Side-effects of henna and semi-permanent 'black henna' tattoos: a full review

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Summary

Henna, the dried and powdered leaf of *Lawsonia inermis*, is widely used as a dye for the skin, hair, and nails, and as an expression of body art, especially in Islamic and Hindu cultures. As it stains the skin reddish-brown, it is also called red henna. Black henna is the combination of red henna with *p*-phenylenediamine (PPD), and is used for temporary 'black henna tattoos'. This article provides a full review of the side-effects of topical application of red and black henna, both cutaneous (allergic and non-allergic) and systemic. Red henna appears to be generally safe, with rare instances of contact allergy and type I hypersensitivity reactions. In children with glucose-6-phosphate dehydrogenase deficiency, topical application of henna may cause life-threatening haemolysis. Black henna tattoos will induce contact allergy to its ingredient PPD at an estimated frequency of 2.5%. Once sensitized, the patients may experience allergic contact dermatitis from the use of hair dyes containing PPD. There are often cross-reactions to other hair dyes, dyes used in textiles, local anaesthetics, and rubber chemicals. The sensitization of children to PPD may have important consequences for health and later career prospects. Systemic toxicity of black henna has been reported in certain African countries.

Key words: black henna; body painting; hair dye; henna; lawsone; mehndi; *p*-phenylenediamine; tattoo; temporary tattoo; textile dye.

Henna is the dried and powdered leaf of the dwarf evergreen shrub *Lawsonia inermis*, a member of the family Lythraceae. The henna plant thrives in arid climates. Saudi Arabia, Iran, Sri Lanka, India, Egypt and the Sudan are its major producers. When applied to the skin, hair, or nails, the pigment lawsone (2-hydroxy-1,4-naphthoquinone; CI 75480; Natural Orange 6), which is present at a concentration of $< 2\%$ in henna leaves and natural henna preparations (1, 2), interacts with the keratin therein to give them a reddish-brown ('rust-red') colour; therefore, a frequently used synonym is 'red henna'. This characteristic makes henna the choice for mehndi (which means 'henna' in the Hindi language; sometimes, the terms mehindi and mehandi are used) body painting. Henna been used as a dye for the skin, hair and nails for over 4000 years, and as an expression of body art, especially in Islamic and Hindu cultures in the Arab, African and Indian world. At events such as wedding parties, public celebrations, and religious ceremonies, henna is applied to the skin of the hands and feet. In India, in particular, the use of henna to create complex pictures on the skin is an ancient art for decorating the body. This is especially true for weddings, when the bride is adorned with complex geometric, symmetrical figures depicting flowers, plants or animals on the night before the ceremony, while intoning *mehindi* chants. These mehndi tattoos are used as a reminder of happiness and as a form of blessing for the wearer (3–7).

To create the henna tattoo, a paste is made by adding water or oil to henna powder or to ground fresh henna leaves. Essential oils [e.g. *citrus limon* peel oil (lemon oil), *Eucalyptus globulus* leaf oil (eucalyptus oil), *Eugenia caryophyllus* bud oil (clove oil), or 'Mahalabiya oil', a

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mixture of various acidic oils], dried powder of indigo plant leafs, mustard oil, lemon juice, beet root juice, nut shell, sugar, tannin concentrates obtained from brewing tea leaves, instant coffee powder, charcoal powder, turpentine, *p*-phenylenediamine (PPD) (especially in African countries) and even animal urine or other (often secret) ingredients may be added to enhance the darkening effect. This paste is applied to the skin and allowed to remain there for a minimum of 30 min to 2–6 hr as the plant's dye penetrates the skin; the longer the exposure, the darker the colour will be. The dried paste is then removed to reveal an orange stain, which will darken over the next 2–4 days. A temporary henna tattoo should last for approximately 2–6 weeks, until the outer layer of the skin exfoliates, depending on skin type, the area of application, sun exposure, and other factors such as bathing and activity level (3, 4, 8).

In Arab countries, henna is also used for medicinal purposes, for example for the treatment of boils and folliculitis, by mixing it with vinegar and making a hot poultice. It may also be used to reduce pain, swelling, and high fevers, and to treat alopecia, burns, headaches, and gastrointestinal symptoms; in addition, henna has alleged antimycotic, tuberculostatic and ultraviolet A-blocking properties (3, 4, 9). In the industrial sector, the powder is used above all by Muslims and Orthodox Jews, because they refuse to use synthetic dyes to tinge silk, wool, and cotton fabrics (7). In India, surgeons sometimes use henna as a durable preoperative skin marker (10).

In recent years, a new mode of henna application, the so-called temporary black henna tattoo,[a] has become fashionable, especially among children, adolescents and young adults in western countries. Black henna is the combination of henna proper and PPD. In this article, the side-effects of both red henna and black henna are reviewed.

Side-effects of Red Henna

Contact allergy

Red henna is relatively safe, with only a few reports of contact allergic reactions, despite its extensive use (summarized in Table 1).

For example, it has been estimated that at least half of the population of India has been exposed to henna at some time in life, so it can be assumed that its sensitizing potential must be negligible (26). Most patients have been tested only with, and have had positive patch test reactions to, henna preparations. It is usually assumed that the allergen in henna is lawsone, but this compound has been tested in only a few studies (14, 15, 23, 25). Thus, in most cases, the actual allergen remained unknown, and some cases of contact allergy may have been caused by other ingredients of the plant or substances added later, for example essential oils (8). Indeed, in 3 cases, the allergen in the henna preparation could be identified as Mahalabiya oil (8). It should also be realized that, whereas contact allergy to red henna or lawsone in some studies was indeed very likely (15, 22, 23, 26) (although the relevance of the positive patch test reaction to lawsone in Ref. 23 was unknown), most cases lacked repeat testing, adequate controls, and exclusion of the possibility that the henna preparations used were adulterated with PPD (or other aromatic amines). Thus, certainly not all 19 cases presented in Table 1 can be taken as proof of contact allergy to red henna.

