1984. Occupational asthma, rhinitis, and dermatitis due to tetrazene in a detonator manufacturer. Thorax 39:470–471.

Bush RK, Yunginger JW, Reed CE. 1978. Asthma due to African zebrawood (Microberlinia) dust. Am Rev Respir Dis 117:601–603.

Cartier A, Chan H, Malo JL, Pineau L, Tse KS, Chan-Yeung M. 1986a. Occupational asthma caused by eastern white cedar (*Thuja occidentalis*) with demonstration that plicatic acid is present in this wood dust and is the causal agent. J Allergy Clin Immunol 77:639–645.

Cartier A, Malo JL, Ghezzo H, McCants M, Lehrer SB. 1986b. IgE sensitization in snow crab-processing workers. J Allergy Clin Immunol 78:344–348.

Cartier A, Malo JL. 1990. Occupational asthma due to tea dust. Thorax 45:203–206.

Chan-Yeung M, Desjardins A. 1992. Bronchial hyperresponsiveness and level of exposure in occupational asthma due to western red cedar (*Thuja plicata*). Serial observations before and after development of symptoms. Am Rev Respir Dis 146:1606–1609.

Chan-Yeung M, Malo JL. 1994. Aetiological agents in occupational asthma. Eur Respir J 7:346–371.

Clarke CW, Aldons PM. 1981. Isophorone diisocyanate induced respiratory disease (IPDI). Aust N Z J Med 11:290–292.

Cockcroft DW, Cartier A, Jones G, Tarlo SM, Dolovich J, Hargreave FE. 1980. Asthma caused by occupational exposure to a furan-based binder system. J Allergy Clin Immunol 66:458–463.

Cohen AJ, Forse MS, Tarlo SM. 1993. Occupational asthma caused by pectin inhalation during the manufacture of jam. Chest 103:309–311.

Colten HR, Polakoff PL, Weinstein SF, Strieder DJ. 1975. Immediate hypersensitivity to hog trypsin resulting from industrial exposure. N Engl J Med 292:1050–1053.

Cote J, Chan H, Brochu G, Chan-Yeung M. 1991. Occupational asthma caused by exposure to neurospora in a plywood factory worker. Br J Ind Med 48:279–282.

Cote J, Kennedy S, Chan-Yeung M. 1990. Sensitivity and specificity of PC20 and peak expiratory flow rate in cedar asthma. J Allergy Clin Immunol 85:592–598.

Coutts II, Dally MB, Taylor AJ, Pickering CA, Horsfield N. 1981. Asthma in workers manufacturing cephalosporins. Br Med J (Clin Res Ed) 283:950.

Coutts IL, Lozewicz S, Dally MB, Newman-Taylor AJ, Burge PS, Flind AC, Rogers DJ. 1984. Respiratory symptoms related to work in a factory manufacturing cimetidine tablets. Br Med J (Clin Res Ed) 288:1418.

Curran AD, Burge PS, Wiley K. 1996. Clinical and immunologic evaluation of workers exposed to glutaraldehyde. Allergy 51:826–832.

Davies RJ, Hendrick DJ, Pepys J. 1974. Asthma due to inhaled chemical agents: ampicillin, benzyl penicillin, 6 amino penicillanic acid and related substances. Clin Allergy 4:227–247.

De Zotti R, Larese F, Bovenzi M, Negro C, Molinari S. 1994. Allergic airway disease in Italian bakers and pastry makers. Occup Environ Med 51:548–552.

Delgado J, Orta JC, Navarro AM, Conde J, Martinez A, Martinez J, Palacios R. 1997. Occupational allergy in greenhouse workers: sensitization to *Tetranychus urticae*. Clin Exp Allergy 27:640–645.

Desjardins A, Malo JL, L'Archeveque J, Cartier A, McCants M, Lehrer SB. 1995. Occupational IgE-mediated sensitization and asthma caused by clam and shrimp. J Allergy Clin Immunol 96:608–617.

Dijkman JH, Vooren PH, Kramps JA. 1981. Occupational asthma due to inhalation of chloramine-T. I. Clinical observations and inhalation-provocation studies. Int Arch Allergy Appl Immunol 64:422–427.

Doekes G, Kamminga N, Helwegen L, Heederik D. 1999. Occupational IgE sensitisation to phytase, a phosphatase derived from *Aspergillus niger*. Occup Environ Med 56:454–459.

Douglas JD, McSharry C, Blaikie L, Morrow T, Miles S, Franklin D. 1995. Occupational asthma caused by automated salmon processing. Lancet 346:737–740.

Drexler H, Beyer B. 1997.Occupational asthma due to pepsin powder in a women checking meat for trichinae. Arbeitsmed Sozialmed Umweltmed 32:145–147.

Drexler H, Weber A, Letzel S, Kraus G, Schaller KH, Lehnert G. 1994. Detection and clinical relevance of a type I allergy with occupational exposure to hexahydrophthalic anhydride and methyltetrahydrophthalic anhydride. Int Arch Occup Environ Health 65:279–283.

Dyne D, Campion K, Griffin P. 1996. Occupational allergy among workers producing arthropods for organic pest conrol purposes. Ann Agric Environ Med 3:33–36.

Eriksson KA, Levin JO, Sandstrom T, Lindstrom-Espeling K, Linden G, Stjernberg NL. 1997. Terpene exposure and respiratory effects among workers in Swedish joinery shops. Scand J Work Environ Health 23:114–120.

Estlander T, Kanerva L, Tupasela O, Keskinen H, Jolanki R. 1993. Immediate and delayed allergy to nickel with contact urticaria, rhinitis, asthma and contact dermatitis. Clin Exp Allergy 23:306–310.

Etkind PH, Odell TM, Canada AT, Shama SK, Finn AM, Tuthill R. 1982. The gypsy moth caterpillar: a significant new occupational and public health problem. J Occup Med 24:659–662.

Falleroni AE, Zeiss CR, Levitz D. 1981. Occupational asthma secondary to inhalation of garlic dust. J Allergy Clin Immunol 68:156–160.

