

Review Article

Allergic contact dermatitis to copolymers in cosmetics – case report and review of the literature

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Copolymers or heteropolymers are large molecules with high molecular weights (>1000 D). They have been underestimated for a long time as to their sensitizing capacities. Allergic contact dermatitis to 6 copolymers in cosmetics and 1 in a medical dressing has been described; however, the nature of the hapten is still unknown. We report a case of allergic contact dermatitis to polyvinylpyrrolidone (PVP)/hexadecene copolymer in a purple-colored lipstick and review the literature on allergic contact dermatitis to 7 copolymers: PVP/hexadecene, PVP/eicosene, PVP/1-triacontene, methoxy polyethyleneglycol (PEG)-22/dodecyl glycols, methoxy PEG-17/dodecyl glycols, phthalic anhydride/trimellitic anhydride/glycols, and polyvinyl methyl/maleic acid anhydride.

Key words: allergic contact dermatitis; copolymer; cosmetics; methoxy PEG-17/dodecyl glycol; methoxy PEG-22/dodecyl glycol; phthalic anhydride/trimellitic anhydride/glycols copolymer; polyvinyl methyl/maleic acid copolymer; PVP/1-triacontene; PVP/eicosene; PVP/hexadecene; sunscreens.
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When a polymer is made by linking together only 1 type of small molecules or monomers, it is called a *homopolymer*. When 2 different types of monomers are joined in the same polymer chain, the polymer is called a *heteropolymer* or a *copolymer*. There are 4 different ways to make a copolymer. The first possibility is arranging 2 monomers in an alternating fashion. This is called an *alternating copolymer*. In a *random copolymer*, the 2 monomers may follow in any order. When all of 1 type of monomer and all of the other types are grouped together, it is called a *block copolymer*. A block copolymer can be thought of as 2 homopolymers joined together at the ends. When chains of a polymer made of a certain monomer are grafted onto a polymer chain of another monomer, we have a *graft copolymer* (<http://pslc.ws/macrog/copoly.htm>). Block and graft copolymers are frequently used to combine 2 nonmixable polymers.

Copolymers are important ingredients in cosmetics, added because of their antistatic, film-forming, binding, suspending, viscosity-increasing, skin-conditioning, and emulsion-stabilizing properties. Copolymers have been underestimated for a long time as to their sensitizing capacities because of their large structures and high molecular weights. Allergic contact dermatitis to copolymers in cosmetics, however, does occur, but the exact nature of the hapten is still unknown.

The copolymers are not likely to be haptens themselves in view of their large molecular weights. The sensitizer could be an additive, an impurity, a product that forms during polymerization, a residual monomer, or a degradation product.

The International Nomenclature of Cosmetic Ingredients inventory lists approximately 200 different copolymers among approximately 7600 ingredients (Table 1) (1). 7 copolymers to which allergic reactions were reported (Table 2) will be discussed in this article.

Case Report

A 28-year-old nonatopic woman presented at our department with a 10-day (D10) history of perioral itching and eczematous dermatitis, which had spread to the cheeks and ears. She had used several cosmetic products, including 2 purple-colored lipsticks and 2 lip balms. There was no history of previous contact allergy. The patient was patch tested to the European standard series and her own cosmetic products. We used van der Bend[®] chambers (van der Bend, Brielle, The Netherlands) mounted on Micropore[®] (3 M; St Paul, MN, USA) and fixed on the intact skin of the back using Mefix[®] (Mölnlycke, Göteborg, Sweden) acrylic tape. The readings were taken after D2 and again after D4. At D2, there was a positive

Table 1. Copolymers listed in the International Nomenclature Cosmetic Ingredients (INCI) inventory (1)^a

