Received: 4 February 2019 | Revised: 6 March 2019 | Accepted: 6 March 2019

DOI: 10.1002/cia2.12055

INVITED ARTICLE

WILEY Journal of Cutaneous Immunology and Allergy

Allergic contact dermatitis from Solvent Orange 60 in spectacle frames

Mamiko Shono MD[1] | **Mitsuru Numata**[2] | **Kazumi Sasaki**[2]

[1]Shono Dermatology Clinic, Machida, Tokyo, Japan

[2]National Institute of Technology and Evaluation (NITE) Biological Resource Center, Kisarazu, Japan

Correspondence
Mamiko Shono, Shono Dermatology Clinic, Machida, Tokyo, Japan.
Email: mamiyamas@keb.biglobe.ne.jp

Abstract

Potential allergens in plastic spectacle frames concern plasticizers, antioxidants, UV filters, and dyes. Among the latter, Solvent Orange 60 (SO 60) has been recognized as an important allergen, and presently 32 cases have been reported in Japan and Scandinavia. In Japan, the first case of allergic contact dermatitis (ACD) from SO 60 in spectacle frames was reported in 1999, and 17 similar cases followed until 2018. Since 2006, 14 cases, observed among plastic production workers, and spectacle and dental goggle users, were reported in Scandinavia. This review provides a summary of the 18 Japanese cases of ACD from SO 60, the clinical manifestations, diagnostic method and results, provenance of causative spectacle plastic plates, as well as some countermeasures to prevent contact allergy to it.

KEYWORDS

allergic contact dermatitis, CAS no. 6829-22-7, CAS no. 6925-69-5, perinone-type dye, plastics, Solvent Orange 60, Solvent Red 179, spectacle frames

1 | INTRODUCTION

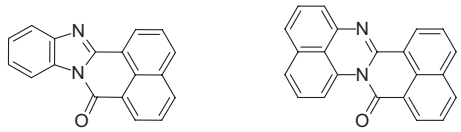
Solvent Orange 60 (SO 60) may cause severe allergic contact dermatitis (ACD) when used in spectacle frames. Since our first publication in 1999, 17 other Japanese cases have been reported, and since 2006, 14 cases came from Scandinavia, some of them due to occupational exposure. This review provides a summary of the 18 Japanese cases of ACD from SO 60; moreover, some countermeasures to prevent contact allergy to it will be discussed.

2 | SOLVENT ORANGE 60

SO 60, CAS no. 6925-69-5, is a perinone-type oil-soluble plastic dye used to provide color to tough plastics, such as acrylonitrile/butadiene/styrene (ABS), polystyrene, polycarbonate, and poly (methyl methacrylate) resins,[1] the production of which has been permitted in Japan since the 1960s. As it has excellent properties such as heat stability, color strength, transparency, ease of dispersion, and good lightfastness in transparent colors, this dye is also widely used in turn-signal lamps of automobiles, as well as in the bodies of household electronic appliances.[1,2]

When used in spectacle frames, SO 60 is blended with other coloring agents, added onto cellulose acetate or propionate resins together with a plasticizer, an ultraviolet light stabilizer, an antioxidant, a solvent, and a polish, which is then heated for mixing.[2] Since the chemical components are not bound to each other, they may leach out and transude into the sebum of peri-auricular skin.[1,2] SO 60 has been found in brown, red, pale pink, and tortoiseshell plastic spectacle frames and earpieces.[1,3]

Solvent Orange 60 may cause cross-reactivity to Solvent Red 179 (SR 179), CAS 6829-22-7, another perinone-type plastic dye also used in plastic spectacle frames.[1,3,4] The chemical and structural formulas of SO 60 and SR 179 are shown in Figure 1.



C.I.Solvent Orange 60
CAS no. 6925-69-5
$C_{18}H_{10}N_2O$
Mol. Wt.: 270.28

C.I.Solvent Red 179
CAS no. 6829-22-7
$C_{22}H_{12}N_2O$
Mol. Wt.: 320.34

FIGURE 1 Structural and chemical formulas of SO 60 and SR 179

3 | REPORTED CASES OF ALLERGIC CONTACT DERMATITIS FROM SO 60

In 1999, Shono and Kaniwa reported the first case of ACD from SO 60 regarding a 66-year-old man, who had developed an itchy, infiltrative, and erythematous dermatitis behind his ears soon after wearing new metal-framed spectacle frames with brown earpieces. Patch tests with the scrapings of the earpieces were strongly positive, and one of the ingredients of the earpieces, that is, SO 60 (1% pet), provoked a +++ vesiculo-bullous reaction with infiltrative erythema of over 10 cm in diameter, associated with an excited skin syndrome (Figure 2).[1,5] Chemical analysis using thin-layer chromatography (TLC) and high-performance liquid chromatography (HPLC) identified the presence of SO 60 in the brown earpieces.[1]