Fawcett IW, Taylor AJ, Pepys J. 1977. Asthma due to inhaled chemical agents–epoxy resin systems containing phthalic acid anhydride, trimellitic acid anhydride and triethylene tetramine. Clin Allergy 7:1–14.

Feo F, Martinez J, Martinez A, Galindo PA, Cruz A, Garcia R, Guerra F, Palacios R. 1997. Occupational allergy in saffron workers. Allergy 52:633–641.

Fernandez-Rivas M, Perez-Carral C, Senent CJ. 1997. Occupational asthma and rhinitis caused by ash (Fraxinus excelsior) wood dust. Allergy 52:196–199.

Fisher R, Saunders WB, Murray SJ, Stave GM. 1998. Prevention of laboratory animal allergy. J Occup Environ Med 40:609–613.

Fraj J, Lezaun A, Colas C, Duce F, Dominguez MA, Alonso MD. 1996. Occupational asthma induced by aniseed. Allergy 51:337–339.

Franz T, McMurrain KD, Brooks S, Bernstein IL. 1971. Clinical, immunologic, and physiologic observations in factory workers exposed to *B. subtilis* enzyme dust. J Allergy 47:170–180.

Friedrich H. 1986. Mealworm asthma. A contribution to the allergic occupational asthma. Allergologie 9:519–521.

Fuortes LJ, Kiken S, Makowsky M. 1995. An outbreak of naphthalene di-isocyanate-induced asthma in a plastics factory. Arch Environ Health 50:337–340.

Gailhofer G, Teubl I, Wilders-Trusching M, Ludvan M. 1987. Allergic asthma caused by Bromelin. Dermatosen 35:174–176.

Gamble JF, McMichael AJ, Williams T, Battigelli M. 1976. Respiratory function and symptoms: an environmental-epidemiological study of rubber workers exposed to a phenolformaldehyde type resin. Am Ind Hyg Assoc J 37:499–513.

Gannon PF, Bright P, Campbell M, O'Hickey SP, Burge PS. 1995. Occupational asthma due to glutaraldehyde and formaldehyde in endoscopy and x ray departments. Thorax 50:156–159.

Gannon PF, Burge PS, Benfield GF. 1992. Occupational asthma due to polyethylene shrink wrapping (paper wrapper's asthma). Thorax 47:759.

Garces Sotillos MM, Blanco Carmona JG, Juste Picon S, Rodriguez Gaston P, Perez Gimenez R, Alonso Gil L. 1995. Occupational asthma and contact urticaria caused by mukali wood dust (*Aningeria robusta*). J Investig Allergol Clin Immunol 5:113–114.

Garcia Lazaro MA, Abengozar Muela R, Arias Irigoyen J, Cabanes Higuero N, Ventas Alguacil P, Moral de Gregorio A, Senent CJ. 1997. Occupational asthma caused by hypersensitivity to ground bugs. J Allergy Clin Immunol 99:267–268.

Gheysens B, Auwerx J, Van den Eeckhout A, Demedts M. 1985. Cobalt-induced bronchial asthma in diamond polishers. Chest 88: 740–744.

Gold BL, Mathews KP, Burge HA. 1985. Occupational asthma caused by sewer flies. Am Rev Respir Dis 131:949–952.

Gottlieb SJ, Garibaldi E, Hutcheson PS, Slavin RG. 1993. Occupational asthma to the slime mold *Dictyostelium discoideum*. J Occup Med 35:1231–1235.

Graham VA, Coe MJ, Davies RJ. 1981. Occupational asthma after exposure to a diazonium salt. Thorax 36:950–951.

Greene SA, Freedman S. 1976. Asthma due to inhaled chemical agents—amprolium hydrochloride. Clin Allergy 6:105–108.

Grzybowski M, Ownby DR, Peyser PA, Johnson CC, Schork MA. 1996. The prevalence of anti-latex IgE antibodies among registered nurses. J Allergy Clin Immunol 98:535–544.

Hagmar L, Welinder H. 1986. Prevalence of specific IgE antibodies against piperazine in employees of a chemical plant. Int Arch Allergy Appl Immunol 81:12–16.

Harindranath N, Prakash O, Subba Rao PV. 1985. Prevalence of occupational asthma in silk filatures. Ann Allergy 55:511–515.

Harries MG, Burge PS, Samson M, Taylor AJ, Pepys J. 1979a. Isocyanate asthma: respiratory symptoms due to 1,5-naphthylene diisocyanate. Thorax 34:762–766.

Harries MG, Cromwell O. 1982. Occupational asthma caused by allergy to pigs' urine. Br Med J (Clin Res Ed) 284:867.

Harries MG, Taylor AN, Wooden J, MacAuslan A. 1979b. Bronchial asthma due to alpha-methyldopa. Br Med J 1:1461.

Hayes JP, Lambourn L, Hopkirk JA, Durham SR, Taylor AJ. 1991. Occupational asthma due to styrene. Thorax 46:396–397.

Helin T, Makinen-Kiljunen S. 1996. Occupational asthma and rhinoconjunctivitis caused by senna. Allergy 51:181–184.

Hendrick DJ, Connolly MJ, Stenton SC, Bird AG, Winterton IS, Walters EH. 1988. Occupational asthma due to sodium iso-nonanoyl oxybenzene sulphonate, a newly developed detergent ingredient. Thorax 43:501–502.

Herold DA, Wahl R, Maasch HJ, Hausen BM, Kunkel G. 1991. Occupational wood-dust sensitivity from *Euonymus europaeus* (spindle tree) and investigation of cross reactivity between E.e. wood and *Artemisia vulgaris* pollen (mugwort). Allergy 46: 186–190.

Hinojosa M, Losada E, Moneo I, Dominguez J, Carrillo T, Sanchez-Cano M. 1986. Occupational asthma caused by African maple (Obeche) and Ramin: evidence of cross reactivity between these two woods. Clin Allergy 16:145–153.

Hinze S, Bergmann K-C. 1995. Cow hair asthma: symptoms and clinical course. Allergo J 4:97–101.

Hollander A, Doekes G, Heederik D. 1996. Cat and dog allergy and total IgE as risk factors of laboratory animal allergy. J Allergy Clin Immunol 98:545–554.