Name	CAS number	Function
Acrylamide/sodium acrylate copolymer	25085-02-3	Antistatic/film forming
Acrylamides copolymer		Antistatic/film forming
Acrylamides/acrylates/DMAPA/methoxy PEG methacrylate copolymer		Film forming
Acrylamidopropyltrimonium chloride/acrylates copolymer		Film forming
Acrylates copolymer	25133-97-5	Antistatic/binding/film forming
Acrylates/acetoacetoxyethyl methacrylate copolymer		Film forming
Acrylates/acrylamide copolymer		Film forming
Acrylates/ammonium methacrylate copolymer		Antistatic/film forming
Acrylates/carbamate copolymer		Hair conditioning/skin conditioning
Acrylates/ceteth-20 itaconate copolymer		Viscosity controlling
Acrylates/ceteth-20 methacrylate copolymer		Viscosity controlling
Acrylates/diacetoneacrylamide copolymer		Film forming/viscosity controlling
Acrylates/dimethicone copolymer		Anticaking/binding/film forming
Acrylates/dimethylaminoethyl methacrylate copolymer		Binding/film forming
Acrylates/ethylhexyl acrylate copolymer		Film forming
Acrylates/ethylhexylacrylamide copolymer		Film forming
Acrylates/PVP copolymer	26589-26-4	Antistatic/binding/film forming
Acrylates/steareth-50 acrylate copolymer		Film forming/viscosity controlling
Acrylates/steareth-20 methacrylate copolymer		Viscosity controlling
Acrylates/steareth-20 itaconate copolymer		Viscosity controlling
Acrylates/VA copolymer	25067-02-1	Film forming
Acrylic acid/acrylonitrogens copolymer	61788-40-7	Film forming
Adipic acid/diethylenetriamine copolymer	25085-20-5	Film forming
Adipic acid/dimethylaminohydroxypropyl diethylenetriamine copolymer	133184-01-7	Antistatic/film forming
Adipic acid/epoxypropyl diethylenetriamine copolymer	25212-19-5	Antistatic/film forming
Adipic acid/isophthalic acid/neopentyl glycol/trimethylolpropane copolymer	25950-34-9	Film forming
Adipic acid/neopentyl glycol/trimellitic anhydride copolymer	28407-73-0	Film forming
Allyl stearate/VA copolymer	56266-37-6	Film forming
Aminoethylacrylate phosphate/acrylates copolymer	57450-97-2	Antistatic/film forming
Ammonium acrylates copolymer		Antistatic/binding/film forming/viscosity controlling
Ammonium acrylates/acrylonitrogens copolymer		Film forming/viscosity controlling
Ammonium styrene/acrylates copolymer		Opacifying
Ammonium VA/acrylates copolymer		Antistatic/binding/film forming
Amp-acrylates copolymer		Film forming
Amp-acrylates/diacetoneacrylamide copolymer		Film forming
Amp-acrylates/dimethylaminoethyl-methacrylate copolymer		Film forming/hair fixing
Ampd-acrylates/diacetoneacrylamide copolymer		Film forming
Benzoic acid/phthalic anhydride/pentaerythritol/neopentyl glycol/palmitic acid copolymer	68647-39-2	Film forming
Butadiene/acrylonitrile copolymer	9003-18-3	Film forming/viscosity controlling
Butyl acrylate/hydroxyethyl methacrylate copolymer	30600-43-2	Film forming
Butyl acrylate/styrene copolymer	25767-47-9	Film forming
Butyl benzoic acid/phthalic anhydride/trimethylolethane copolymer	68814-19-7	Film forming
Butyl ester of ethylene/MA copolymer	68954-39-2	Antistatic/binding/film forming
Butyl ester of PVM/MA copolymer	25119-68-0	Antistatic/film forming
Butylene/ethylene copolymer	9019-29-8	Viscosity controlling
Calcium/sodium PVM/MA copolymer	94290-13-8	Film forming/hair fixing
Corn starch/acrylamide/sodium acrylate copolymer		Antistatic/film forming/hair conditioning/hair fixing/stabilizing
Dea-styrene/acrylates/DVB copolymer		Opacifying
Decene/butene copolymer	30973-93-4	Viscosity controlling
Dicyclopentadiene/tbutylcresol copolymer	220997-66-0	Antioxidant
Diethylene glycolamine/epichlorohydrin/piperazine copolymer		Film forming
Diglycol/chdm/isophthalates/SIP copolymer		Film forming
Diglycol/isophthalates/SIP copolymer	240818-591	Film forming
Dihydroxyethyl tallowamine/IPDI copolymer	223705-29-1	Film forming/hair conditioning/skin conditioning
Dilinoleic acid/ethylenediamine copolymer		Film forming
Dilinoleyl alcohol/IPDI copolymer	224948-76-9	Film forming
Dimethicone/mercaptopropyl methicone copolymer		Film forming/skin conditioning
Dimethicone/sodium PG-propyl dimethicone thiosulfate copolymer		Film forming/skin conditioning
Dimethiconol/IPDI copolymer	183281-67-3	Film forming

Table 1. Continued

Name	CAS number	Function
Dimethiconol/silsesquioxane copolymer	68554-67-6	Hair conditioning/skin conditioning
Dimethiconol/stearyl methicone/phenyl trimethicone copolymer		Stabilizing/skin conditioning
Dimethylol urea/phenol/sodium phenol-sulfonate copolymer	220604-23-9	Viscosity controlling
Dioctyldodecyl stearoyl dimer dilinoleate		Skin conditioning
DMAPA acrylates/acrylic acid/acrylonitrogens copolymer		Film forming
Dodecanedioic acid/cetearyl alcohol/glycol copolymer		Film forming/viscosity controlling
Ethyl ester of PVM/MA copolymer	25087-06-3	Antistatic/film forming/hair fixing
Ethylene/acrylic acid copolymer	9010-77-9	Binding/emulsion stabilizing/film forming/opacifying
Ethylene/acrylic acid/VA copolymer	26713-18-8	Film forming
Ethylene/calcium acrylate copolymer	26445-96-5	Film forming/opacifying
Ethylene/MA copolymer	9006-26-2	Binding/film forming
Ethylene/magnesium acrylate copolymer		Film forming
Ethylene/propylene copolymer	9010-79-1	Film forming/bulking/abrasive
Ethylene/sodium acrylate copolymer	25750-82-7	Film forming/emulsion stabilizing/opacifying/binding
Ethylene/VA copolymer	24937-78-8	Binding/emulsion stabilizing/film forming
Ethylene/zinc acrylate copolymer		Film forming
Glycereth-7 hydroxystearate/IPDI copolymer	162730-24-7	Film forming
Glycereth-7/IPDI copolymer	51606-33-8	Skin conditioning/viscosity controlling/film forming
Hydrogenated butylene/ethylene/styrene copolymer		Emollient/viscosity controlling/skin conditioning
Hydrogenated styrene/butadiene copolymer	66070-58-4	Film forming/viscosity controlling
Hydrogenated ethylene/propylene/styrene copolymer		Emollient/viscosity controlling/stabilizing
Hydrogenated styrene/methyl styrene/indene copolymer		Film forming/viscosity controlling
Hydrolyzed wheat protein/dimethicone copolyol phosphate copolymer		Humectant/skin conditioning/film forming
Hydrolyzed wheat protein/PEG-20 acetate copolymer	222400-37-5	Hair conditioning
Isobutylene/isoprene copolymer	9010-85-9	Viscosity controlling
Isobutylene/MA copolymer	26426-80-2	Viscosity controlling/hair fixing/film forming
Isobutylene/sodium maleate copolymer		Film forming/viscosity controlling
Isoprene/pentadiene copolymer	31303-93-2	Viscosity controlling
Isopropyl ester of PVM/MA copolymer	31307-95-6	Antistatic/binding/emulsion stabilizing/film forming/hair fixing
Lauryl acrylate/VA copolymer		Film forming/foam boosting/skin conditioning
Lauryl methacrylate/glycol dimethacrylate copolymer	61181-29-1	Film forming
Methacryloyl ethyl betaine/acrylates copolymer	87435-35-6	Antistatic/film forming/hair fixing
Methoxy PEG-17/dodecyl glycol copolymer	88507-00-0	Emulsifying/skin conditioning
Methoxy PEG-22/dodecyl glycol copolymer	88507-00-0	Emulsion stabilizing/viscosity controlling
Methylstyrene/vinyltoluene copolymer	9017-27-0	Viscosity controlling
Nylon-12/6/66 copolymer		Film forming
Octadecene/MA copolymer	25266-02-8	Viscosity controlling/stabilizing
Octylacrylamide/acrylates/butylaminoethyl methacrylate copolymer	70801-07-9	Antistatic/film forming/hair fixing
PEG-8/SMDI copolymer	39444-87-6	Film forming
PEG-22/dodecyl glycol copolymer	78336-31-9	Emulsifying
PEG-45/dodecyl glycol copolymer	78336-31-9	Emulsion stabilizing
PEG-100/IPDI copolymer	39318-45-1	Binding/emulsion stabilizing/viscosity controlling
PEG/PPG-17/6 copolymer	2594628	Solvent
PEG/PPG-18/4 copolymer	2594628	Solvent
PEG/PPG-23/50 copolymer	2594628	Solvent
PEG/PPG-35/9 copolymer	2594628	Emollient
PEG/PPG-150/30 copolymer	9003-11-6	Emulsifying/surfactant
PEG/PPG-125/30 copolymer	2594628	Emollient
PEG/PPG-296/57 copolymer		Solvent
PEG/PPG-300/55 copolymer	2594-62-8	Surfactant
Phthalic anhydride/adipic acid/castor oil/neopentyl glycol/PEG-3/trimethylolpropane copolymer		Film forming
Phthalic anhydride/benzoic acid/trimethylolpropane copolymer		Film forming
Phthalic anhydride/butyl benzoic acid/propylene glycol copolymer		Film forming