Immediate reactions

Immediate-type allergy to henna has been reported infrequently. It is an occupational hazard for hairdressers in the form of presumably IgE-mediated reactions, with symptoms such as sneezing, conjunctivitis, running nose, dry cough, dyspnoea, swelling of the face, or generalized urticaria (27–32). The main event for sensitization is inhalation of henna powder dispersed in the air, but application of pure henna dough on 1 patient's hand was accompanied by the immediate onset of generalized cutaneous pruritus, rhinitis, conjunctivitis, and decreased expiratory airflow (33). The diagnosis is made by prick testing with henna solutions; in one study, inhalation tests provoked an asthmatic attack (32). The allergen in henna is unknown. In the two studies in which prick tests were performed with lawsone, they were negative (28, 31). Henna-specific IgE has been shown in only one study (27). One patient with allergic contact dermatitis caused by PPD in a henna tattoo had a positive prick test reaction to 1% henna in water; the relevance was not mentioned (34). A 12-year-old boy had a black henna tattoo applied; he developed rapidly progressive dyspnoea after a few minutes, and allergic contact dermatitis later ensued. Prick tests were positive for black henna, red henna, and latex. Ten controls were negative. It was hypothesized that there was a type I cross-reaction between the henna and latex (35). A 38-year-old woman developed severe swelling of the face and eyelids within hours of dyeing her hair with henna; she had previously used 'natural henna' several times without problems. The diagnosis was

[a] The term black henna is sometimes also used to indicate the powder of another bush, *Indigofera argentea* (of the Fabaceae family), which is a distinct botanical species (Scibilia J, Galdi E, Biscaldi G, Moscato G. Occupational asthma caused by black henna. *Allergy* 1997; 52: 231–232).

Table 1. Possible cases of allergic contact dermatitis to plain, red henna

Year	No.	Sex	Age (years)	Clinical data	Positive patch test reactions	Comments	Ref.
2011	1	F	3	Bullous eruption 1 day after applying henna paste to the hand	Pure henna powder paste 10% pet.; PPD negative	The paste was made of dried leaves of the henna plant with no additions of any kind; no control tests performed	(11)
2009	1	F	30	Erythema and oedema of the leg 1 week after applying henna in vinegar	Henna powder 1% in saline and in vinegar; negative to vinegar and PPD	No control tests performed	(12)
2008	1	F	60	Acute bilateral palpebral dermatitis after applying henna paste to the hair	Henna powder 10% pet.; PPD negative	The patient had had a similar reaction to henna 1 year earlier; no additives were used; no control tests performed	(13)
2006	1	M	9	Two weeks after a black henna tattoo, generalized dermatitis developed	Lawsone 10% pet.; also PPD, IPPD, and benzocaine	Later, the patient had allergic contact dermatitis caused by permanent, non-henna hair dye; the allergy to lawsone was considered to be provoked by the reaction to PPD; no control tests performed	(14)
2003	1	F	50	Three episodes of acute palpebral dermatitis after dyeing hair with henna	Henna powder 10% pet. and lawsone 5% pet.; PPD negative	20 controls were negative to henna 10% pet. and to lawsone 5% pet.	(15)
2002	1	M	26	Within 2 weeks after a henna tattoo, lichenoid dermatitis developed	Henna powder pure, 10% aqua and 20% aqua positive; PPD and black henna preparation positive	The natural henna powder did not contain PPD (mass spectrometry); 'control tests' were negative	(16)
2001	1	M	26	Dermatitis 14 days after a black henna tattoo containing PPD	PPD; natural henna powder 10% and 20% aqua	It was not ascertained that the 'natural' henna powder used for patch testing did not contain PPD; no control tests performed	(17)
2001	1	F	9	Two days after a second tattoo on day 7, dermatitis appeared at the application site	PPD and natural henna (not stated how tested); commercial henna was negative	No control tests performed	(18)
2001	1	F	38	Oedema of the face and tongue within 4 hr after applying commercial henna hair dye	PPD, commercial henna 1% and natural henna 1% in saline	No control tests performed; it was not ascertained that the natural henna did not contain PPD	(19)
2000	1	M	35	Ten days after a black henna tattoo, dermatitis developed	PPD; unrelated henna powder 10% pet. positive; another pure henna sample 1% aqua negative	It was not checked whether the unrelated henna powder contained PPD; no control tests performed	(9)
2000	1	M	38	Twenty days after a henna non-permanent tribal tattoo, lichenoid dermatitis developed	PPD, henna (ground dry leaves in pet.)	No control tests performed with henna; unknown whether the tribal tattoo contained PPD	(20)
1999	2	F	22, 52	Dermatitis after traditional dyeing of the hands with (plain) henna	Henna ground leaves in pet. jelly (test concentration unknown) in 1 after 2 days; PPD was not tested; the other patient was not tested	Both patients had previous episodes of allergic contact dermatitis caused by plain henna; no control tests performed	(8)

