

Occupational allergic contact dermatitis caused by coconut fatty acids diethanolamide

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Summary

Background. Coconut fatty acids diethanolamide [cocamide diethanolamine (cocamide DEA)] is a surface-active derivative of coconut oil that is used in industrial, household and cosmetic products. Cocamide DEA contact allergy has been reported relatively seldom.

Objectives. To describe cocamide DEA-positive patients in an occupational dermatology clinic.

Methods. We retrieved allergic reactions to cocamide DEA from test files, and studied the occupation, exposure, concomitant allergic reactions and diagnoses of the positive patients.

Results. Of the 2572 patients tested, 25 (1%) had an allergic reaction to cocamide DEA. Nineteen patients were occupational cases, and 11 worked in the metal industry. Hand cleansers constituted the main source of sensitization ($n = 17$). Other sources included two dishwashing liquids, one barrier cream, and one metalworking fluid. Three patients reacted to monoethanolamine and 2 to diethanolamine. Diethanolamine is an impurity of cocamide DEA, and can be found in cocamide DEA-containing products and in commercial patch test substances, which may explain some concomitant reactions.

Conclusions. Cocamide DEA allergy is relatively common in patients with occupational hand dermatitis, and mainly derives from hand cleansers. However, exposure to detergents, metalworking fluids and barrier creams must also be taken into account. Concomitant reactions to ethanolamines are possible.

Key words: barrier cream; diethanolamine; dishwashing liquid; hand cleanser; metal industry; metalworking fluid; monoethanolamine.

Coconut fatty acids diethanolamide [cocamide diethanolamine (cocamide DEA), coconut diethanolamide; CAS no. 68603-42-9 or 61791-31-9; Fig. 1] is a water-soluble derivative of a fatty acid mixture derived from coconut oil (Table 1). It is an agent with surface-active properties, and thus functions as, for example,

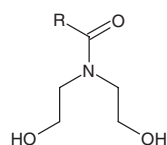
a surfactant/emulsifier, corrosion inhibitor and cleansing agent in industrial and household products such as cleaning agents, waxes and wax removers, cutting fluids, industrial hand cleansers, and protective creams. According to the International Cosmetic Ingredient Dictionary and Handbook of 2000 (1), it is used in cosmetics as an antistatic agent, foam booster and viscosity-increasing agent in product categories including shampoos, hair colours, bath soaps, tonics, hair styling preparations, shaving creams, and deodorants.

Cocamide DEA allergy has been reported relatively seldom. The sources of exposure have been both occupational (2–6) and personal care products at home (2, 7, 8). Here, we present an analysis of cocamide

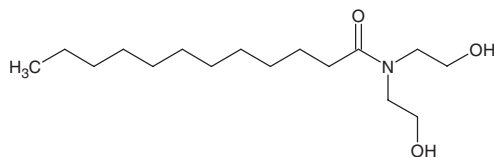
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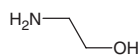
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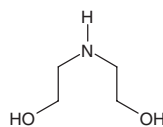
Coconut fatty acids diethanolamide
(cocamide DEA)
R = C6–C20



Lauric acid diethanolamide (C12),
the main component of cocamide DEA



Monoethanolamine



Diethanolamine (DEA)

Fig. 1. Chemical structures of coconut fatty acids diethanolamide (cocamide DEA), its main component lauric acid diethanolamide, monoethanolamine, and diethanolamine.

Table 1. Fatty acid composition of coconut oil and names of the corresponding diethanolamine (DEA) derivatives

Fatty acid	Number of carbons (chain length)	Coconut oil (%)	Corresponding DEA derivative
Caproic	6	0.5	Caproamide DEA
Caprylic	8	7.8	Caprylamide DEA
Capric	10	6.7	Capramide DEA
Lauric	12	47.5	Lauramide DEA
Myristic	14	18.1	Myristamide DEA
Palmitic	16	8.8	Palmitamide DEA
Stearic	18	2.6	Stearamide DEA
Oleic (monounsaturated)	18	6.2	Oleamide DEA
Linoleic (polyunsaturated)	18	1.6	Linolamide DEA
Arachidic	20	0.1	Arachidamide DEA

DEA-allergic patients in an occupational dermatology clinic.