Table 1. Continued

Name	CAS number	Function
Phthalic anhydride/glycerine/glycidyl decanoate copolymer		Antistatic/film forming/viscosity controlling
Phthalic anhydride/trimellitic anhydride/glycols copolymer		Film forming
Piperylene/butane/pentene copolymer		Binding/viscosity controlling
Polydiethyleneglycol adipate/IPDI copolymer	55636-50-5	Film forming
Polyoxyisobutylene/methylene urea copolymer		Film forming
PPG-7/succinic acid copolymer		Emolient/hair conditioning/film forming
PPG-12/SMDI copolymer	9042-82-4	Emolient/hair fixing/skin conditioning/film forming
PPG-26/TDI copolymer		Film forming/plasticizer
PPG-51/SMDI copolymer	9042-82-4	Film forming/hair conditioning/hair fixing
PVM/MA copolymer	9011-16-9	Antistatic/binding/emulsion stabilizing/film forming/hair fixing
PVM/MA decadiene copolymer	136392-67-1	Binding/film forming
PVP/acrylates/lauryl methacrylate copolymer	240818-89-7	Hair fixing
PVP/decene copolymer		Binding/film forming
PVP/dimethylaminoethylmethacrylate copolymer	30581-59-0	Antistatic/binding/emulsion stabilizing/film forming/hair conditioning
PVP/DMAPA acrylates copolymer		Hair fixing
PVP/eicosene copolymer	28211-18-9	Antistatic/binding/film forming/viscosity controlling/skin protecting
PVP/hexadecene copolymer	63231-81-2	Antistatic/binding/film forming/viscosity controlling/skin protecting
PVP/VA copolymer	25086-89-9	Antistatic/binding/emulsion stabilizing/film forming/hair fixing
PVP/VA/itaconic acid copolymer	68928-72-3	Antistatic/binding/film forming
PVP/VA/vinyl propionate copolymer		Antistatic/film forming/viscosity controlling/hair fixing
PVP/vinyl caprolactam/DMAPA acrylates copolymer	243643-82-5	Hair fixing
Ricinoleic acid/adipic acid/AEEA copolymer	221278-30-4	Viscosity controlling
Sodium acrylate/vinyl alcohol copolymer	27599-56-0	Antistatic/binding/emulsion stabilizing/film forming/viscosity controlling
Sodium acrylates copolymer		Binding/opacifying
Sodium acrylates/acrolein copolymer		Binding
Sodium C4-12 olefin/maleic acid copolymer		Binding/emulsion stabilizing/film forming/viscosity controlling
Sodium DVB/acrylates copolymer		Film forming
Sodium isooctylene/MA copolymer		Binding/film forming/viscosity controlling
Sodium MA/diisobutylene copolymer	37199-81-8	Film forming
Sodium methacrylate/styrene copolymer	33970-45-5	Opacifying
Sodium styrene/acrylamide copolymer		Film forming/opacifying
Sodium styrene/acrylates copolymer		Film forming/opacifying
Sodium styrene/acrylates PEG-10 dimaleate copolymer		Film forming/opacifying
Sodium styrene/PEG-10 maleate/nonoxynol-10 maleate/acrylates copolymer		Film forming/opacifying
Sodium styrene/acrylates/divinyl-benzene copolymer		Film forming/opacifying
Sodium tauride acrylates/acrylic acid/acrylonitrogens copolymer		Film forming
Starch/acrylates/acrylamide copolymer		Binding/film forming
Steareth-10 allyl ether/acrylates copolymer		Film forming
Stearoxymethicone/dimethicone copolymer		Emollient/skin conditioning
Stearyl/aminopropyl methicone copolymer	110720-64-4	Emollient
Stearylvinyl ether/MA copolymer	28214-64-4	Antistatic/film forming/viscosity controlling
Styrene/acrylamide copolymer	24981-13-3	Opacifying
Styrene/acrylates copolymer		Opacifying
Styrene/acrylates/acrylonitrile copolymer		Film forming/viscosity controlling
Styrene/acrylates/ammonium methacrylate copolymer		Film forming/opacifying
Styrene/allyl benzoate copolymer		Film forming/viscosity controlling
Styrene/butadiene copolymer	9003-55-8	Opacifying
Styrene/DVB copolymer	9003-70-7	Opacifying
Styrene/isoprene copolymer	25038-32-8	Film forming/opacifying
Styrene/MA copolymer	9011-13-6	Binding/emulsion stabilizing/film forming
Styrene/PVP copolymer	25086-29-7	Film forming/opacifying
Styrene/methylstyrene/indene copolymer	149613-90-1	Film forming/opacifying