Honda I, Kohrogi H, Ando M, Araki S, Ueno T, Futatsuka M, Ueda A. 1992. Occupational asthma induced by the fungicide tetrachloroisophthalonitrile. Thorax 47:760–761.

Houba R, Heederik D, Doekes G. 1998. Wheat sensitization and work-related symptoms in the baking industry are preventable. An epidemiologic study. Am J Respir Crit Care Med 158:1499–1503.

Hytonen M, Martimo KP, Estlander T, Tupasela O. 1996. Occupational IgE-mediated rhinitis caused by ninhydrin. Allergy 51:114–116.

Igea JM, Fernandez M, Quirce S, de la Hoz B, Diez Gomez ML. 1994. Green bean hypersensitivity: an occupational allergy in a homemaker. J Allergy Clin Immunol 94:33–35.

Jansen A, Vermeulen A, van Toorenenbergen AW, Dieges PH. 1995. Occupational asthma in horticulture caused by *Lathyrus odoratus*. Allergy Proc. 16:135–139.

Jansen AP, Visser FJ, Nierop G, de Jong NW, Waanders-de Lijster de Raadt J, Vermeulen A, van Toorenenbergen AW. 1996. Occupational asthma to amaryllis. Allergy 51:847–849.

Jeebhay MF, Prescott R, Potter PC, Ehrlich RI. 1996. Occupational asthma caused by imbuia wood dust. J Allergy Clin Immunol 97: 1025–1027.

Jimenez Gomez I, Anton E, Picans I, Jerez J, Obispo T. 1996. Occupational asthma caused by mink urine. Allergy 51:364–365.

Johnsen CR, Sorensen TB, Ingemann Larsen A, Bertelsen Secher A, Andreasen E, Kofoed GS, Fredslund Nielsen L, Gyntelberg F. 1997. Allergy risk in an enzyme producing plant: a retrospective follow up study. Occup Environ Med 54:671–675.

Jones RN, Hughes JM, Lehrer SB, Butcher BT, Glindmeyer HW, Diem JE, Hammad YY, Salvaggio J, Weill H. 1982. Lung function consequences of exposure and hypersensitivity in workers who process green coffee beans. Am Rev Respir Dis 125:199–202.

Juniper CP, How MJ, Goodwin BF, Kinshott AK. 1977. *Bacillus subtilis* enzymes: a 7-year clinical, epidemiological and immunological study of an industrial allergen. J Soc Occup Med 27: 3–12.

Kammermeyer JK, Mathews KP. 1973. Hypersensitivity to phenylglycine acid chloride. J Allergy Clin Immunol 52:73–84.

Kanerva L, Estlander T, Jolanki R, Tarvainen K. 1995. Occupational allergic contact dermatitis and contact urticaria caused by polyfunctional aziridine hardener. Contact Dermatitis 33:304–309.

Kaufman GL, Gandevia BH, Bellas TE, Tovey ER, Baldo BA. 1989. Occupational allergy in an entomological research centre. I. Clinical aspects of reactions to the sheep blowfly *Lucilia cuprina*. Br J Ind Med 46:473–478.

Kennes B, Garcia-Herreros P, Dierckx P. 1981. Asthma from plexiglas powders. Clin Allergy 11:49–54.

Kersten W, von Wahl PG. 1994. Occupational disease in the wood-processing industry. Allergologie 17:55–60.

Keskinen H, Ostman P, Vaheri E, Tarvainen K, Grenquist-Norden B, Karppinen O, Nordman H. 1991. A case of occupational asthma, rhinitis and urticaria due to sesame seed. Clin Exp Allergy 21: 623–624.

Keskinen H, Kalliomaki PL, Alanko K. 1980. Occupational asthma due to stainless steel welding fumes. Clin Allergy 10:151–159.

Kopp SK, McKay RT, Moller DR, Cassedy K, Brooks SM. 1985. Asthma and rhinitis due to ethylcyanoacrylate instant glue. Ann Intern Med 102:613–615.

Krakowiak A, Szulc B, Gorski P. 1997. Occupational respiratory diseases in laboratory animal workers: initial results. Int J Occup Med Environ Health 10:31–36.

Kramps JA, van Toorenenbergen AW, Vooren PH, Dijkman JH. 1981. Occupational asthma due to inhalation of chloramine-T. II. Demonstration of specific IgE antibodies. Int Arch Allergy Appl Immunol 64:428–438.

Kujala VM, Reijula KE, Ruotsalainen EM, Heikkinen K. 1995. Occupational asthma due to chloramine-T solution. Respir Med 89:693–695.

Kwaselow A, Rowe M, Sears-Ewald D, Ownby D. 1990. Rose hips: a new occupational allergen. J Allergy Clin Immunol 85:704–708.

Lachance P, Cartier A, Dolovich J, Malo JL. 1988. Occupational asthma from reactivity to an alkaline hydrolysis derivative of gluten. J Allergy Clin Immunol 81:385–390.

Lagier F, Cartier A, Dolovich J, Malo JL. 1989. Occupational asthma in a pharmaceutical worker exposed to penicillamine. Thorax 44: 157–158.

Lam S, Tan F, Chan H, Chan-Yeung M. 1983. Relationship between types of asthmatic reaction, nonspecific bronchial reactivity, and specific IgE antibodies in patients with red cedar asthma. J Allergy Clin Immunol 72:134–139.

Lambourn EM, Hayes JP, McAllister WA, Taylor AJ. 1992. Occupational asthma due to EPO 60. Br J Ind Med 49:294–295.

Lander F, Gravesen S. 1988. Respiratory disorders among tobacco workers. Br J Ind Med 45:500–502.

Larese F, Fiorito A, Casasola F, Molinari S, Peresson M, Barbina P, Negro C. 1998. Sensitization to green coffee beans and work-related allergic symptoms in coffee workers. Am J Ind Med 34: 623–627.

Lavaud F, Perdu D, Prevost A, Vallerand H, Cossart C, Passemard F. 1994. Baker's asthma related to soybean lecithin exposure. Allergy 49:159–162.

Lee HS, Wang YT, Yeo CT, Tan KT, Ratnam KV. 1989a. Occupational asthma due to tylosin tartrate. Br J Ind Med 46:498–499.