Materials and Methods

Patients examined at the Finnish Institute of Occupational Health (FIOH) all have a suspected occupational skin disease. They are patch tested with Finn Chambers® (Epitest, Tuusula, Finland) according to the recommendations of the International Contact Dermatitis Research Group. We usually read the tests two or three times: on D2, D3, and D4, or D2, D3, and D6, or D2 and D5, depending on the day of application. The patients are tested with a modified European baseline series, antimicrobials, series according to exposure, and the patients' own materials from work and home, for example industrial chemicals, hand cleansers, and creams.

At the FIOH, cocamide DEA (0.5% pet.; Chemotechnique, Vellinge, Sweden) has been tested in coconut fatty acid derivatives, oils and cutting fluids, and cosmetics series, and occasionally independently outside the test series. We analysed the clinical files of the patients with positive (+/++/+++) reactions to cocamide DEA in 1993–2011 in detail. The analysis involved studying the patients' profession and diagnoses, the location of the dermatitis and exposure details, and other contact allergies, especially allergy to other coconut compounds and ethanolamines. Exposure to coconut fatty acid derivatives was identified from either the product labels or safety data sheets, or by additional inquiries to the suppliers.

Results

During the study period, cocamide DEA was tested on 2572 patients. Of these, 25 (1%) had an allergic reaction, and 100 (3.2%) had an irritant reaction. The number of erythematous doubtful reactions was 2 (0.08%). The 25 allergic patients, together with the test reactions and exposure, are shown in Table 2. Of these, 18 (patients 1–18) had occupational exposure to cocamide DEA or its component oleic acid diethanolamide [oleamide diethanolamine (oleamide DEA), CAS no. 93-83-4] during the time of the dermatitis, and were thus diagnosed with occupational allergic contact dermatitis (OACD). In 1 case (patient 19), although it was no longer possible to assess the exposure in detail, a diagnosis of past OACD caused by cocamide DEA was made. Of the 19 patients with a diagnosis of OACD caused by cocamide DEA, 14 were men, and 11 worked in the metal industry. All of the patients had hand dermatitis. The most common source of cocamide DEA sensitization was hand cleansers at work (17 patients). The hand

Table 2. Coconut fatty acids diethanolamide (CDEA) – allergic patients; their occupation, age, sex, and patch test reactions to CDEA, ethanolamines, and other substances; exposure to CDEA; and CDEA-related diagnosis