Table 1. Continued

Name	CAS number	Function
Styrene/VA copolymer	25213-29-0	Film forming/opacifying
Sucrose benzoate/sucrose acetate iso-butyrate copolymer		Film forming/viscosity controlling
Sucrose benzoate/sucrose acetate iso-butyrate/butyl benzyl phthalate/methylmethacrylate copolymer		Film forming/viscosity controlling
Sucrose benzoate/sucrose acetate iso-butyrate/butyl benzyl phthalate copolymer		Film forming/viscosity controlling
Tea-acrylates/acrylonitrogens copolymer		Film forming
Terephthalic acid/isophthalic acid/sodium isophthalic acid sulfonate/glycol copolymer	104677-82-9/ 88473-41-0	Film forming/hair fixing
Trimethylpentanediol/isophthalic acid/trimellitic anhydride copolymer		Film forming
Tromethamine acrylates/acrylonitrogens copolymer		Film forming
VA/butyl maleate/isobornyl acrylate copolymer	136392-68-2	Film forming
VA/crotonates copolymer	25609-89-6	Antistatic/binding/film forming/hair fixing
VA/crotonates/methacryloxybenzophenone-1 copolymer		Film forming/hair fixing
VA/crotonates/vinyl neodecanoate copolymer	58748-38-2/ 55353-21-4	Antistatic/film forming/hair fixing
VA/crotonates/vinyl propionate copolymer	25035-26-1	Film forming/hair fixing
VA/crotonates/itiko acid/PEG-20M copolymer	208707-53-3	Film forming
VA/DBM copolymer		Film forming
VA/isobutyl maleate/vinyl neodecanoate copolymer		Film forming
VA/vinyl butyl benzoate/crotonates copolymer		Film forming/hair fixing
Vinyl caprolactam/PVP/dimethyl-aminoethyl methacrylate copolymer	102972-64-5	Film forming/skin conditioning

PVP, polyvinylpyrrolidone; PVM, polyvinyl methyl; PEG, polyethyleneglycol; MA, maleic acid; DMAPA, dimethyl-aminopropylamine; SIP, sulfoisophthalate; VA, vinylacetate; DVB, divinylbenzene; IPDI, isophorone diisocyanate; PG, propyleneglycol; SMDI, saturated methylene dithenyl diisothionate; AEEA, aminoethylethanolamine; TDI, toluene diisocyanate.

^aCopolymers consisting of 4 or more monomers may be given an INCI name according to their class followed by an arbitrary number, with the monomers listed in the entry definition of the material. These copolymers are not listed here.

(+) reaction to 1 of the purple-colored lipsticks only, becoming stronger at D4 (++). A positive reaction (+) to oxidized *d*- and *l*-limonene [(3% petrolatum (pet.))] was also observed (for which no relevance could be found). 4 months later, the ingredients of the lipstick were obtained from the company and could be tested. At D2 and D4, there were positive reactions to polyvinylpyrrolidone (PVP)/hexadecene copolymer diluted 10% (++), 5% (++), and 1% (+) in pet. only (Fig. 1). PVP/eicosene copolymer diluted 10%, 5%, and 1% in pet. was also tested (being an ingredient of 1 of the lip balms), but remained negative.

Discussion

In the literature, we found 3 PVP-, 2 methoxy polyethyleneglycol (PEG) (alkoxylated alcohols), and 1 other copolymer in cosmetics to which contact allergic reactions have been described. We also found a seventh copolymer, used in cosmetic products, in a medical dressing to which allergic contact dermatitis has been reported. All the 7 copolymers are discussed in this article.

PVP/hexadecene copolymer

Chemical information. PVP/hexadecene copolymer is a graft polymer of hexadecene and vinyl-

pyrrolidone monomers. The Chemical-Abstract-Service (CAS) registry name is 2-pyrrolidinone, 1-ethenyl-, polymer with 1-hexadecene, and the CAS registry numbers are 63231-81-2 (<http://www.ispcorp.com>) and 32440-50-9. Its chemical formula is C₆H₉NO·C₁₆H₃₂ and has a molecular weight of 7300 D. Figure 2 shows the structural formula of PVP/hexadecene copolymer; 'x' represents a number of vinylpyrrolidone monomers and 'y' represents a number of 1-hexadecene monomers, numbers varying according to the synthesis and polymerization procedures.

Trade names. The trade names are Antaron[®] V-216, Ganex[®] V-216 (ISP, Wayne, NJ, USA), and Unimer[®] U-151 (Induchem, Volketswil, Switzerland) (2). It is also used in mixtures, such as Escalol[®] T-100 (titanium dioxide dispersed in Escalol[®] 557, Ganex V-216, alumina, and dimethicone) and Escalol Z-100 (Zinkoxide dispersed

Table 2. Copolymers to which allergic contact dermatitis has occurred

1.	Polyvinylpyrrolidone/hexadecene copolymer
2.	Polyvinylpyrrolidone/eicosene copolymer
3.	Polyvinylpyrrolidone/1-triacontene copolymer
4.	Methoxy PEG-22/dodecyl glycol copolymer
5.	Methoxy PEG-17/dodecyl glycol copolymer
6.	Phthalic anhydride/trimellitic anhydride/glycol copolymer
7.	Polyvinyl methyl/maleic acid copolymer

PEG, polyethyleneglycol.