Table 1. continued

Year	No.	Sex	Age (years)	Clinical data	Positive patch test reactions	Comments	Ref.
1997	1	F	33	Ectopic dermatitis on the eyelids, cheeks and forehead after application of henna to the nails on various occasions; the dermatitis stopped and did not recur after cessation of the use of henna	Henna dye 2% aqua, nickel; reaction to PPD not mentioned	No control tests performed	(21)
1997	1	F	30	Dermatitis of the face and scalp after applying an aqueous paste of natural henna to the hair on two occasions, starting within hours	Pure powdered henna 10% pet.; nickel; negative to PPD; open test with henna negative after 30 min	10 healthy controls were negative	(22)
1992	1	M	69	Recurring dermatitis on the face and oedema of the eyelids from using a sunscreen cream	Sunscreen cream; lawsone 5% pet. (twice);CI 12 150 (Solvent Red 1); CI 12 010 (Solvent Red 3)	Lawsone was negative in 10 controls; the colours were both ingredients of the sunscreen cream, but the source of sensitization to lawsone remained unknown	(23)
1988	1	M	19	Acute swelling, oedema, itching and burning within 2 h after applying a paste of fresh henna leaves ground in water	Paste of fresh henna leaves ground in water; commercial henna (test concentration not mentioned)	No control tests performed	(24)
1986	1	F	13	Recurring dermatitis after applying commercial henna powder or a paste of fresh henna leaves to the backs of the hands	Strongly positive to commercial henna, henna leaves made into a paste, and lawsone	No test concentrations mentioned; no control tests performed	(25)
1980	1	F	46	Dermatitis of the right index finger spreading to other fingers after applying henna to the hands of her husband; the patient had several previous episodes of dermatitis of her hands after applying henna on them	Repeatedly positive to henna aqueous paste; positive to extracts of henna powder	Three controls with aqueous extracts of henna were negative	(26)

F, female; IPPD, *N*-isopropyl-*N*′-phenyl-*p*-phenylenediamine; M, male; PPD, *p*-phenylenediamine.

angioedema, and it was suggested to be a type I allergy to henna. However, no prick tests were performed, and patch tests were positive for PPD and henna (commercial and natural), so a type IV allergy to PPD or henna is more likely (19, 36).

Other side-effects

Extravagant floral henna tattoo patterns on both forearms and hands may cause problems with peripheral venous cannulation (37). The structure and redox potential of lawsone (2-hydroxy-1,4-naphthoquinone) are similar to those of 1,4-naphthoquinone, a metabolite of naphthalene and a potent oxidant of glucose-6-phosphate dehydrogenase (G6PD)-deficient cells. Topical application of henna may therefore cause life-threatening haemolysis in children with G6PD deficiency. Signs and symptoms may include pallor, lethargy, vomiting, jaundice, anaemia, tachycardia, poor peripheral perfusion, shock, and even death (38–44).

Side-effects of Black Henna

In the past 15 years, a new mode of henna application, the so-called temporary black henna tattoo (also sometimes called skin painting or pseudo-tattooing), has become fashionable, ever since the Spice Girls decorated themselves with these body designs. Black henna (sometimes also termed blue henna) is the combination of red henna and PPD. No natural black henna exists. Some of these 'henna' preparations do not even contain red henna at all (1, 2). PPD is added to henna to accelerate the dyeing and drying process (to only 30 min), to strengthen and darken the colour, to enhance the design pattern of the tattoo, and to make the tattoo last longer. These tattoos stain the skin black, and have the appearance of a real tattoo. Because black henna tattoo mixtures are often extemporaneously prepared by the artist with a variety of materials and sources, the actual concentrations of PPD and other ingredients may vary greatly. Black henna can be distinguished from red henna in that it is dark brown or black, does not change colour when moistened, and is fixed on the skin in < 1 hr. In contrast, pure red henna is green–grey in colour, tends to turn orange when moistened, and needs between 2 and 12 hr to be fixed on the skin (1).

Black henna tattoos are readily available worldwide, last several weeks on the skin, and offer a self-limited, convenient alternative to a permanent tattoo. In contrast to permanent tattooing, it is a painless procedure that involves no needles, as the dye is applied by brushes or special pens on the skin. There is no skin penetration or piercing. Moreover, as the tattoos are not permanent and matrices are often used, no proficiency, specific expertise, skill or artistic talent is required to apply them. There is no risk of introducing infective agents. The henna materials are perceived and propagated as 'natural' and therefore safe. Many parents are unaware of the hazards, and may unknowingly allow their children to participate in this cosmetic novelty trend.

The temporary black henna tattoos are usually applied to young people and children in holiday resort areas such as the coastal areas of southern Europe (Spain, Canary islands, France, and Greece), Turkey, Egypt, the United States (Hawaii, Florida, and California), Mexico, Australia, South-east Asia (Indonesia, Thailand, India, and the Philippines), and South Africa, and in attraction parks, at festivals and at fairs by street artisan tattoo artists with mobile studios. Black henna preparations are also available as do-it-yourself kits (18, 36) and ready-to-use henna paste, or are made by patients themselves (45, 46).

Since 1997, black henna tattoos have been increasingly reported as a cause of allergic skin reactions. Most patients have been children, adolescents, or young adults. Reported cases in the English-language literature that could be accessed by the author, with some details, are shown in Table 2 (*de novo* sensitization from the tattoo), Table 3 (allergic contact dermatitis in black henna tattoos in patients already sensitized to PPD), and Table 4 (allergic reactions to products containing PPD or related compounds, such as hair dyes, in patients probably previously sensitized by black henna tattoo).