Until 2004, eight Japanese males, aged 26-67, including the first case, have been reported, some of which as abstracts only; they all had presented with ACD from SO 60 contained in several metal spectacle frame brown earpieces.[6–10] In 2001, the Japanese Society for Contact Dermatitis started a multicenter patch-test study with SO 60 1%, 0.5%, and 0.25% pet.: 230 patients were investigated in 22 hospitals and clinics, of whom three with a positive reaction, including one male with a definite history of ACD from spectacle earpieces already described in the eight above-mentioned cases.[8]

After 2004, there was no new case report in Japan, probably because most dermatologists stopped patch testing this dye, or no longer reported new cases. But since 2017, another 10 new cases have been reported; all females aged 20-75. The causative spectacle frame parts in these cases were five metal frame earpieces, three ordinary plastic frame temples, and three olefin elastomer temple ear parts.[3,11–15]

In Japan, only spectacle frames were found to be the sensitizing culprits, in contrast to occupational cases in Scandinavia reported since 2006, the first such case in Sweden,[16] followed by another case observed in Finland; both were plastic industry workers. Two other Finnish cases concerned a spectacle user and an orange dental goggle, respectively.[17] In 2018, ten additional SO 60–positive cases were described in Sweden, of whom six suspected of spectacle frame dermatitis.[18]

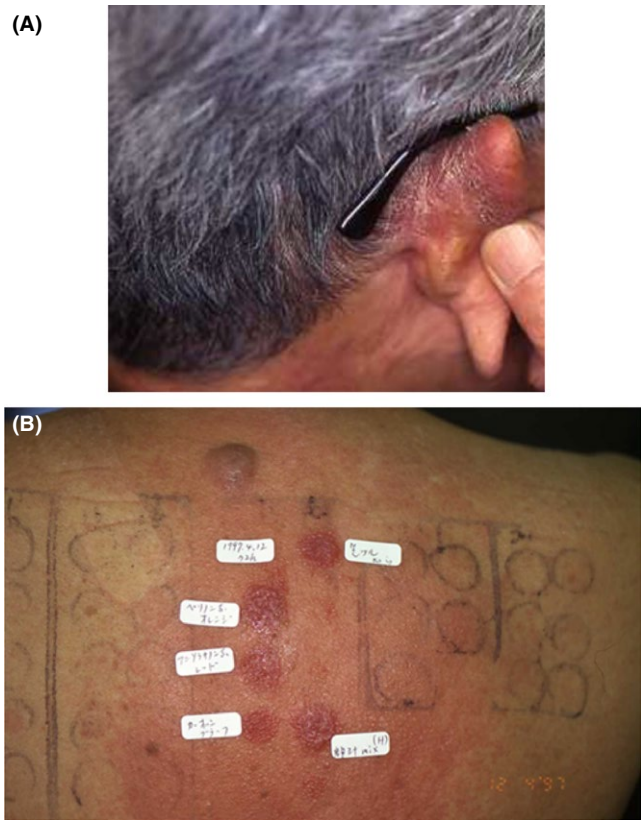


FIGURE 2 The first reported case of Shono and Kaniwa in 1999 regarding a 66-year-old male. Solvent Orange 60 (1% in petrolatum) provoked +++ vesicular reaction extending over 10 cm with infiltrative erythema and spreading (Cited from Contact Dermatitis,[1] with permission from Visual Dermatology[5])

4 | CLINICAL MANIFESTATION, PATCH TESTS, AND CHEMICAL ANALYSIS OF CAUSATIVE SPECTACLE FRAMES IN THE REPORTED CASES

Generally, the patients sensitized to SO 60 presented with erythema and edema, or an itchy, infiltrated, and erythematous dermatitis located at the skin area in contact with the causative plastic spectacle frames (Figures 2-4), appearing 3 days to several years following their first use. The dermatitis sometimes became chronic, pigmented, and lichenified (Figure 1), when, despite the presence of itching lesions, the patients kept wearing the causative spectacles for several years.[1]