Fig. 1. Positive patch tests to polyvinylpyrrolidone/hexadecene copolymer 10%, 5%, and 2.5% pet. (day 4).

in Escalol 557, Ganex V-216, and methicone) with Escalol 557 (ISP Van Dyk, Wayne, NJ, USA), which is ethylhexyl methoxycinnamate, the most widely used sunscreen in the world, being water insoluble and having a broad UV-B absorbance profile (http://www.amisol.com/Product_Search_General.htm).

Functions. PVP/hexadecene copolymer is used as a binder, a film former, a hair fixative, a suspending agent (nonsurfactant), a viscosity-increasing agent (nonaqueous), a dispersant for pigments, and a solubilizer for dyes (2). It is used to impart the following features of skin care and cosmetic products: water resistance, pigment dispersion, rich feel, and improvement of stick integrity (3). The copolymer also has a function in the petroleum industry as sludge and detergent dispersant (http://www.infochems.com/chemdb/product_list.asp).

Allergic contact dermatitis to PVP/hexadecene copolymer. PVP/hexadecene copolymer was first reported to be a contact allergen in cosmetics in 1988 by De Groot et al. (4) in an article on allergens in cosmetics. 3 cases of patch-test-positive contact allergy to PVP/hexadecene have already been described: in 1995, Fowler reported a case of allergic contact dermatitis to Ganex V-216 in a bath oil, and 2 years later, Scheman and Cummins reported a case of allergy to Ganex V-216 in the same oil, but used as a spray (3-7).

Cosmetic applications. We could find PVP/hexadecene copolymer as an ingredient in 38 lipsticks, 8 lip glosses, 6 lip balms, 2 lip liners, 6 eye shadows, 7 different kinds of mascara, 1 eye makeup remover, 2 eyeliners, 2 foundations, 8 concealers,

27 sunscreens, 1 bronzer, 1 blusher, 9 moisturizers, and 1 body paint.

PVP/eicosene copolymer

Chemical information. PVP/eicosene copolymer is a polymer of vinylpyrrolidone and 1-eicosene monomers. Its CAS registry name is 2-pyrrolidinone, 1-ethenyl-, polymer with 1-eicosene, and the CAS numbers are 28211-18-9 and 77035-98-4 (2). This copolymer belongs (as does PVP/hexadecene copolymer) to the family of graft copolymers of vinylpyrrolidone and long-chain alpha-olefins (8), i.e. C-20 (eicosene), with a molecular weight of 8600 D. The empirical formula of this synthetic copolymer is $C_6H_9NO \cdot C_{20}H_{40}$ (9). Figure 3 shows the structural formula of PVP/eicosene copolymer (2, 9). x represents a number of vinylpyrrolidone monomers and y represents a number of 1-eicosene monomers, x and y varying with procedures of synthesis and polymerization (9).

Trade names. The trade names of PVP/eicosene copolymer are Antaron V-220 (ISP), Ganex V-220 (ISP), and Unimer U-15 (Induchem). Trade names of mixtures containing it are Suncaps[®] 664 (encapsulated octyl-methoxycinnamate), 797, and 903 (=encapsulated octyl-methoxycinnamate with benzophenone 3) (SunSmart, Toronto, Ontario, Canada), used as sunscreens (2).

Functions. PVP/eicosene copolymer functions as a binder, a film former, a suspending agent (nonsurfactant), and a viscosity-increasing agent (nonaqueous) (2). It is present in many sunscreens to enhance water resistance (9). This copolymer is also used as an inert ingredient in pesticides,

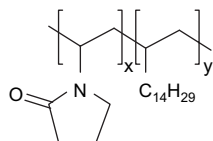


Fig. 2. Structural formula of polyvinylpyrrolidone/hexadecene copolymer.

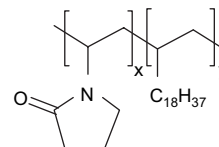


Fig. 3. Structural formula of polyvinylpyrrolidone/eicosene copolymer.

as a protective colloid, as a microcapsulating resin, as a dispersant for pigment, as a solubilizer for dyes, and also in the petroleum industry as a sludge and detergent dispersant (9) (http://www.amisol.com/Product_Search_General.htm).

Allergic contact dermatitis to PVP/eicosene copolymer. PVP/eicosene copolymer has first been discovered as a contact allergen in a sunblock by Smith et al. in 1999 (10). To the best of our knowledge, only 3 cases of contact dermatitis to PVP/eicosene have been reported between 1999 and 2006: in 2000, Le Coz et al. reported another case of allergy to PVP/eicosene copolymer in a sunscreen, and in 2004, Gallo et al. reported a case of allergic contact dermatitis to Ganex V-220 in an emollient cream (8–11). Although PVP and eicosene alone are regarded as nonsensitizing, their copolymer may elicit skin sensitization. The exact sensitizer (presumably an impurity, a by-product, or an additive) is not yet known (9).

Cosmetic applications. We found PVP/eicosene copolymer as an ingredient in 2 lipsticks, 7 lip balms, 3 lip glosses, 22 different kinds of mascara, 3 eye shadows, 3 eyeliners, 1 around-eye cream, 1 brow liner, 2 foundations, 90 sunscreens, 3 sunless tanners, 2 insect repellents, 9 moisturizers, 1 anti-itch cream, and 1 hair removal wax.