In cases where it was not clear whether a reaction in a tattoo was attributable to *de novo* (active) sensitization or from previous sensitization, the scenario considered most likely was chosen. The English-language literature on the subject of henna tattoo reactions up to 2001 has been reviewed in Ref. (73); another more recent review is provided in Ref. (7). Case reports and small case series (examples) have also been reported in the German (122–125), French (126–128), Danish (129, 130), Norwegian (131), Swedish (132), Spanish (133–135), Finnish (136), Polish (137), Dutch (138, 139) and Icelandic (140) literature.

Aetiology

Most patients with an allergic reaction become sensitized to PPD in the tattoo itself. Incubation periods (the time between application of the tattoo and the first signs of dermatitis) were usually between 8 and 14 days, but, in many instances of active sensitization, short incubation periods of 4–7 days have been observed, especially in children (Table 2). This is attributed to the strong

Table 2. Cases of black henna tattoo allergic contact dermatitis resulting from sensitization to *p*-phenylenediamine (PPD)in the tattoo

Year	No.	Sex	Age (years)	Positive patch test reactions	Latency time	Comments	Ref.
2012	2	M	5, 7	Both to PPD, PTD, PAP, DO3, Acid Yellow 36, Bismark Brown R, thiuram mix, DY3; 1 to Disperse Red (unspecified), FM1	<1 week	Generalized dermatitis, admitted to hospital; 2 brothers	(47)
	1	F	4	PPD, DO3, Acid Yellow 36	10 days	Systemic reaction with erythema multiforme-like lesions	(47)
2011	1	M	35	PPD	1 week	–	(48)
2010	1	M	8	No patch tests performed	2 weeks	Three weeks after the tattoo was placed, localized (transient) hypertrichosis appeared	(49)
2010	1	M	22	PPD	14 days	Hypertrophic scarring	(50)
2010	1	M	9	No patch tests performed	11 days	–	(51)
2010	1	F	16	No patch tests performed	5 days	Extensive keloid scarring	(46)
2009	1	M	11	PPD	1 week	Generalized erythema multiforme	(52)
2009	1	M	9	PPD	10 days	–	(53)
2008	1	M	6	No patch tests performed	8 days	Generalized vesicular erythema multiforme-like eruption	(54)
2008	1	F	18	PPD, black rubber mix, DY3, DO1, DO3, DR1, DR17, Solvent Orange 3 (azo dye in a marker pen)	4 days	Four months later, the patient had allergic contact dermatitis caused by hair dye within 24 hr of applying it	(55)
2008	1	F	19	No patch tests performed	6 days	Not specified whether red or black henna had been applied	(56)
2007	1	M	8	PPD, DY3, thiuram mix, nickel, hydroquinone	1 week	Widespread dermatitis	(57)
2007	1	M	6	No patch tests performed	10 days	–	(58)
2007	2	M, F	7, 14	PPD and DO3 in both, PTD and DDM in 1	2–3 weeks	Persistent leukoderma ('contact vitiligo') after 2 years	(59)
2007	2	M	7, 9	No patch tests performed	1 week, 2 weeks	–	(60)
	1	F	3	PPD	2 weeks	–	(60)
	2	M	9, 39	Both PPD, 1 to formaldehyde	5 days, 1 week	–	(60)
2007	31	?	?	PPD (27), henna mix (2), PPD negative (2); no reactions to natural henna	4–7 days	All schoolchildren; long-lasting hyperpigmentation and hypopigmentation in most patients	(3)
2007	1	M	11	PPD	7 days	–	(61)
2007	1	M	12	PPD, DY3, DB124, thiuram mix, mercaptobenzothiazole, black henna; positive prick tests for red and black henna and for latex	2 weeks (?)	Rapidly progressive dyspnoea a few minutes after skin application of the dye; cross-reactivity between black henna and latex was considered	(35)
2006	1	M	32	PPD, DY3, DR1, 'orange red', 4,5-aminophenol (unknown chemical)	10 days	The dermatitis appeared 4 days after a second tattoo on day 6	(62)
2006	1	M	9	PPD, IPPD, benzocaine, lawsone 10% pet.	14 days	Sensitization to PPD from the tattoo led to allergic contact dermatitis from hair dyeing 6 months later	(14)
2006	1	M	7	PPD, DY3, DB124	10 days	–	(63)
2006	1	M	19	PPD	11 days	–	(64)
2005	1	F	4	PPD	4 weeks	Persistent hypopigmentation after 6 months	(65)
2005	2	F	15,17	Both PPD; 1 to IPPD, Disperse dyes (Blue 124/106 mix, Orange 1, Red 1, Yellow 3), Direct Orange 34, PTDS, nitro-phenylenediamine (not further specified)	10 days	The girls were sisters; long-lasting hyperpigmentation	(66)
2005	10	?	?	All PPD	7–21 days	Ten cases seen in one dermatology office in a period of 6 months	(67)