We did not only patch test with SO 60, but we also took fine scrapings from the spectacle frames using a knife (as permitted by these patients) which we incorporated in a small amount of petrolatum (pet), and subsequently patch tested using a Finn chamber. In Scandinavia, a water/ethanol/acetone extract of earpieces, or of the causative plastic material, has been used for patch testing.[2,18]

In most of the reported cases, scrapings and SO 60 1% pet caused strong patch-test reactions, often ++ to +++ (Figures 2-4), extending the patch-test area, within the case reported by Nishihara et al,[12] a spreading vesicular patch-test reaction associated with a

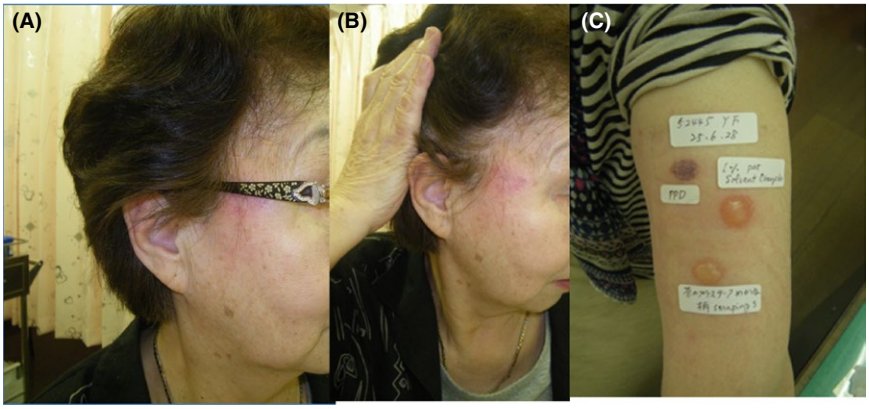


FIGURE 3 A 75-year-old woman developed infiltrative erythematous dermatitis on cheeks and peri-auricular region 6 mo after she started to wear brown Japanese plastic spectacle frames with golden lacquer painting outside of the temple. A and B, The producer in Sabae City bankrupted 2 y previously, and further product information was not provided. C, +++ bullous positive reactions to scrapings of the plastic temple and the 1% pet. dilution of SO 60 on Day 3 (Cited from Nihon Hifu Meneki Arerugi Gakkai Zasshi[3])