Patient no.	Occupation Sex/Age (years)	Allergic reactions to CDEA	Reactions to ethanolamines	Other contact allergies	Exposure to CDEA (patch test reactions to CDEA-containing products)	CDEA-related diagnosis
1	Machinist/assembler M 24	+	MEA – DEA – TEA –	HDI trimmers, formaldehyde	CDEA in a liquid soap (10%, ?+) and an industrial hand cleanser (10%, +; 3.2%, ?+) at work	OACD from CDEA
2	Machinist M 58	++	MEA + DEA + TEA –	Formaldehyde, chromium, glyoxal, DMAPIA	Oleamide diethanolamide (component of CDEA) in an industrial hand cleanser ^a (10%, ++)	OACD from oleamide diethanolamide/CDEA and ethanolamines in MWI
3	Machinist M 41	+	MEA – DEA – TEA –	Cetearyl alcohol	CDEA in two hand cleansers at work (cleaning agent A 10% pet., +; cleaning agent B 10% pet., ?+)	OACD from CDEA (dermatitis healed)
4	Machine shop entrepreneur M 48	+	MEA NT DEA NT TEA IR	Lanolin, epoxy resin, formaldehyde	CDEA in a hand cleanser ^a (10%, ?+) at work	OACD from CDEA
5	Punching tool setter M 49	++	NT	Epoxy resin, formaldehyde	CDEA in a cream soap ^a (NT) and a liquid soap ^a (10% pet., ?+; 5% pet., ?+)	OACD from CDEA
6	Machinist M 53	+	MEA ?+ DEA ?+ TEA –	Formaldehyde	CDEA in a liquid soap ^a (100%, ++; 10% pet., ++ and an industrial hand cleanser ^a (10% pet., ++; 5% pet., +)	OACD from CDEA
7	Metalworker M 33	++	MEA I + MEA II – DEA – TEA –	Colophonium, lanolin, Amerchol® L101	3.9% CDEA in a liquid hand cleanser ^c (10%, ++) Fatty acid polydiethanolamide (CAS no. 68603-38-3) in an MWI (10%, ++; 3.2%, ++; 1%, ++), fatty acid polydiethanolamide (1% pet., ++; 0.32% pet., ++; 0.1% pet., +) (related to CDEA, fatty acid chains unsaturated, C16–C18)	OACD from CDEA and related substances in MWI
8	Catalytic converter worker F 49	+	NT	Nickel, cobalt, palladium, phenolic resin, PTBPR	CDEA in a liquid hand cleanser ^a (10% pet., ++; 5% pet., ?+)	OACD from CDEA
9	Motor vehicle mechanic M 54	++	MEA – DEA – TEA –	–	CDEA in a hand cleanser ^b (NT) at work	OACD from CDEA
10	Locomotive mechanic M 54	++	MEA NT DEA NT TEA –	Formaldehyde, MDBGN, colophonium, DPG	CDEA in a hand cleanser ^c (10% pet., +) and a dishwashing agent ^a at work	OACD from CDEA
11	Welder M 32	++	MEA – DEA – TEA –	–	CDEA in a hand cleanser ^b (10% pet., ++; 5% pet., ++; 2.5% pet., ++; 1.25% pet., ++ at work	OACD from CDEA (dermatitis healed)
12	Lorry cleaner M 37	+++	MEA – DEA – TEA –	–	CDEA in a hand cleanser ^c (10% pet., ++; 5% pet., ++ at work	OACD from CDEA
13	Maintenance man M 40	++	NT	–	4% CDEA in a protective cream ^c (as is, –) at work Use test with the protective cream positive on D3	OACD from CDEA (dermatitis healed)
14	Plumber M 51	+	MEA – DEA – TEA –	–	CDEA in a industrial hand cleanser (10% pet., +) at work	OACD from CDEA (dermatitis healed)

Table 2. Continued.

Patient no.	Occupation Sex/Age (years)	Allergic reactions to CDEA	Reactions to ethanolamines	Other contact allergies	Exposure to CDEA (patch test reactions to CDEA-containing products)	CDEA-related diagnosis
15	Sawmill worker M 49	+	MEA NT DEA NT TEA –	–	CDEA in a hand cleanser ^a (100%, +; 10% pet., ?+) at work	OACD from CDEA
16	Kitchen assistant F 61	+	MEA – DEA – TEA –	MDBGN, Preventol [®] D2	CDEA in a dishwashing liquid ^c (10% pet., ?+) and a liquid hand cleanser ^c (10% pet., –) at work	OACD from CDEA
17	Kitchen assistant F 49	++	MEA NT DEA NT TEA –	Thiurams, MCI/MI, corticosteroids, CAPB, oleamidopropyl DMA	CDEA in a hand cleanser (10%, ++++) at work	OACD from CDEA
18	Assistant nurse F 41	+	MEA NT DEA NT TEA –	MDBGN, hydroxycitronellal, Amerchol [®] L101, CAPB, cyclohexyl thiophthalimide	CDEA in two hand cleansers ^c at work Hand cleanser A (100%, +; 32%, +; 10%, ?+; 3.2%, ?+) Hand cleanser B (100%, ?+; 10%, ?+)	OACD from CDEA
19	Day nursery assistant F 59	++	NT	Thiurams, neomycin, formaldehyde	Probable past exposure to CDEA in cleaning agents in previous work	Past OACD from CDEA
20	Assistant nurse F 58	+	NT	Thiurams, MDA, colophonium, fragrances	CDEA in a liquid soap at home	CA to CDEA
21	Nurse F 38	++	NT	Thiurams, fragrances, formaldehyde	No exposure to CDEA found at work	CA to CDEA
22	Medical instrument attendant F 53	+	NT		No exposure to CDEA found at work	CA to CDEA
23	Filer M 50	++	MEA NT DEA NT TEA –	PAN, ethylene glyceroldinitrate	No exposure to CDEA found at work	CA to CDEA
24	Metalworker M 24	++	MEA ++ DEA + TEA –	Formaldehyde, colophonium	No exposure to CDEA found at work	CA to CDEA OACD from ethanolamines in MWF
25	Cleaner F 54	++	NT		No exposure to CDEA found at work	CA to CDEA

^aProduct labelling.^bSafety data sheet.^cInformation from the manufacturer.