Lee HS, Wang YT, Cheong TH, Tan KT, Chee BE, Narendran K. 1991. Occupational asthma due to maleic anhydride. Br J Ind Med 48: 283–285.

Lee HS, Yap J, Wang YT, Lee CS, Tan KT, Poh SC. 1989b. Occupational asthma due to unheated polyvinylchloride resin dust. Br J Ind Med 46:820–822.

Lemiere C, Desjardins A, Cloutier Y, Drolet D, Perrault G, Cartier A, Malo JL. 1995. Occupational asthma due to formaldehyde resin dust with and without reaction to formaldehyde gas. Eur Respir J 8: 861–865.

Lemiere C, Cartier A, Lehrer SB, Malo JL. 1996a. Occupational asthma caused by aromatic herbs. Allergy 51:647–649.

Lemiere C, Desjardins A, Lehrer S, Malo JL. 1996b. Occupational asthma to lobster and shrimp. Allergy 51:272–273.

Lemiere C, Malo JL, McCants M, Lehrer S. 1996c. Occupational asthma caused by roasted coffee: immunologic evidence that roasted coffee contains the same antigens as green coffee, but at a lower concentration. J Allergy Clin Immunol 98:464–466.

Liebers V, Hoernstein M, Baur X. 1993. Humoral immune response to the insect allergen Chi t I in aquarists and fish-food factory workers. Allergy 48:236–239.

Liss GM, Bernstein D, Genesove L, Roos JO, Lim J. 1993. Assessment of risk factors for IgE-mediated sensitization to tetrachlorphthalic anhydride. J Allergy Clin Immunol 92:237–247.

Lopez-Rubio A, Rodriguez J, Crespo JF, Vives R, Daroca P, Reano M. 1998. Occupational asthma caused by exposure to asparagus: detection of allergens by immunoblotting. Allergy 53:1216–1220.

Losada E, Hinojosa M, Moneo I, Dominguez J, Diez Gomez ML, Ibanez MD. 1986. Occupational asthma caused by cellulase. J Allergy Clin Immunol 77:635–639.

Losada E, Hinojosa M, Quirce S, Sanchez-Cano M, Moneo I. 1992. Occupational asthma caused by alpha-amylase inhalation: clinical and immunologic findings and bronchial response patterns. J Allergy Clin Immunol 89:118–125.

Lozewicz S, Davison AG, Hopkirk A, Burge PS, Boldy DA, Riordan JF, McGivern DV, Platts BW, Davies D, Newman Taylor AJ. 1985. Occupational asthma due to methyl methacrylate and cyanoacrylates. Thorax 40:836–839.

Luczynska CM, Marshall PE, Scarisbrick DA, Topping MD. 1984. Occupational allergy due to inhalation of ipecacuanha dust. Clin Allergy 14:169–175.

Luczynska CM, Hutchcroft BJ, Harrison MA, Dornan JD, Topping MD. 1990. Occupational asthma and specific IgE to a diazonium salt intermediate used in the polymer industry. J Allergy Clin Immunol 85:1076–1082.

Lutsky I, Teichtahl H, Bar-Sela S. 1984. Occupational asthma due to poultry mites. J Allergy Clin Immunol 73:56–60.

Malo JL, Cartier A. 1988. Occupational asthma in workers of a pharmaceutical company processing spiramycin. Thorax 43: 371–377.

Malo JL, Cartier A, Desjardins A. 1995. Occupational asthma caused by dry metabisulphite. Thorax 50:585–586.

Malo JL, Cartier A, Desjardins A, Van de Weyer R, Vandenplas O. 1995. Occupational asthma caused by oak wood dust. Chest 108: 856–858.

Malo JL, Cartier A, Doepner M, Nieboer E, Evans S, Dolovich J. 1982. Occupational asthma caused by nickel sulfate. J Allergy Clin Immunol 69:55–59.

Malo JL, Cartier A, Dolovich J. 1993. Occupational asthma due to zinc. Eur Respir J 6:447–450.

Malo JL, Cartier A, L'Archeveque J, Ghezzo H, Soucy F, Somers J, Dolovich J. 1990. Prevalence of occupational asthma and immunologic sensitization to guar gum among employees at a carpet-manufacturing plant. J Allergy Clin Immunol 86:562–569.

Malo JL, Cartier A, L'Archeveque J, Trudeau C, Courteau JP, Bherer L. 1994a. Prevalence of occupational asthma among workers exposed to eastern white cedar. Am J Respir Crit Care Med 150: 1697–1701.

Malo JL, Cartier A, Pineault L, Dugas M, Desjardins A. 1994b. Occupational asthma due to heated polypropylene. Eur Respir J 7:415–417.

Malo JL, Gagnon G, Cartier A. 1984. Occupational asthma due to heated freon. Thorax 39:628–629.

Mapp CE, Corona PC, De Marzo N, Fabbri L. 1988. Persistent asthma due to isocyanates. A follow-up study of subjects with occupational asthma due to toluene diisocyanate (TDI). Am Rev Respir Dis 137:1326–1329.

Marks GB, Salome CM, Woolcock AJ. 1991. Asthma and allergy associated with occupational exposure to ispaghula and senna products in a pharmaceutical work force. Am Rev Respir Dis 144: 1065–1069.

Massin N, Bohadana AB, Wild P, Kolopp-Sarda MN, Toamain JP. 1995. Airway responsiveness to methacholine, respiratory symptoms, and dust exposure levels in grain and flour mill workers in eastern France. Am J Ind Med 27:859–869.

Meadway J. 1980. Asthma and atopy in workers with an epoxy adhesive. Br J Dis Chest 74:149–154.

Meister W. 1978. Professional asthma owning to Daphnia-allergy. Allergie und Immunologie 24:191–193.

Menon MP, Das AK. 1977. Tetracycline asthma—a case report. Clin Allergy 7:285–290.

Merget R, Bergmann E, Schärling B. 1995. Severe occupational asthma from papain. Allergo J 4:365–369.