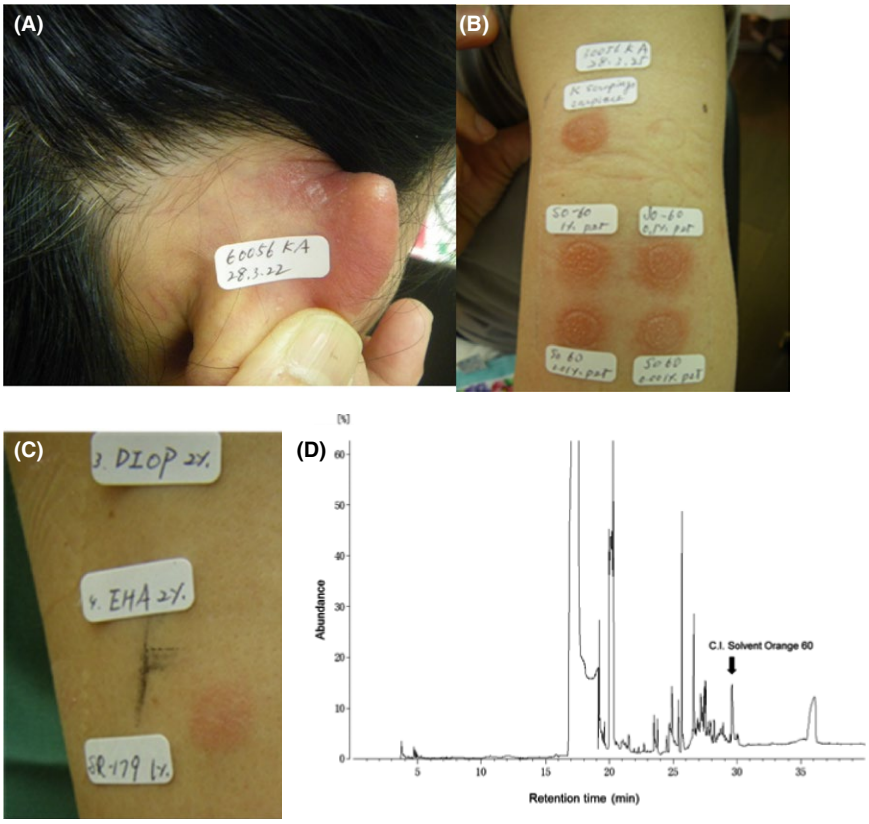


FIGURE 4 A 45-year-old piano teacher developed in 2016 infiltrative erythema spreading to the upper part of bilateral pinna (A) 6 wk after she had started to wear new reddish-brown spectacle frames. The spectacle frames were made in China using Chinese spectacle frame plate, and final assembly work was performed and sold as "made in Japan." Scrapings of the plastic frame temples and Solvent Orange 60 diluted 1%, 0.1%, 0.01%, and 0.001% pet. provoked +++ reactions (B) on Day 3. C, Solvent Red 179 with the same dilutions was + positive only at 1% dilution. D, GC/MS of the causative temple plastic detected Solvent Orange 60 but not Solvent Red 179. Thus, this patient was sensitized to SO 60 in the spectacle frame plastic and cross-reacted to SR 179. The spectacle frame plate producer in Hong Kong first denied the content of SO 60, but admitted it when we showed GC/MS result. The spectacle producer in Sabae City decided to abandon future use of SO 60 in all their spectacle frames and also withdrew those containing SO 60 from their shops (Cited from Contact Dermatitis,[11] and Nihon Hifu Meneki Arerugi Gakkai Zasshi[3])

systemic erythematous rash. Strong reactions were also observed in Scandinavia: 2 of the 10 patients described by Linauskiene et al presented with a +++ reaction to SO 60 1% pet, having spread 20 cm outside the test area, comparable to the first case of Shono and Kaniwa (Figure 1)[1,18]; one of these two patients reacted positively to SO 60 down to 1 ppm acetone. Spontaneous flare-ups of patch tests

have not been reported thus far though. One positive control patient among 31 patch tested has been observed.[2]

Cross-sensitivity between SO 60 and SR 179 was first shown by Tsunoda et al,[4] who reported ACD from a spectacle earpiece because of SR 179, with cross-reactivity to SO 60. Moreover, two cases sensitized to SO 60 cross-reacted to SR 179 (Figure 4).[3,11,18] In spite of the extreme reaction to SO 60, the first patient described by Shono and Kaniwa did not cross-react to SR 179.[1]

Spectacle frame dermatitis can be treated with topical corticosteroids, but severe patch-test reactions did require systemic steroid treatment in some cases.[1,3] In spectacle shops, causative earpieces can be taken off from metal temples and changed to earpieces free of SO 60 and SR 179. If a patient wishes to wear new plastic spectacle frames, they should ask the producer to confirm the absence of these dyes.[3]

In 13 out of 18 reported Japanese cases, chemical analysis using TLC/HPLC or gas chromatography/mass spectrometry (GC/MS) detected SO 60 in the causative spectacle frames (Figure 4).[1,3,6,7,9,10,12,14,15]

5 | PROVENANCE OF CAUSATIVE SPECTACLE PLASTIC PLATES

Sabae City in Fukui Prefecture, famous because of their fine titanium ones, produces 95% of the Japanese spectacle frames; however, during the last 20 years, sales have decreased to 60% of its golden age. Nowadays, large Italian companies have obtained worldwide brand licenses and marketing channels in high-quality spectacles frames; moreover, China and Korea started to produce cheaper middle- and lower-class spectacles with similar quality, which have become increasingly popular. Production shifted abroad, foreign plastic plates are used to make some of the Japanese spectacles,[3,19] and a country, in which the last process of production is performed, becomes an "original country"; hence, "made in Japan" does not mean that every part of the spectacle frames is Japan made.[3] Notwithstanding the increase in spectacle frame dermatitis in Japan, to obtain product information has become more difficult, mainly because of globalization and competition, in contrast to 20 years ago, when we did get product information from Sabae City.