PVP/1-triacontene copolymer

Chemical information. PVP/1-triacontene or tricontanyl PVP is a graft copolymer of vinylpyrrolidone and 1-triacontene. The structural formula is shown in Fig. 4, where R represents the triacontene moiety or hydrogen (2). The CAS registry name of this copolymer is 2-pyrrolidinone, 1-ethenyl-, polymer with 1-triacontene. Its CAS number is 136445-69-7. The molecular formula of tricontanyl PVP is $C_6H_9NO \cdot C_{30}H_{60}$. The molecular weight of tricontanyl PVP is more than 1000 D. It is incorporated specifically into sunscreen agents to contribute to the water-resistant nature of the formulation, by helping its adherence to the skin (12) (<http://www.nicnas.gov.au/publications/car/new/na/nasummr/na0000sr/na71.asp>).

Trade names. Trade names of tricontanyl PVP are Antaron WP-660 (ISP), Ganex WP-660 (ISP),

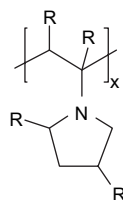


Fig. 4. Structural formula of polyvinylpyrrolidone/1-triacontene copolymer.

Ganex V-230, Unimer U-6 (Induchem), and Agent[®] ACP-1009 (2) (<http://www.nicnas.gov.au/publications/car/new/na/nasummr/na0000sr/na71.asp>). Tricontanyl PVP is also a part of the mixture Unitamer[®] T-40 (titanium dioxide, tricontanyl PVP, and isoeicosane), which is an SPF booster and an improver of water resistance (<http://www.cheshamchemicals.co.uk>).

Functions. Tricontanyl PVP is used as a water-proofing, a film-forming, a viscosity-increasing, and a pigment-dispersing agent in cosmetics (2). In these cosmetics (usually mascara and lipstick), it is generally used at concentrations of less than 5% by weight of the final product (<http://www.nicnas.gov.au/publications/car/new/na/nasummr/na0000sr/na71.asp>).

Allergic contact dermatitis to PVP/1-triacontene copolymer. To prove that the copolymer was not sensitizing, a human study was done with a total of 102 human subjects (21 men and 81 women) who completed a repeat insult patch test (<http://www.nicnas.gov.au/publications/car/new/na/nasummr/na0000sr/na71.asp>). A series of 9 induction patches were applied to the subjects over a period of 3 weeks. Approximately 200 mg of tricontanyl PVP was applied to each patch and placed on the left upper back area for D1. The site was observed before each repatching. 2 weeks after the removal of the last induction patch, the subjects were challenged at a new site. The test material was applied for D1, and both the induction and the challenge sites were observed immediately, D2 and D3 after the patch test. During the induction phase, 6 subjects exhibited a minimal reaction. Induction sites did not exhibit adverse reactions during the rest period or at the challenge. 1 subject exhibited a minimal reaction at the challenge site. Under the conditions of the study, tricontanyl PVP did not elicit skin sensitization in humans (<http://www.nicnas.gov.au/publications/car/new/na/nasummr/na0000sr/na71.asp>).

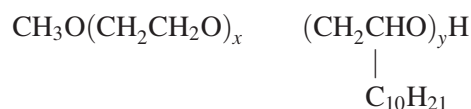
However, the first case of allergic contact dermatitis to PVP/1-triacontene in a sunscreen was reported by Stone et al. in 2002 (12). Since then, no other cases of allergic contact dermatitis to this copolymer have been reported.

Cosmetic applications. We found 1 lip gloss, 21 different kinds of mascara, 32 hair conditioners, 12 shampoos, 1 styling mousse, 12 styling gels, 26 sunscreens, 1 anti-aging sunscreen, 1 depilatory foam, 1 skin illuminator, and 2 moisturizers in which PVP/1-triacontene is used.

Methoxy PEG-22 and PEG-17/dodecyl glycol copolymers

Chemical information. Methoxy PEG-22 and methoxy PEG-17 dodecyl glycol copolymers are

alkoxylated alcohols (nonionic polyalkylene glycols and synthetic polymers). The methoxy PEG-22 has the CAS registry name oxirane, decyl-, polymer with oxirane, monomethyl ether [22 mol, ethylene oxide (EO), 7 mol decyl oxirane, average molar ratios] and CAS numbers 88507-00-0 and 89678-44-4 (2) (<http://www.surface.akzonobel.com>). The average molecular weight is 1800 D. The methoxy PEG-17 copolymer constitutes 17 mol EO and 1 mol decyl oxirane, average molar ratios, and its CAS number is 88507-00-0 (2) (<http://www.surface.akzonobel.com>). The average molecular weight of this copolymer is around 1000 D (13). Both copolymers conform to the general formula:



where x has an average value of 22 and y an average value of 7 (2), respectively, x having an average value of 17 and y an average value of 1 (2). Figure 5 shows their structural formula (13).

Trade names. Trade names of methoxy PEG-22/dodecyl glycol copolymer are AEC methoxy PEG-22/dodecyl glycol copolymer (A&E Connock, Hampshire, UK) and Elfacos[®] E 200 (Akzo Nobel, Arnhem, The Netherlands) (2). Trade names of the methoxy PEG-17 copolymer are AEC methoxy PEG-17/dodecyl glycol copolymer (A&E Connock) and Elfacos OW 100 (Akzo Nobel) (2).

Functions. Methoxy PEG-22/dodecyl glycol copolymer is used as an emulsion stabilizer (water-in-oil) and as a suspending (nonsurfactant) and viscosity-increasing (aqueous and non-aqueous) agent (2) (http://www.amisol.com/Product_Search_General.htm). Methoxy PEG-17/dodecyl glycol copolymer is not only used as an emulsion stabilizer (oil-in-water) but also as a skin

conditioner (miscellaneous), and a suspending (nonsurfactant) and a viscosity-increasing agent (nonaqueous) in cosmetics (2, 13).