Merget R, Heger M, Wahl R, Cromwell O, Rasche K, Schultze-Werninghaus G. 1994. Seasonal occupational asthma in an agricultural products merchant—a case report. Allergy 49:897–901.

Merget R, Schultze-Werninghaus G, Muthorst T, Friedrich W, Meier-Sydow J. 1988. Asthma due to the complex salts of platinum—a cross-sectional survey of workers in a platinum refinery. Clin Allergy 18:569–580.

Moller DR, Gallagher JS, Bernstein DI, Wilcox TG, Burroughs HE, Bernstein IL. 1985. Detection of IgE-mediated respiratory sensitization in workers exposed to hexahydrophthalic anhydride. J Allergy Clin Immunol 75:663–672.

Moneo I, Alday E, Ramos C, Curiel G. 1993. Occupational asthma caused by *Papaver somniferum*. Allergol Immunopathol (Madr) 21:145–148.

Moscato G, Biscaldi G, Cottica D, Pugliese F, Candura S, Candura F. 1987. Occupational asthma due to styrene: two case reports. J Occup Med 29:957–960.

Moscato G, Dellabianca A, Vinci G, Candura SM, Bossi MC. 1991. Toluene diisocyanate-induced asthma: clinical findings and bronchial responsiveness studies in 113 exposed subjects with work-related respiratory symptoms. J Occup Med 33:720–725.

Moscato G, Galdi E, Scibilia J, Dellabianca A, Omodeo P, Vittadini G, Biscaldi GP. 1995. Occupational asthma, rhinitis and urticaria due to piperacillin sodium in a pharmaceutical worker. Eur Respir J 8: 467–469.

Moscato G, Omodeo P, Dellabianca A, Colli MC, Pugliese F, Locatelli C, Scibilia J. 1997. Occupational asthma and rhinitis caused by 1,2-benzisothiazolin-3-one in a chemical worker. Occup Med (Oxf) 47:249–251.

Moscato G, Naldi L, Candura F. 1984. Bronchial asthma due to spiramycin and adipic acid. Clin Allergy 14:355–361.

Muir DC, Verrall AB, Julian JA, Millman JM, Beaudin MA, Dolovich J. 1997. Occupational sensitization to lactase. Am J Ind Med 31: 570–571.

Muittari A, Veneskoski T. 1978. Natural and synthetic fibers as causes of asthma and rhinitis. Ann Allergy 41:48–50.

Murdoch RD, Pepys J, Hughes EG. 1986. IgE antibody responses to platinum group metals: a large scale refinery survey. Br J Ind Med 43:37–43.

Musk AW, Venables KM, Crook B, Nunn AJ, Hawkins R, Crook GD, Graneek BJ, Tee RD, Farrer N, Johnson DA. 1989. Respiratory symptoms, lung function, and sensitisation to flour in a British bakery. Br J Ind Med 46:636–642.

Nagy L, Orosz M. 1984. Occupational asthma due to hexachlorophene. Thorax 39:630–631.

Nahm DH, Park JW, Hong CS. 1996. Occupational asthma due to deer dander. Ann Allergy Asthma Immunol 76:423–426.

Nakazawa T, Matsui S. 1990. Ethylenediamine-induced late asthmatic responses. J Asthma 27:207–212.

Nemery B, Demedts M. 1989. Occupational asthma in a chicory grower. Lancet 1:672–673.

Newmark FM. 1978. Hops allergy and terpene sensitivity: an occupational disease. Ann Allergy 41:311–312.

Ng TP, Lee HS, Malik MA, Chee CB, Cheong TH, Wang YT. 1995. Asthma in chemical workers exposed to aliphatic polyamines. Occup Med (Oxf) 45:45–48.

Nielsen J, Bensryd I, Almquist H, Dahlqvist M, Welinder H, Alexandersson R, Skerfving S. 1991. Serum IgE and lung function in workers exposed to phthalic anhydride. Int Arch Occup Environ Health 63:199–204.

Nielsen J, Welinder H, Skerfving S. 1989. Allergic airway disease caused by methyl tetrahydrophthalic anhydride in epoxy resin. Scand J Work Environ Health 15:154–155.

Niinimaki A, Saari S. 1978. Dermatological and allergic hazards of cheesemakers. Scand J Work Environ Health 4:262–263.

Nilsson R, Nordlinder R, Wass U, Meding B, Belin L. 1993. Asthma, rhinitis, and dermatitis in workers exposed to reactive dyes. Br J Ind Med 50:65–70.

Normand JC, Grange F, Hernandez C, Ganay A, Davezies P, Bergeret A, Prost G. 1989. Occupational asthma after exposure to azodicarbonamide: report of four cases. Br J Ind Med 46:60–62.

Novey HS, Habib M, Wells ID. 1983. Asthma and IgE antibodies induced by chromium and nickel salts. J Allergy Clin Immunol 72:407–412.

Oertmann C, Bergmann K-C. 1993. Airway diseases in woodworkers. Allergologie 16:334–340.

Oertmann C, Müsken H, Bergmann K-C. 1995. Allergy by house dust mites in the poultry house. Allergologie 18:327–330.

Olaguibel JM, Hernandez D, Morales P, Peris A, Basomba A. 1990. Occupational asthma caused by inhalation of casein. Allergy 45: 306–308.

Ordinance on Hazardous Substances (Gefahrstoffverordnung) of 26. Oktober 1993, version of 12. Juni 1996.

Ostrom NK, Swanson MC, Agarwal MK, Yunginger JW. 1986. Occupational allergy to honeybee-body dust in a honey-processing plant. J Allergy Clin Immunol 77:736–740.

Pankow W, Hein H, Bittner K, Wichert P. 1989. Persulfate asthma in hairdressers. Pneumologie 43:173–175.

Park HS, Nahm DH. 1996. Buckwheat flour hypersensitivity: an occupational asthma in a noodle maker. Clin Exp Allergy 26: 423–427.

Park HS, Nahm DH. 1997. New occupational allergen in a pharmaceutical industry: serratial peptidase and lysozyme chloride. Ann Allergy Asthma Immunol 78:225–229.

Park HS, Yu HJ, Jung KS. 1994. Occupational asthma caused by chromium. Clin Exp Allergy 24:676–681.