When a positive patch-test reaction to the scrapings of spectacle frames was obtained, we brought them to the shop where they had been bought, who could find out the producer or importer from the code printed on the plastic. Product information was thus obtainable if a Japanese spectacle company was involved in the production process (design, or final assembly work, etc.), particularly when the presence of SO 60 in the causative spectacles through patch test or chemical analysis had been confirmed. When the causative spectacle frames were totally foreign made,[3] such information upon inquiry through a Japanese importer was not available.

Among the 18 reported Japanese SO 60 contact allergy cases, we could trace four causative earpieces that were made in Japan,[1,3,5] four in China,[3,12] and one in Korea[9]; moreover, causative dyes used in one of the Japanese earpieces had been imported from China.[8] Three causative plastic spectacle frames were based on Chinese plastic plates,[3,14] and three olefin elastomer temple ear parts were made in China.[13] Indeed, since 2013, the causative plastic spectacle plates reported in Japan had most often been manufactured in China. We recently asked Japan's top plastic company, Daicel Corporation, if they were using SO 60 in their spectacle frame plastic plates: They answered that they stopped using it in spectacle plastic plates in 2009, when the Fukui Optical Industrial Association had informed all the spectacle producers in Sabae City about SO 60 contact allergy.

6 | CONCLUSION

Solvent Orange 60 is suspected of being a strong sensitizer, also taking the very strong patch-test reactions in sensitized subjects into account. Its use should best be avoided in plastic materials such as spectacle frames and hearing aids that touch the skin for prolonged periods of time. Today, plastic spectacle frames seem more popular than metal ones, because they are more fashionable, inexpensive, and easier to produce. Therefore, the frequency of ACD cases from SO 60 might increase. However, there are probably many undetected cases, and SO 60 and SR 179, along with other reported allergens, should be patch tested in all suspected spectacle frame dermatitis cases (Table 1),[20,21] the more since production is globalized and international.

Solvent Orange 60 may cause extremely severe patch-test reactions; hence, patch testing should be carefully performed, in a 0.1% pet. concentration at most. Linauskiene et al even recommended lowering of the test concentration down to 0.01% if there is a strong suspicion of contact allergy to it. Availability of commercial allergens of these dyes is helpful. Reactions to SR 179 are less strong, so it can probably be patch tested at 1% pet. but needs further confirmation.

TABLE 1 Allergens in spectacle frames[20,21,22]

Metals Ni, Co, Cr, Pd, Au	Dyes
Epoxy resin	*p*-Phenylenediamine
Colophony	Disperse Orange 3
Thiuram mix	Disperse Red 17
Plastics	Disperse Yellow 3
Butyl acrylate	Disperse Yellow 54
Methyl methacrylate	Disperse Blue 27
Diethyl, dimethyl, and dibutyl phthalate	Solvent Yellow 3
Diethylhexyl phthalate	Solvent Yellow 33
Tricresyl phosphate	Solvent Red 26
Triphenyl phosphate	Solvent Red 481
Resorcinol	Solvent Orange 60
Resorcinol monobenzoate	Solvent Red 179
Phenyl salicylate	
Triethylene glycol bis (2-ethylhexanoate)	
2-Ethylhexyl 4-methoxycinnamate	

Dermatologists should provide newly obtained information from the cases observed, patch test, or chemical analysis, to the glass shops and producers. In fact, they were all surprised with the strong reactions of the frame scrapings and SO 60, and would not have used the dye if they had known this. They have a network of spectacle frame producers extending abroad, and the information may be promptly and directly transmitted to the plastic plate producer and their business world. One spectacle producer in Sabae City decided to abandon future use of SO 60 in all their spectacle frames when we informed that one of their customers got severe contact dermatitis from the spectacles frames they had sold (Figure 4).[3,11] Hence, they checked all their products and immediately withdrew spectacle frames that contained SO 60 from their shops.

ACKNOWLEDGMENTS

The authors thank Prof. Dr. An Goossens of Leuven University, Belgium, and Mrs Kuulei Park Fukumoto for their kind advice.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