CA, contact allergy; CAPB, cocamidopropylbetaine; DEA, diethanolamine; DMAPA, dimethylaminopropylamine; DPG, diphenylguanidine; F, female; HDI, hexamethylenedisocyanate; IR, irritant reaction; M, male; MCI/MI, methylchloroisothiazolinone/methylisothiazolinone; MDA, diaminodiphenylmethane; MDBGN, methyldibromo glutaronitrile; MEA, monoethanolamine; MWF, metalworking fluid; NT, not tested; OACD, occupational allergic contact dermatitis; oleamidopropyl DMA, oleamidopropyl dimethylamine; PAN, phenyl- α -naphthylamine; PTBPPR, *p*-tert-butyl-phenol formaldehyde resin; TEA, triethanolamine; I, first patch test session; II, second patch test session.

cleanser of patient 2 was labelled as containing oleamide DEA, a component of cocamide DEA. We did not test oleamide DEA as such. One contact allergy (patient 13) was caused by protective cream. In 2 cases, the patients had used cocamide DEA-containing dishwashing liquids in addition to hand cleansers (patients 10 and 16). In 1 case (patient 7), a patch test-positive metalworking fluid contained fatty acid polydiethanolamide (CAS no. 68603-38-3; also positive on patch testing), which is structurally related to cocamide DEA.

Seventeen occupational cases were tested with their own cocamide DEA-containing products. A total of 22 such products were tested, and these elicited 15 allergic reactions, 5 doubtful reactions, and 2 negative reactions. In 1 case (patient 13), a use test was performed with protective cream after a negative patch test result, and this was positive on D3.

In 6 cases, contact allergy to cocamide DEA was not considered to be occupational, but 5 of these patients were diagnosed with another occupational disease – allergic contact dermatitis caused by other allergens or irritant contact dermatitis.

Some reactions to ethanolamines occurred: 2 patients reacted to both monoethanolamine (CAS no. 141-43-5; Fig. 1) and diethanolamine (DEA) (CAS no. 111-42-2; Fig. 1), and had been exposed to ethanolamines in metalworking fluids. In addition, 1 patient reacted to monoethanolamine once, but retesting gave a negative result. A total of 11 patients were tested with monoethanolamine and DEA. There were no allergic reactions to triethanolamine (17 patients were tested). Seventeen of the patients had other contact allergies.

In 1997, the raw material for Chemotechnique's cocamide DEA test substance was analysed by liquid chromatography, and found to contain 0.4% DEA.

Discussion

In previous reports of cocamide DEA contact allergy, occupational sources of sensitization have included protective hand gel (5), hydraulic mining oil (3), barrier creams (6), hand cleansers (4, 6), and metalworking fluids (6), and non-occupational sources of sensitization have included shampoos (7, 8) or other personal care products (2). In the present study population, hand cleansers dominated, but exposure to cocamide DEA or related compounds was also found via a barrier cream, two dishwashing liquids, and a metalworking fluid.

In 2013, the Finnish Product Register of Chemicals declared cocamide DEA in 140 products: 19% ($n = 27$) were hand or skin cleansers, 15% ($n = 21$) were car shampoos, 14% ($n = 19$) were cleaning and finishing

agents for metal surfaces, 8% ($n = 11$) were hand dishwashing agents, and 5% ($n = 7$) were raw material products for the manufacture of cleaning agents. The rest were cleaning agents for ovens, boats, toilet seats, or laundry, or had no named special purpose.

In an Australian study on occupational skin disease, cocamide DEA was positive in 11.5% of 103 female patients with OACD and in 2.3% of 265 male patients with OACD. From these figures, we calculated that the frequency of cocamide DEA allergy among all 2449 investigated patients was at least 0.7%, not much lower than our figure (1.0%). Cocamide DEA was an occupational allergen among hairdressers, healthcare workers, fitters, food handlers, printers, and cleaners. The authors did not mention the products that had caused sensitization (9).