Table 2. continued

Year	No.	Sex	Age (years)	Positive patch test reactions	Latency time	Comments	Ref.
2005	1	M	35	PPD, unrelated henna powder 10% pet. (from 1982); negative to pure henna	10 days	It was not checked whether the 1982 sample contained PPD	(9)
2003	1	F	9	PPD, commercial henna	10 days	Dermatitis developed 2 days after a second tattoo on day 8	(36)
	1	M	7	Commercial henna prep	?	–	(36)
	1	F	12	PPD	Several days	In Ref. (27), the same case is presented; there, the latency time is 'several hours'	(36)
	1	M	10	PPD	?	Dermatitis after a second tattoo	(36)
2003	1	M	11	No patch tests performed	14 days	–	(68)
2003	3	F	11, 17, 18	PPD	4 days	–	(5)
	1	M	18	PPD	1 week	Lichenoid dermatitis	(5)
	1	F	12	No patch tests performed	3 weeks	–	(5)
2003	1	F	29	PPD, DO3, PAAB, Bismark Brown R	10 days	The patient was sensitized by a henna tattoo, and shortly thereafter had a generalized exacerbation from black clothing	(69)
2002	1	M	9	PPD, benzocaine, thiuram mix, DY3, paraben mix, thiomersal	2 weeks	Erythema multiforme-like eruption	(70)
	1	F	7	Negative to PPD, henna not tested	> 2 weeks	Hypopigmentation persisting for > 6 months	(70)
2002	1	M	26	PPD, black and natural henna (pure, 10% and 20% aqua)	< 2 weeks	Lichenoid dermatitis; the natural henna did not contain PPD	(16)
	2	M	24, 28	No patch tests performed	< 1 week	Lichenoid dermatitis	(16)
	1	M	28	PPD, black henna	<1 week	–	(16)
	1	F	22	No patch tests performed	<1 week	Lichenoid dermatitis	(16)
	1	F	20	PPD	< 1 week	–	(16)
	1	M	22	PPD, cobalt	< 2 weeks	Lichenoid dermatitis	(16)
2002	1	M	8	PPD, PTD, DO3, DY3, PAAB, PAP, IPPD, DDM, TBHQ	1 week	Hypopigmentation after 1 year	(71)
	1	F	18	PPD, PTD, DO3, PAAB	2 weeks	Acute periocular dermatitis after dyeing eyebrows and lashes in black	(71)
2002	1	F	10	PPD and 'a number of substances found in hair products, predominantly dyes'	10 days	–	(72)
2002	1	F	17	PPD, PTD, ONPPD, PAP, MAP, IPPD, benzocaine	4 days	Seven months later, the patient developed allergic contact dermatitis from dyeing her hair	(73)
2001	1	F	9	PPD, nickel, commercial henna, 'natural henna'	9 days	Dermatitis developed 2 days after a seond tattoo on day 8; same patient as in Ref. (74)	(18)
	1	M	11	Commercial henna; PPD negative	?	–	(18)
2001	1	M	26	PPD, henna powder 10% and 20% aqua	14 days	Whether the henna contained PPD was not investigated	(17)
	3	F	24, 28, 28	PPD	10–14 days	–	(17)
2001	1	M	26	PPD	1 week	–	(75)
2001	2	F	32, 33	PPD	9–14 days	One patient had generalized dermatitis; in 2 patients, the eruption started within 2 days after the application of a second tattoo, 7 and 10 days after the first one	(76)
	2	M	31,43	PPD			
2001	3	F	young	PPD, DDM, PAAB, PTD, DY3	?	The label of one of the used dyes warned about allergic reactions	(77)
2001	1	F	27	PPD, used henna powder 10% in water and pet. positive; pure henna negative	14 days	–	(78)

Table 2. continued

Year	No.	Sex	Age (years)	Positive patch test reactions	Latency time	Comments	Ref.
2001	3 2	F M	9, 11, 17 11, 13	All PPD; DO3 (3), PAP (3) PTD (2), IPPD (1), PAAB (1), MAP (1)	7–12 days	One had erythema multiforme-like contact dermatitis; long-lasting depigmentation; 2 were sisters and another 2 were siblings; most reactions started 1–3 days after a second tattoo application on days 6–9	(79)
2001	1	F	11	PPD; negative to henna and lawsone; thiomersal, ethyl mercury	3–4 days	Long-lasting hypopigmentation; she was considered to be presensitized from an unknown source (mother hairdresser); possibly sensitization by the tattoo itself	(80)
2000	1	F	25	PPD, IPPD, five chemical dyes	? (article not accessed)	The henna preparation contained a primary amine but not PPD	(81)
2000	2 1	F M	8, 10 17	PPD –	5–12 days	One patient developed contact dermatitis 8 days after a second tattoo on day 4; 1 patient had a positive prick test to henna 1% aqua (relevance not stated)	(34)
2000	1	F	42	PPD, black rubber mix, 'related hair dyes and textile azo dyes'	12 days	Generalized dermatitis	(82)
	1	M	20	PPD, black rubber mix, 'some azo dyes'	10–12 days	Pustular contact dermatitis; generalized dermatitis; the tattoo dye contained 2.94% PPD according to the label	(83)
2000	1	M	25	PPD	11 days	–	(83)
	1	M	8	No patch tests performed	14 days	–	(83)
2000	1	F	26	PPD, DO3, the product 10% aqua	14 days	The alleged 'henna' turned out to be a powder hair dye with a label warningabout contact allergy	(84)
2000	1	F	30	No patch tests performed	10 days	–	(85)
2000	2	F	30,36	PPD	2 and 4 weeks	PPD was a labelled ingredient in the henna paste used by 1 patient	(86)
1999	3	F	34, 37, 50	PPD	Not mentioned	Uncertain whether the patients were sensitized by the tattoo itself	(8)
1999	1	M	12	PPD, PAAB, DY3, DO3, DO1, PAP, PDTS, black rubber mix	Not mentioned	Uncertain whether the patient was sensitized by the tattoo itself	(87)
1999	1	M	17	No patch tests performed	< 14 days	Few details provided	(88)
	1	F	?	No patch tests performed	Few days	Increased hair growth, presumably at the site of the tattoo reaction; uncertain whether the patient was sensitized by the tattoo itself	(88)
1998	2	F	23, 32	PPD, PTD; NPPPD in 1	7 days, 14 days	Long-lasting (> 1 year) hypopigmentation in 1 patient; 1 patient had actually used black hair dye for the temporary tattoo	(45)
1997	1	F	7	PPD	15 days	First reported case of contact allergy to PPD in black henna tattoo; the reaction started 1 day after a second tattoo on day 14	(89)