Parra FM, Igea JM, Quirce S, Ferrando MC, Martin JA, Losada E. 1992. Occupational asthma in a hairdresser caused by persulphate salts. Allergy 47:656–660.

Pepys J, Pickering CA. 1972. Asthma due to inhaled chemical fumes—amino-ethyl ethanolamine in aluminium soldering flux. Clin Allergy 2:197–204.

Perfetti L, Cartier A, Malo JL. 1997. Occupational asthma in poultry-slaughterhouse workers. Allergy 52:594–595.

Perfetti L, Lehrer SB, McCants M, Malo JL. 1997. Occupational asthma caused by cacao. Allergy 52:778–780.

Perrin B, Malo JL, Cartier A, Evans S, Dolovich J. 1990. Occupational asthma in a pharmaceutical worker exposed to hydralazine. Thorax 45:980–981.

Picon SJ, Blanco Carmona JG, Garces Sotillos MD. 1991. Occupational asthma caused by vetch (*Vicia sativa*). J Allergy Clin Immunol 88:135–136.

Piirila P, Estlander T, Hytonen M, Keskinen H, Tupasela O, Tuppurainen M. 1997a. Rhinitis caused by ninhydrin develops into occupational asthma. Eur Respir J 10:1918–1921.

Piirila P, Estlander T, Keskinen H, Jolanki R, Laakkonen A, Pfaffli P, Tupasela O, Tuppurainen M, Nordman H. 1997b. Occupational asthma caused by triglycidyl isocyanurate (TGIC). Clin Exp Allergy 27: 510–514.

Piirila P, Keskinen H, Leino T, Tupasela O, Tuppurainen M. 1994. Occupational asthma caused by decorative flowers: review and case reports. Int Arch Occup Environ Health 66:131–136.

Pisati G, Zedda S. 1994. Outcome of occupational asthma due to cobalt hypersensitivity. Sci Total Environ 150:167–171.

Quirce S, Cuevas M, Diez-Gomez M, Fernandez-Rivas M, Hinojosa M, Gonzalez R, Losada E. 1992. Respiratory allergy to Aspergillus-derived enzymes in bakers' asthma. J Allergy Clin Immunol 90: 970–978.

Quirce S, Garcia-Figueroa B, Olaguibel JM, Muro MD, Tabar AI. 1993. Occupational asthma and contact urticaria from dried flowers of *Limonium tataricum*. Allergy 48:285–290.

Raghuprasad PK, Brooks SM, Litwin A, Edwards JJ, Bernstein IL, Gallagher J. 1980. Quillaja bark (soapbark)–induced asthma. J Allergy Clin Immunol 65:285–287.

Report by the German Federal Ministry of Labor and Social Affairs (Bundesministerium für Arbeit und Sozialordnung), Report "Arbeitssicherheit, Unfallverhütungsbericht Arbeit", 1998.

Resta O, Foschino-Barbaro MP, Carnimeo N, Di Napoli PL, Pavese I, Schino P. 1982. Occupational asthma from fish-feed Echinodorus plamosus larva. Med Lav 73:234–236.

Rodriguez J, Reano M, Vives R, Canto G, Daroca P, Crespo JF, Vila C, Villarreal D, Bensabat Z. 1997. Occupational asthma caused by fish inhalation. Allergy 52:866–869.

Romano C, Sulotto F, Pavan I, Chiesa A, Scansetti G. 1992. A new case of occupational asthma from reactive dyes with severe anaphylactic response to the specific challenge. Am J Ind Med 21:209–216.

Rosenberg M, Aaronson D, Evans C. 1984. Asthmatic responses to inhaled aminophylline: a report of two cases. Ann Allergy 52: 97–98.

Rosenman KD, Bernstein DI, O'Leary K, Gallagher JS, D'Souza L, Bernstein IL. 1987. Occupational asthma caused by himic anhydride. Scand J Work Environ Health 13:150–154.

Rossi GL, Corsico A, Moscato G. 1994. Occupational asthma caused by milk proteins: report on a case. J Allergy Clin Immunol 93: 799–801.

Royce S, Wald P, Sheppard D, Balmes J. 1993. Occupational asthma in a pesticides manufacturing worker. Chest 103:295–296.

Rubin JM, Duke MB. 1974. Unusual cause of bronchial asthma. Cacoon seed used for decorative purposes. N Y State J Med 74: 538–539.

Sander I, Raulf-Heimsoth M, Siethoff C, Lohaus C, Meyer HE, Baur X. 1998. Allergy to Aspergillus-derived enzymes in the baking industry: identification of beta-xylosidase from *Aspergillus niger* as a new allergen (Asp n 14). J Allergy Clin Immunol 102:256–264.

Sargent EV, Brubaker RE, Mitchell CA. 1976. Respiratory effects of occupational exposure to an epoxy resin system. Arch Environ Health 31:236–240.

Sastre J, Olmo M, Novalvos A, Ibanez D, Lahoz C. 1996. Occupational asthma due to different spices. Allergy 51:117–120.

Savonius B, Keskinen H, Tuppurainen M, Kanerva L. 1993. Occupational respiratory disease caused by acrylates. Clin Exp Allergy 23:416–424.

Savonius B, Keskinen H, Tuppurainen M, Kanerva L. 1994. Occupational asthma caused by ethanolamines. Allergy 49:877–881.

Schroeckenstein DC, Meier-Davis S, Bush RK. 1990. Occupational sensitivity to *Tenebrio molitor Linnaeus* (yellow mealworm). J Allergy Clin Immunol 86:182–188.

Scibilia J, Galdi E, Biscaldi G, Moscato G. 1997. Occupational asthma caused by black henna. Allergy 52:231–232.

Seaton A, Wales D. 1994. Clinical reactions to *Aspergillus niger* in a biotechnology plant: an eight year follow up. Occup Environ Med 51:54–56.

Shelton D, Urch B, Tarlo SM. 1992. Occupational asthma induced by a carpet fungicide—tributyl tin oxide. J Allergy Clin Immunol 90: 274–275.

Sherson D, Hansen I, Sigsgaard T. 1989. Occupationally related respiratory symptoms in trout-processing workers. Allergy 44: 336–341.