Cocamide DEA is synthesized from coconut oil and DEA. Coconut oil is composed of fatty acids with varying chain lengths of C6–C20 (Table 1), the main component being lauric acid (C12). Cocamide DEA is a mixture of DEA derivatives of the fatty acids of coconut oil, and its main component is accordingly lauric acid diethanolamine [lauramide diethanolamine (lauramide DEA); CAS no. 120-40-1; Fig. 1], the derivative of lauric acid. Lauramide DEA is used as such in cosmetic products, and contact allergy to lauramide DEA in a shampoo has been described (7). Our study population included 1 patient (patient 2) whose hand cleanser contained oleamide DEA, another component of cocamide DEA. Allergic contact dermatitis caused by undecylenamide diethanolamine (undecylenamide DEA) in a liquid soap has also been reported (10). Undecylic acid (undecanoic acid) is a saturated C11 fatty acid, and undecylenamide DEA is structurally closely related to cocamide DEA, although it is not one of its components. The 'fatty acid polydiethanolamide' (CAS no. 68603-38-3), a raw material of the metalworking fluid of patient 7, is structurally related to cocamide DEA. Its fatty acid components are unsaturated and have chain lengths of C16–C18. The patient's allergic reaction to cocamide DEA probably also reflected sensitization to the 'fatty acid polydiethanolamide', although he had also used a cocamide DEA-containing hand cleanser. Quite recently, we reported a patient with contact allergy to a monoethanolamine derivative of tall oil fatty acids, which was an ingredient of a metalworking fluid (11). Tall oil contains fatty acids with chain lengths of C16–C19. The patient did not react to cocamide DEA or ethanolamines.

Previous reports of cocamide DEA allergy have not mentioned concomitant reactions to ethanolamines. The present study population included 3 such patients: 2 reacted to DEA and 3 to monoethanolamine. DEA is

an impurity in cocamide DEA that derives from the manufacturing process. The cocamide DEA used for Chemotechnique's test substance was analysed in 1997 at the FIOH, and found to contain 0.4% DEA. This concentration is high enough to explain allergic reactions to cocamide DEA in DEA-allergic patients. Patient 24 was exposed to ethanolamines in metalworking fluids, but cocamide DEA was not found in his products. It is possible that his allergic reaction to cocamide DEA was attributable to a DEA impurity in the test substance. Other explanations for concomitant allergic reactions to cocamide DEA and ethanolamines are concomitant exposure and possible cross-allergy resulting from their structural similarities.

Interestingly, 11 of 19 of the occupational cases (patients 1–11) and 2 of 6 of the non-occupational cases (patients 23 and 24) in the present study worked in the metal industry, and many of them had handled metalworking fluids. It is possible that this occupational field has some unidentified sources of fatty acid diethanolamide, or that related ingredients are poorly declared in the safety data sheets of metalworking fluids. Cocamide DEA is classified as a skin irritant in the EU, so it should be listed in the safety data sheet if present in a concentration of > 1%. However, the occupational cases working in the metal industry had been exposed to cocamide DEA in hand cleansers.

We test cocamide DEA together with cocamidopropyl betaine (CAPB) and related substances [dimethylamino

propylamine, cocamidopropyl dimethylamine (cocamidopropyl DMA; amidoamine), and oleamidopropyl dimethylamine] in almost all of our patients, because daily exposure to these compounds in liquid soaps is so common. The frequency of allergic reactions to CAPB-related substances was 1.3% in our recent report from 2002–2009 (12), almost the same as that for cocamide DEA. Cocamide DEA and CAPB-related allergens are not structurally related, and these allergies do not usually overlap: the 2002–2009 study population did not include any cases of concomitant allergy. Cocamide DEA elicited fewer irritant reactions than the CAPB-related substances. In addition, cocamide DEA-containing products often elicit an allergic reaction on patch testing, which further supports the diagnosis of allergic contact dermatitis. Although most of our patients had multiple other contact allergies and several causes for their occupational hand dermatitis, 4 patients healed soon after ceasing use of the cocamide DEA-containing product(s); 2 of them did not have any other contact allergies, and 2 had only one other allergic reaction.

Conclusions

Cocamide DEA contact allergy is relatively common in patients with occupational skin disease. Hand cleansers at the workplace constitute the main source of sensitization, but detergents, metalworking fluids and barrier creams also need to be taken into account. Concomitant reactions to ethanolamines are possible.

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