DB, Disperse Blue; DDM, 4,4′-diaminodiphenylmethane; DO, Disperse Orange; DR, Disperse Red; DY, Disperse Yellow; F, female; FM, Fragrance Mix; IPPD, *N*-isopropyl-*N*′-phenyl-*p*-phenylenediamine; M, male; MAP, *m*-aminophenol; NPPPD, *N*-phenyl-*p*-phenylenediamine; ONPPD, *o*-nitro-*p*-phenylenediamine; PAAB, *p*-aminoazobenzene; PAP, *p*-aminophenol; PTD, *p*-toluenediamine (toluene-2,5-diamine); PTDS, *p*-toluenediamine sulfate (toluene-2,5-diamine sulfate); TBHQ, *tert*-butylhydroquinone.

Table 3. Cases of black henna tattoo allergic contact dermatitis in patients previously sensitized to *p*-phenylenediamine (PPD) or related chemicals

Year	No.	Sex	Age (years)	Positive patch test reactions	Latency time	Comments	Ref.
2013	1	M	11	PPD	< 24 hr	Sensitized by a previous tattoo	(90)
2012	1	F	20	PPD, DO3, permanent marker	? (< 3 days)	Probably sensitized by previous tattoos; the marker presumably contained an azo dye related to PPD	(91)
2011	1	F	20	No patch tests performed	2 days	Erythema multiforme-like eruption	(92)
2011	1	F	20	PPD	<24 hr	Source of previous sensitization not stated	(93)
2009	1	F	23	PPD	3 days	On day 5, acute eruption of Sweet syndrome; the patient may previously have been sensitized by a henna tattoo	(94)
2009	1	F	30	PPD, ONPPD, benzocaine, procaine	2 days	Swelling of the lips from using a benzocaine gel for aphthous ulcers	(95)
2009	1	M	15	PPD	<48 hr	Source of previous sensitization unknown	(96)
	1	M	14	No patch tests performed	<48 hr	Sensitized by a tattoo 4 years earlier	(96)
2009	1	M	43	No patch tests performed	< 2 days	Some weeks earlier, the patient had had allergic contact dermatitis caused by a hair dye	(97)
2008	1	F	8	PPD, DO1, DY3, Direct Orange 34	2 days	The patient developed acute dermatitis of the feet and legs after wearing dark-coloured cotton tights. She was allegedly sensitized to black henna tattoo, but had developed contact dermatitis 2 days after applying a 'black transferable picture tattoo', which was unlikely to contain PPD	(98)
2007	2	F	13, 15	Both PPD and aniline, 1 IPPD	< 2 days	Sisters; source of sensitization not mentioned	(99)
2006	1	M	11	PPD, thiuram mix	< 1 day	Sensitized by a tattoo 1 year earlier	(100)
2006	1	M	13	PPD	< 2 days	Urticarial rash with conjunctivitis and swelling of the lips; the patient had had a localized reaction to a henna tattoo 8 years earlier	(101)
2006	1	M	6	No patch tests performed	1 day	Probably sensitized by a tattoo applied 1 year earlier	(102)
2006	1	M	40	PPD	Several hours	The patients had been sensitized by a tattoo 4 years earlier, when he had developed dermatitis after 2 weeks; hypopigmentation persisting for > 1 year	(103)
2005	1	F	69	PPD, two hair dyes, three rubber ingredients, four sulfonamide antibiotics, six PABA-derived local anaesthetics, and seven azo dyes (see below under cross-reactions)	Few days	The patient had been sensitized by a previous tattoo 1 year earlier; the reaction was so fierce that she could hardly walk	(104)
2004	1	F	9	PPD, benzocaine, colophonium, dye mix, thiuram mix	< 2 days	The sensitization to colophonium and rubber (thiuram mix) was ascribed to the use of a stick-on rubber stencil that was used to apply designs more easily; source of sensitization not mentioned	(105)
2003	1	F	12	PPD	Several days	In Ref. (27), the same case is presented; there the latency time is 'several hours'	(36)
2003	1	M	11	PPD, benzocaine, FM 1	1 day	Probably presensitized to benzocaine	(5)
2003	1	F	17	PPD	< 3 days	One year earlier, first tattoo without problems	(106)
2003	1	M	9	PPD	?	The patient was probably sensitized by a tattoo applied 1 year earlier	(107)