Allergic contact dermatitis to methoxy PEG-22 and PEG-17/dodecyl glycol copolymers. Methoxy PEG-17/dodecyl copolymer was first reported in 2001 by Le Coz and Heid (13) as a contact allergen in a moisturizing milk. Methoxy PEG-22/dodecyl glycol has first been reported as a contact allergen in a tissue accompanying a warm hair removal wax by Goossens et al. in 2002 (14, 15). Presumably, this allergic contact dermatitis was enhanced in combination with skin irritation after hair removal with the wax. With regard to the ingredients present in the tissue, among the 21 patients (from Belgium and France) tested with methoxy PEG-22/glycol copolymer 10% in pet., 19 reacted positively. 7 of 19 methoxy PEG-22-positive patients were also tested with methoxy PEG-17/dodecyl glycol 10% in pet. Of 7 patients tested, 5 reacted positively (14). Hence, it is important to test both PEG-22 and PEG-17, otherwise allergic reactions may be missed if only 1 component is tested. The haptens are likely to be alkyl epoxides used for polymerization, by-pass products occurring during polymerization, or some impurity such as 1,4-dioxane, obtained from dimerization of ethylene oxide, and therefore inherent to all PEG products (13).

Cosmetic applications. We found methoxy PEG-22/dodecyl glycol copolymer listed as an ingredient in 18 moisturizers, 1 sunscreen, 1 foundation, and the tissue accompanying a warm hair removal wax, discussed above. Only 3 products were identified with the methoxy PEG-17/dodecyl glycol copolymer, i.e. a purifying lotion, a skin-firming fluid, and a hydrating body milk.

Phthalic anhydride/trimellitic anhydride/glycols copolymer

Chemical information. Phthalic anhydride/trimellitic anhydride/glycols (PTG) copolymer (CAS number 186688-25-5) results from the condensation of phthalic anhydride (C₈H₄O₃, Fig. 6), trimellitic anhydride (C₉H₄O₅, Fig. 7), ethylene glycol (C₂H₆O₂, Fig. 8), and neopentyl glycol (C₅H₁₂O₂, Fig. 10) monomers (16, 17).

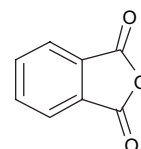


Fig. 6. General structural formula of phthalic anhydride.

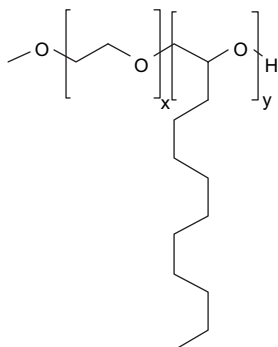


Fig. 5. Structural formula of methoxy polyethyleneglycol (PEG)-22 and PEG-17/dodecyl glycol copolymers.

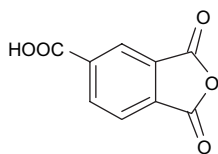


Fig. 7. Structural formula of trimellitic anhydride.

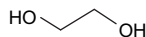


Fig. 8. Structural formula of ethylene glycol.

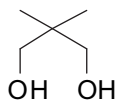


Fig. 9. Structural formula of neopentyl glycol.

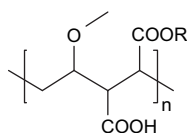


Fig. 10. General structural formula of polyvinyl methyl/maleic acid copolymer.

Trade names. The trade name of PTG copolymer is Polynex Resin (Estron, Calvert City, KY, USA). Trade name of a mixture containing it is 7809 Polyester Resin (Degen, Jersey City, NJ, USA) (PTG copolymer and butyl acetate) (2).

Functions. This synthetic copolymer is a non-aqueous agent, which increases viscosity, and is responsible for forming a film when used in nail polish and enamel, such as tosylamide/formaldehyde resin or phthalic anhydride/glycerine/glycidyl decanoate copolymer (16, 17). It is also used in the manufacture of dyes, pharmaceuticals, and insecticides, and as a hardener for resins (17).

Phthalic and trimellitic anhydrides are both low-molecular-weight acid anhydrides, used as epoxy hardeners. Phthalic anhydrides are also used in the production of phthalate plasticizers. Trimellitic anhydrides are also used in the production of adhesives, polymers, dyes, and printing inks. Phthalic anhydride was introduced a few years ago in some formulations of nail polishes as an alternative to toluenesulfonamide formaldehyde resin (17, 18).

Allergic contact dermatitis to PTG copolymer. Phthalic and trimellitic anhydrides have both been well documented as causing respiratory irritancy and allergy mediated via specific immunoglobulin E antibodies. Allergic contact urticaria and contact dermatitis have been described following airborne exposure in factory workers (18). Contact allergy to PTG copolymer in nail varnish was first reported by Moffitt

and Sansom (18) in 2002. In 2004, le Coz et al. presented 3 further cases of allergic contact dermatitis to PTG copolymer in nail varnish (16), while Gach et al. (17) reported the largest series of cases (4) in 2005. The majority of contact allergic reactions to nail varnish elicit dermatitis of the head and neck, especially around the eyes. These reactions are commonly caused by allergy to tosylamide/formaldehyde resin. Other reported allergens in nail varnish include formaldehyde, nitrocellulose, guanine, polyester resin, acrylates, acetates, and pigments (18, 19). In the case of PTG copolymer allergic contact dermatitis, the use of tosylamide/formaldehyde-based nail polish is an alternative (16).

Cosmetic applications. We found PTG copolymer in 32 different nail polishes and 10 other nail treatment products.

Polyvinyl methyl/maleic acid copolymer

Chemical information. Polyvinyl methyl (PVM)/maleic acid (MA) copolymer (CAS name 2,5-furandione, polymer with methoxyethylene and CAS numbers 25087-06-3 and 9011-16-9) is a copolymer of methyl vinyl ether and maleic anhydride. It is available in several forms and conforms to the empirical formula $(C_4H_2O_3 \cdot C_3H_6O)_x$ (2). Its molecular weight is 41 000 D (http://www.amisol.com/Product_Search_General.htm). Figure 10 shows the general structural formula of PVM/MA copolymer, where 'n' is the average number of PVM/MA copolymers.