Shimoda T. 1990. Detection of IgE antibodies specific to isonicotinic acid hydrazide and its metabolite by enzyme-linked immunosorbent assay and the mechanism of sensitization by inhalation or ingestion of this compound. Jpn J Allergol 39:567–576.

Shirakawa T, Kusaka Y, Fujimura N, Kato M, Heki S, Morimoto K. 1990. Hard metal asthma: cross immunological and respiratory reactivity between cobalt and nickel? Thorax 45:267–271.

Shirakawa T, Morimoto K. 1997. Interplay of cigarette smoking and occupational exposure on specific immunoglobulin E antibodies to cobalt. Arch Environ Health 52:124–128.

Shmunes E, Taylor JS, Petz LD, Garratty G, Fudenberg HH. 1976. Immunologic reactions in penicillin factory workers. Ann Allergy 36:313–323.

Simpson C, Garabrant D, Torrey S, Robins T, Franzblau A. 1996. Hypersensitivity pneumonitis-like reaction and occupational asthma associated with 1,3-bis(isocyanatomethyl) cyclohexane pre-polymer. Am J Ind Med 30:48–55.

Siracusa A, Bettini P, Bacoccoli R, Severini C, Verga A, Abbritti G. 1994. Asthma caused by live fish bait. J Allergy Clin Immunol 93: 424–430.

Slovak AJ. 1981. Occupational asthma caused by a plastics blowing agent, azodicarbonamide. Thorax 36:906–909.

Smith AB, Bernstein DI, London MA, Gallagher J, Ornella GA, Gelletly SK, Wallingford K, Newman MA. 1990. Evaluation of occupational asthma from airborne egg protein exposure in multiple settings. Chest 98:398–404.

So SY, Lam WK, Yu D. 1981. Colophony-induced asthma in a poultry vender. Clin Allergy 11:395–399.

Soparkar GR, Patel PC, Cockcroft DW. 1993. Inhalant atopic sensitivity to grasshoppers in research laboratories. J Allergy Clin Immunol 92:61–65.

Spieksma FT, Vooren PH, Kramps JA, Dijkman JH. 1986. Respiratory allergy to laboratory fruit flies (*Drosophila melanogaster*). J Allergy Clin Immunol 77:108–113.

Spiewak R, Bozek A, Maslowski T, Brewczynski PZ. 1994. Occupational asthma due to wood dust exposure (ash, oak, beech and pine)—a case study. Ann Agric Environ Med 1:73–76.

Steinberg DR, Bernstein DI, Gallagher JS, Arlian L, Bernstein IL. 1987. Cockroach sensitization in laboratory workers. J Allergy Clin Immunol 80:586–590.

Stejskal VD, Forsbeck M, Olin R. 1987. Side-chain-specific lymphocyte responses in workers with occupational allergy induced by penicillins. Int Arch Allergy Appl Immunol 82:461–464.

Stenton SC, Dennis JH, Walters EH, Hendrick DJ. 1990. Asthmagenic properties of a newly developed detergent ingredient: sodium isononanoyl oxybenzene sulphonate. Br J Ind Med 47:405–410.

Stenton SC, Dennis JH, Hendrick DJ. 1995. Occupational asthma due to ceftazidime. Eur Respir J 8:1421–1423.

Stenton SC, Kelly CA, Walters EH, Hendrick DJ. 1989. Occupational asthma due to a repair process for polyethylene-coated electrical cables. J Soc Occup Med 39:33–34.

Stevens JJ. 1976. Asthma due to soldering flux: a polyether alcohol-polypropylene glycol mixture. Ann Allergy 36:419–422.

Straßburger K, Bossert J, Baur X, Zober A. 1998. Sensitization due to the enzymes phytase and xylanase. In: Hallier E, Bünger J, editors. 38. Jahrestagung Dtsch Ges Arbeits Umweltmedizin, Fulda, p 525–527.

Stücker W, Roggenbuck D, v. Kichbach G. 1996. Asthmatic reaction after occupational exposure to the food colouring material cochineal/carmine. Allergo J 5:143–146.

Subiza J, Subiza JL, Escribano PM, Hinojosa M, Garcia R, Jerez M, Subiza E. 1991. Occupational asthma caused by Brazil ginseng dust. J Allergy Clin Immunol 88:731–736.

Subiza J, Subiza JL, Hinojosa M, Varela S, Cabrera M, Marco F. 1995. Occupational asthma caused by grass juice. J Allergy Clin Immunol 96:693–695.

Symington IS, Kerr JW, McLean DA. 1981. Type I allergy in mushroom soup processors. Clin Allergy 11:43–47.

Tarlo SM. 1992. Occupational asthma induced by tall oil in the rubber tyre industry. Clin Exp Allergy 22:99–101.

Tarlo SM, Wai Y, Dolovich J, Summerbell R. 1996. Occupational asthma induced by *Chrysonilia sitophila* in the logging industry. J Allergy Clin Immunol 97:1409–1413.

Tarvainen K, Jolanki R, Estlander T, Tupasela O, Pfaffli P, Kanerva L. 1995. Immunologic contact urticaria due to airborne methylhexahydrophthalic and methyltetrahydrophthalic anhydrides. Contact Dermatitis 32:204–209.

Travainen K, Kanerva L, Tupasela O, Grenquist-Norden B, Jolanki R, Estlander T, Keskinen H. 1991. Allergy from cellulase and xylanase enzymes. Clin Exp Allergy 21:609–615.

Tee RD, Gordon DJ, Hawkins ER, Nunn AJ, Lacey J, Venables KM, Cooter RJ, McCaffery AR, Newman Taylor AJ. 1988. Occupational allergy to locusts: an investigation of the sources of the allergen. J Allergy Clin Immunol 81:517–525.

Vallieres M, Cockcroft DW, Taylor DM, Dolovich J, Hargreave FE. 1977. Dimethyl ethanolamine-induced asthma. Am Rev Respir Dis 115:867–871.

van Hage-Hamsten M, Ihre E, Zetterstrom O, Johansson SG. 1988. Bronchial provocation studies in farmers with positive RAST to the storage mite Lepidoglyphus destructor. Allergy 43:545–551.