Table 3. continued

Year	No.	Sex	Age (years)	Positive patch test reactions	Latency time	Comments	Ref.
2003	1	M	67	No patch tests performed	< 24 hr	The patient had known allergies to benzocaine and sulfonamides with probable cross-reactivity to PPD in the tattoo	(108)
2002	1	F	22	PPD, nickel, thiuram mix, black henna	< 2 days	Previously allergic to hair dye	(16)
	1	M	28	No patch tests performed	< 2 days	Source of previous sensitization unknown	(16)
	1	F	18	PPD, cobalt, black henna	< 2 days	Source of previous sensitization unknown	(16)
2002	1	F	30	PPD, IPPD, nickel	3–4 days	Previously sensitized by henna hair dye containing PPD	(109)
	2	M	8, 10	PPD	< 24 h	Brothers who had both been sensitized by a previous tattoo	(109)
2002	1	F	37	PPD; henna mixture; lawsone negative; three commercial henna negative samples	1–2 days	Former hairdresser, who had previously had scalp dermatitis after dyeing her hair; the henna mixture was shown to contain 15.7% PPD by weight	(110)
2001	1	F	12	Commercial henna; PPD negative	Hours	Source of sensitization unknown; same patient as in Ref. (74), contradictory data	(18)
2001	1	F	39	PPD, DY3, DO3, PAAB, pieces of black clothing	< 24 hr	The patient had previously been sensitized to azo dyes in clothes, leading to cross-sensitivity to PPD in the tattoo dye	(111)
2001	1	F	11	PPD; negative to henna and lawsone; thiomersal, ethyl mercury	3–4 days	Long-lasting hypopigmentation; she was considered to be presensitized from an unknown source (mother hairdresser); possibly sensitization by the tattoo itself	(80)
2000	1	F	20	PPD	5 days	The patient had previously suffered from allergic contact dermatitis caused by hair dyes	(83)
	1	M	7	PPD, PTD, PAP, PAAB, DO3, ONPPD, tixocortol pivalate	< 24 hr	Sensitized by a tattoo 5 months earlier	(83)
2000	1	F	48	PPD (previously demonstrated)	Hours	Previous reaction to PPD in hair dye	(86)
1999	1	M	4	No patch tests performed	Several hours	The allergic reaction resulted in 'scarring' (last seen 8 weeks after the reaction); source of previous sensitization not mentioned	(112)
1998	1	F	25	PPD	1 day	Source of previous sensitization unknown	(45)

DO, Disperse Orange; DY, Disperse Yellow; F, female; FM, Fragrance Mix; IPPD, *N*-osopropyl-*N*′-phenyl-*p*-phenylenediamine; M, male; ONPPD, *o*-nitro-*p*-phenylenediamine; PAAB, *p*-aminoazobenzene; PAP, *p*-aminophenol; PPD, *p*-phenylenediamine; PTD, *p*-toluenediamine (toluene-2,5-diamine).

sensitizing properties of PPD, and, indeed, PPD is an extreme sensitizer (141, 142). At a concentration of 10%, it sensitized all 24 subjects tested in a human maximization study (141). Other predictive assays have confirmed its sensitizing potential (142), and there were so many cases of patch test sensitization to PPD 1% in petrolatum that the German Contact Dermatitis Research Group decided to remove it from the baseline series (143). Several studies have investigated the presence and amount of PPD in black henna preparations. In Germany, the henna dyes contained, on average, 6% PPD [(122), cited in (47)]; concentrations of > 10% have been found in Spain (1, 144), the United Arab Emirates (145), and the United States (110, 146). In the largest study thus far, from Turkey, PPD was found in 24 of 25 'commercial henna' samples, at concentrations of up to 7.04% wt/wt, and in six of the 10 'natural henna' samples, at concentrations of up to 6.07% wt/wt (147). In the United States, the Food and Drug Administration found PPD in four of 10 henna samples (hair dye, powders, paste, kit, ink, and tattoo), with concentrations ranging from 4.28% to 27.24% (146). The results of the various studies identifying and quantifying PPD in black henna preparations are summarized in Table 5.

Table 4. Cases of allergic contact dermatitis caused by products containing *p*-phenylenediamine (PPD) or related chemicals after probable previous sensitization to black henna tattoos (see also Refs 14, 55, 71 and 73 in Table 2)

Year	No.	Sex	Age (years)	Positive patch test reactions	Latency time	Comments	Ref.
2012	1	F	17	PPD, PTD, PAP, MAP, IPPD, benzocaine, hydroquinone, pyrogallol, DB124/106, thiuram mix, mercapto mix FM I, propolis	2 days	Allergic contact dermatitis caused by hair dye; the patient had been sensitized by a black henna tattoo 3 months earlier	(47)
2012	7	3 M, 4 F	14–59	PPD (7), MAP (5), PAP (5), PDT (5), DO3 (5), DY3 (5), benzocaine (4), hydroquinone (2); one reaction each to DO1, DY9, DR17, cinchocaine-HCl, thiuram mix, FM I, FM II, turpentine, textile mix, sodium benzoate, sodium thiosulfatoaurate	Hours (2), < 24 hr (1), not mentioned (4)	Five patients had contact allergic reactions to hair dye; one from dyeing eyebrows and lashes; one had localized dermatitis at the site of a nervous block from a local anaesthetic; all patients had been previously sensitized by henna tattoos	(113)
2012	1	F	27	PPD	Not specified	Fierce allergic contact dermatitis from hair dye; suggested but not ascertained that the patient had previously been sensitized by a black henna tattoo	(114)
2008	1	F	8	PPD, DO1, DY3, Direct Orange 34	2 days	The patient developed acute dermatitis of the feet and legs after wearing dark-coloured cotton tights. She was allegedly sensitized to black henna tattoo, but had developed contact dermatitis 2 days after applying a 'black transferable picture tattoo', which was unlikely to contain PPD (but possibly contained textile azo dyes)	(98)
2007	6	F	14–38	PPD, PTD, PAP, ONPPD	1–2 days	All presented with allergic contact dermatitis caused by hair dyes; all had had previous henna tattoos, and 4 of 6 local allergic tattoo reactions	(74)
2006	1	F	16	No patch tests performed	12 hr	Allergic contact dermatitis caused by hair dye; 'possibly' sensitized by previous tattoos	(115)
2006	6	3 F, 3 M	14–15	All PPD, DO3 (4/4), PTD, (5), PAP (6), MAP (5/5), IPPD (5), hydroquinone (4), caine mix or benzocaine (3), PAAB (4), pyrogallol (3), thiuram mix (2), DB124 (1) 4-amino-*m*-cresol (1)	< 24–48 hr	All patients had previously had a black henna tattoo with a subsequent reaction to it, and now presented with allergic contact dermatitis after dyeing their hair; 5 had to be hospitalized, 1 in the intensive care unit	(116)
2005	1	F	14	PPD, thiuram mix, DO3, DY3, DR1, DB106, DB124; positive prick test with natural latex rubber	Hours	Allergic contact dermatitis within hours after dyeing her hair; 3 years earlier, she had used a henna tattoo, with eruption after several days. The allergy to thiuram mix and the type I reaction to latex were ascribed to the tacky material that had been applied to outline the tattoo	(117)
2005	2	1 F, 1 M	14, 15	Both to PPD, hydrogen peroxide, MAP, PAP, and methyl(chloro)isothiazolinone; 1 to ammonium persulfate, cocamidopropyl betaine, caine mix, neomycin, formaldehyde, colophonium, *Myroxylon pereirae* resin, PDTS	Few hours, < 24 hr	The patients developed allergic contact dermatitis from dyeing their hair, life-threatening in 1 of them. Both patients had previously been sensitized by a black henna tattoo	(118)