Half-ester derivatives of PVM/MA copolymer (such as *n*-butylmonoester and ethyl ester) are produced by reacting the anhydride with the corresponding alcohol. These copolymers are available with different alkyl chain lengths and are supplied as 50% ethanol solutions. These esters are used particularly in enteric film coatings and ostomy adhesives (20). These are less tacky than neutralized PVM/MA copolymer. Both Dansac[®] soft paste and Stomahesive[®] paste contain *n*-butylmonoester of PVM/MA copolymer.

The ethyl ester of PVM/MA copolymer in an ethanol solution has a molecular weight of approximately 100 000–150 000 D. Figure 11 shows the structural formula of the half-ester derivatives of PVM/MA copolymer. Figure 11a shows the *n*-butylmonoester of PVM/MA copolymer and Fig. 11b shows the ethyl ester of PVM/MA copolymer.

Trade names. The trade names of PVM/MA copolymer are Gantrez[®] AN-119 (ISP), Gantrez AN-139 (ISP), Gantrez AN-149 (ISP), Gantrez AN-169 (ISP), Gantrez S-95 (ISP), Gantrez S-97 (ISP), and Luviform[®] FA-139 (BASF, Ludwigshafen,

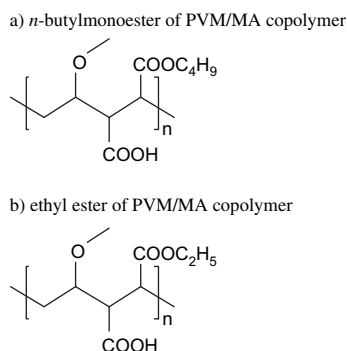


Fig. 11. Structural formula of the half-ester derivatives of polyvinyl methyl/maleic acid (PVM/MA) copolymer. (a) *n*-Butylmonoester of PVM/MA copolymer. (b) Ethyl ester of PVM/MA copolymer.

Germany) (2) (<http://www.ispcorp.com>). Gantrez is actually an umbrella term for a series of copolymers with slightly varying chemical structures, which are used in a variety of products. Trade names of mixtures containing it are Lubrajel Oil[®] (Guardian, Fort Saskatchewan, Alberta, Canada) (glycerin, glyceryl acrylate/acrylic acid copolymer, propylene glycol, and PVM/MA copolymer) (<http://www.u-g.com/pinfo/LubrajelOil.pdf>) and Zilgel Oil[®] (Zile, Evry Cedex, France) (glycerine, water, sodium polyacrylate, and PVM/MA copolymer) (<http://www.rtvanderbilt.com/No546.pdf>). Gantrez ES is the trade name of the half-ester derivatives of PVM/MA copolymer. The trade name of *n*-butylmonoester of PVM/MA copolymer is Gantrez ES-425. Gantrez ES-225 is the trade name of ethyl ester of PVM/MA copolymer.

Functions. These copolymers are used in a variety of noncosmetic products, including shoe polishes, decorative and protective sprays, paper- and leather-coating aerosols, spray bandages, some enteric and sustained-release coating agents for tablets, tackifiers, binders, plasticizers, printing inks, textile dyes, and finishes (http://www.amisol.com/Product_Search_General.htm). Gantrez has a significant ability to adhere to wet or moist areas. It is capable of forming highly polar films on these difficult surfaces. In adhesives, Gantrez not only increases specific adhesion and shear strength but also improves 'wet grab' (21). It can be used in a broad spectrum of hygiene and cosmetic products (such as toothpastes, mouthwashes, denture fixatives, and hairstyling aerosols) with slight variations in its chemical structure.

Allergic contact dermatitis to PVM/MA copolymer. The GAF Company (which produces Gantrez) reported only 3 irritant reactions in 700 patch tests performed in 150 volunteers (incidence of 0.21%) in predictive testing and

no allergic contact dermatitis upon rechallenge. Storrs and coworkers at the Oregon Health Sciences University performed patch tests with Gantrez 5% in pet. on 15 volunteers with no irritant or allergic reactions (22).

Contact allergy to Gantrez ES-425 in Stomahe-sive paste (a medical dressing) causing peristomal allergic contact dermatitis in a colostomy patient was first reported in 1987 by Heskell (22). This patient also showed sensitivity to the closely related compound Gantrez ES-225. Gantrez is not likely to be a hapten because of its high molecular weight. The presence of a residual monomer or impurity could, however, not be identified by Heskell nor by the GAF company. So the precise nature of the allergen is not known (22). The second case of patch-test-positive peristomal allergy to Gantrez ES-425 was reported by Scalf and Fowler (21) in 2000. Furthermore, Martin et al. (20) in 2005 reported a case of allergic contact dermatitis to Gantrez ES-425 in Dansac soft paste. This means that only 3 cases of contact allergic reactions to Gantrez have been described, and they all concerned peristomal allergic contact dermatitis; 2 of which were due to Stomahe-sive paste and 1 to Dansac soft paste. A peristomal allergic contact dermatitis to another compound of Stomahe-sive paste has been reported by Gallo et al. in 2002. The allergen was not Gantrez, but remained unknown (23). Contact allergic reactions to Gantrez AN products have not been reported yet.

Cosmetic applications. We have found PVM/MA copolymer as an ingredient in 20 toothpastes, 2 mouthwashes, 4 denture fixatives, 3 hairstyling aerosols, 19 skin care products, and 1 nail strengthener (24).

Conclusions

With this case report and review, we would like to draw attention to copolymers being unexpectedly potential skin sensitizers, notwithstanding their high molecular weights; the exact nature of the haptens involved is not yet known. Copolymers, and particularly the PVP type, are widely used in cosmetic products, for instance, in many sunscreen products. The recent increased skin cancer prevalence and promotion of their use may lead to enhanced risk of contact sensitivity to them.

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