REFERENCES

1. Shono M, Kaniwa M. Allergic contact dermatitis from a perinone-type dye C.I. Solvent Orange 60 in spectacle frames. Contact Dermatitis. 1999;41:181–4.
2. Yeo L, Kuuliala O, Whhite IR, Aalto-Korte K. Allergic contact dermatitis caused by Solvent Orange 60 dye. Contact Dermatitis. 2011;64:354–6.
3. Shono M, Numata M, Sasaki K. Allergic contact dermatitis from solvent orange 60 in spectacle frames - A report of four cases. Nihon Hifu Meneki Arerugi Gakkai Zasshi. 2018;1:54–60.
4. Tsunoda T, Kaniwa M, Shono M. Allergic contact dermatitis from a perinone-type dye C.I. Solvent Red 179 in spectacle frames. Contact Dermatitis. 2001;45:166–7.
5. Shono M, Kaniwa M. Spectacles. Vis Dermatol. 2008;7:300–1.
6. Hino H, Hasegawa T, Wakugawa M, Kaniwa M, Kenjo K. Allergic contact dermatitis due to coloring agents in end-pieces of eyeglasses. Rinsho Hifuka. 1998;52:701–8.
7. Kaniwa M, Ikarashi Y. Investigative study on the cause of allergic contact dermatitis from plastic spectacles. Environ Dermatol (Nagoya). 2000;7(Supple.1):106.
8. Kobayashi H. Research Group of Japanese Society for Contact Dermatitis; Group study for optimum concentration of disperse orange 3, disperse blue 124, and solvent orange 60 for patch testing and patch test results of Japanese standard allergens. Environ Dermatol (Nagoya). 2001;8(Supple 1):49.
9. Yamazaki N, Nakada Y, Kamide R, Niimura M, Kaniwa M. A case of contact dermatitis from spectacle frame. Jpn J Dermatoallergol. 2002;11:8–12.
10. Ito A, Kaniwa M, Yamamoto Y, Takatsuka S, Shimomura N, Ito M. A case of allergic contact dermatitis due to dyes in end-pieces of eyeglasses. Rinsho Hifuka. 2004;58:124–8.
11. Shono M, Numata M, Sasaki K. Allergic contact dermatitis caused by Solvent Orange 60 in spectacle frames in Japan. Contact Dermatitis. 2017;78:83–4.
12. Nishihara S, Kozuka T, Sasaki K. Allergic contact dermatitis caused by Solvent Orange 60 dye in the temple tips of eyeglasses and a review of cases of eyeglass allergic contact dermatitis. J Cutan Immunol Allergy. 2018;1:64–8.
13. Tsunoda T, Yaguchi Y, Sato F. Allergic contact dermatitis from Solvent Orange 60 in spectacle frames. 378th Tohoku local lecture meeting of Japanese Dermatological Association.
14. Numata M, Kikukawa M, Sasaki K, Ito A, Tsunoda T, Matsunaga K. Allergic contact dermatitis from Solvent Orange 60 used in plastic spectacle frames. Nihon Hifu Meneki Arerugi Gakkai Zasshi. 2017;1:112.
15. Watanabe Y. Allergic contact dermatitis from Solvent Orange 60 in spectacle frames. Nihon Hifu Meneki Arerugi Gakkai Zasshi. 2018;2:185.
16. Zimerson E, Bruze M. Skin problems in a plastic industry. Contact Dermatitis. 2006;55(Supple 1):29.
17. Suomela S, Aalto-Korte K. Solvent Orange 60 contact allergy caused by goggles used in dentistry. Contact Dermatitis. 2014;70:81–2.
18. Linauskiene K, Zimerson E, Antelmi A, Bruze M, Hagvall L, Hamnerius N, et al. Solvent Orange 60 is a potent contact sensitizer in occupational and everyday life. Contact Dermatitis. 2018;79:123–6.
19. Yoon D, Kato A. A comparative study on the eyewear district of Japan and Italy. Administration Inform. 2008;20:1–19.
20. Walsh G, Wilkinson M. Materials and allergens within spectacle frames: a review. Contact Dermatitis. 2006;55:130–9.
21. Andersen KE, Vestergaard ME, Christensen LP. Triethylene glycol bis (2-ethylhexanoate) -a new contact allergen identified in a spectacle frame. Contact Dermatitis. 2013;70:112–6.
22. Adachi A, Ohtsuka H, Yamano N, Inoue T, Shirai S, Numata M, et al. A case of allergic contact dermatitis from 2-Ethyl 4-methoxycinnamate used in spectacle frames. Nihon Hifu Meneki Arerugi Gakkai Zasshi. 2017;1:112.

How to cite this article: Shono M, Numata M, Sasaki K. Allergic contact dermatitis from Solvent Orange 60 in spectacle frames. *J Cutan Immunol Allergy*. 2019;2:44–48. https://doi.org/10.1002/cia2.12055