Vandenplas O, Cartier A, Lesage J, Perrault G, Grammer LC, Malo JL. 1992. Occupational asthma caused by a prepolymer but not the monomer of toluene diisocyanate (TDI). J Allergy Clin Immunol 89:1183–1188.

Vandenplas O, Cartier A, Lesage J, Cloutier Y, Perreault G, Grammer L, Shaughnessy MA, Malo JL. 1993a. Prepolymers of hexamethylene diisocyanate as a cause of occupational asthma. J Allergy Clin Immunol 91:850–861.

Vandenplas O, Depelchin S, Toussaint G, Delwiche JP, Weyer RV, Saint-Remy JM. 1996. Occupational asthma caused by sarsaparilla root dust. J Allergy Clin Immunol 97:1416–1418.

Vandenplas O, Malo JL, Dugas M, Cartier A, Desjardins A, Levesque J, Shaughnessy MA, Grammer LC. 1993b. Hypersensitivity pneumonitis-like reaction among workers exposed to diphenylmethane diisocyanate (MDI). Am Rev Respir Dis 147:338–346.

Vandenplas O, Vander Borght T, Delwiche JP. 1998. Occupational asthma caused by sunflower-seed dust. Allergy 53:907–908.

Vanhanen M, Tuomi T, Hokkanen H, Tupasela O, Tuomainen A, Holmberg PC, Leisola M, Nordman H. 1996. Enzyme exposure and enzyme sensitisation in the baking industry. Occup Environ Med 53:670–676.

Vaswani SK, Hamilton RG, Valentine MD, Adkinson NF, Jr. 1996. Psyllium laxative-induced anaphylaxis, asthma, and rhinitis. Allergy 51:266–268.

Venables KM, Tee RD, Hawkins ER, Gordon DJ, Wale CJ, Farrer NM, Lam TH, Baxter PJ, Newman Taylor AJ. 1988. Laboratory animal allergy in a pharmaceutical company. Br J Ind Med 45: 660–666.

Verraes S, Michel O. 1995. Occupational asthma induced by ethylene oxide. Lancet 346:1434–1435.

Vidal C, Gonzalez-Quintela A. 1995. Food-induced and occupational asthma due to barley flour. Ann Allergy Asthma Immunol 75:121–124.

Waclawski ER, McAlpine LG, Thomson NC. 1989. Occupational asthma in nurses caused by chlorhexidine and alcohol aerosols. BMJ 298:929–930.

Wagner W. 1980. Karaya gum hypersensitivity in an enterostomal therapist. JAMA 243:432.

Wallenstein G, Bergmann I, Rebohle E, Gemeinhardt H, Thürmer H. 1980. Occupational respiratory diseases due to moulds in millers and bakers. Z Erkrank Atm-Org 154:229–233.

Weir DC, Robertson AS, Jones S, Burge PS. 1989. Occupational asthma due to soft corrosive soldering fluxes containing zinc chloride and ammonium chloride. Thorax 44:220–223.

Welinder H, Hagmar L, Gustavsson C. 1986. IgE antibodies against piperazine and N-methyl-piperazine in two asthmatic subjects. Int Arch Allergy Appl Immunol 79:259–262.

Welinder H, Nielsen J, Bensryd I, Skerfving S. 1988. IgG antibodies against polyisocyanates in car painters. Clin Allergy 18:85–93.

Welinder H, Nielsen J, Gustavsson C, Bensryd I, Skerfving S. 1990. Specific antobodies to methyltetrahydrophthalic anhydride in exposed workers. Clin Exp Allergy 20:639–645.

Wernfors M, Nielsen J, Schutz A, Skerfving S. 1986. Phthalic anhydride-induced occupational asthma. Int Arch Allergy Appl Immunol 79:77–82.

Wiessmann KJ, Baur X. 1985. Occupational lung disease following long-term inhalation of pancreatic extracts. Eur J Respir Dis 66: 13–20.

Wigger-Alberti W, Elsner P, Wuthrich B. 1996. Immediate-type allergy to the hair dye basic blue 99 in a hairdresser. Allergy 51:64–65.

Wilhelmsson B, Jernudd Y, Ripe E, Holmberg K. 1985. Nasal hypersensitivity in wood furniture workers. Rhinology 23:297–302.

Yassin MS, Lierl MB, Fischer TJ, O'Brien K, Cross J, Steinmetz C. 1994. Latex allergy in hospital employees. Ann Allergy 72:245–249.

Zachariae H, Hoech-Thomsen J, Witmeur O, Wide L. 1981. Detergent enzymes and occupational safety. Observations on sensitization during Esperase production. Allergy 36:513–516.

Zammit-Tabona M, Sherkin M, Kijek K, Chan H, Chan-Yeung M. 1983. Asthma caused by diphenylmethane diisocyanate in foundry workers. Clinical, bronchial provocation, and immunologic studies. Am Rev Respir Dis 128:226–230.

Zeiss RC, Mitchell JH, van Peenen PF, Kavich D, Collins MJ, Grammer L, Shaughnessey M, Levitz D, Henderson J, Patterson R. 1992. A clinical and immunologic study of employees in a facility manufacturing trimellitic anhydride. Allergy Proc. 13:193–198.

Zentner A, Jeep S, Wahl R, Kunkel G, Kleine-Tebbe J. 1997. Multiple IgE-mediated sensitizations to enzymes after occupational exposure: evaluation by skin prick test, RAST, and immunoblot. Allergy 52: 928–934.

Zuskin E, Kanceljak B, Skuric Z, Butkovic D. 1985. Bronchial reactivity in green coffee exposure. Br J Ind Med 42:415–420.

Zuskin E, Kanceljak B, Mustajbegovic J, Schachter EN, Kern J. 1994. Respiratory function and immunological reactions in sisal workers. Int Arch Occup Environ Health 66:37–42.

Zuskin E, Mustajbegovic J, Schachter EN, Doko-Jelinic J. 1997. Respiratory function of textile workers employed in dyeing cotton and wool fibers. Am J Ind Med 31:344–352.