Table 4. continued

Year	No.	Sex	Age (years)	Positive patch test reactions	Latency time	Comments	Ref.
2004	1	M	28	PPD, PAAB, DY3, DR1, DR17, DO1, Direct Orange 34, nickel, cobalt	Not mentioned	The patient had allergic contact dermatitis caused by wearing dark clothes and socks; he had previously had allergic contact dermatitis caused by hair dye; it was suggested that the patient had been sensitized by a tattoo, but this is unlikely, as dermatitis had already appeared after 2 days, and he had dyed his hair before that	(119)
2003	1	F	18	PPD	Not mentioned	Allergic contact dermatitis after dyeing hair; several tattoos in the previous year, vesicular reaction from the last one	(36)
2003	1	F	38	PPD, IPPD	1 day	Allergic reaction after dyeing eyelashes; 6 weeks later, xanthelasmata appeared	(120)
2003	1	F		PPD, DO3, PAAB, Bismark, Brown R		The patient was sensitized by a henna tattoo, and shortly thereafter had a generalized exacerbation from black clothing	(69)
2002	1	F	18	PPD, PTD, DO3, PAAB	?	Acute periocular dermatitis after dyeing eyebrows and lashes in black; previously sensitized by a black henna tattoo	(71)
1999	1	F	18	PPD	Some days	Allergic contact dermatitis after hair dyeing; probably previously sensitized by black henna tattoo	(121)

DB, Disperse Blue; DO, Disperse Orange; DR, Disperse Red; DY, Disperse Yellow; F, female; FM, Fragrance Mix; IPPD, *N*-isopropyl-*N*′-phenyl-*p*-phenylenediamine; M, male; MAP, *m*-aminophenol; ONPPD, *o*-nitro-*p*-phenylenediamine; PAAB, *p*-aminoazobenzene; PAP, *p*-aminophenol; PPD, *p*-phenylenediamine; PTD, *p*-toluenediamine (toluene-2,5-diamine); PTDS, *p*-toluenediamine sulfate (toluene-2,5-diamine sulfate).

These high concentrations of sensitizing materials, the long duration of skin contact and the lack of a neutralizing (oxidizing) agent will all increase the risk of skin sensitization. Possibly, the presence of oils or solvents and the fact that warm skin (the tattoos are usually applied in countries with a warm climate) may enhance percutaneous penetration may contribute. In addition, some henna artists use a syringe to apply the dye. The needle scratches the stratum corneum, and there is no time lost in passing the upper layer of the skin before the allergen can be presented to the Langerhans cells. Also, occlusive dressings [many sorts of seal (every henna artist has a favourite), several types of wrap, gloves, and first aid non-irritating paper tape bandage] used to keep the henna attached to the skin enhance the penetration and could facilitate sensitization (3). Retouching the tattoo as soon as it starts to fade can also favour the development of an allergic reaction, owing to re-exposure to the allergen. Indeed, many patients developed dermatitis soon after a second tattoo being performed within 7–14 days after the first one (18, 34, 36, 62, 76, 79, 89).

Allergic contact dermatitis caused by henna tattoos may also develop in patients who are already sensitized to PPD or related (cross-reacting) chemicals. In these cases, the tattoo reactions develop within 1–2 days (Table 3). The majority have probably been sensitized by a tattoo previously performed (sometimes up to 8 years previously), which had caused either some itching, swelling, localized mild dermatitis, or no reaction at all (Table 3). Some patients have previously been sensitized to PPD or structurally related compounds from hair dyeing (83, 86, 97, 109), from occupational exposure (110), from azo dyes in clothes (111), from benzocaine (5, 108), or from sulfonamides (108).

It has been suggested that black henna may contain diaminobenzenes other than PPD (83) and diaminotoluenes (83). In one study (147), the contents of aromatic amines in 10 'natural' hennas (black, dark

Table 5. Identification and quantification of *p*-phenylenediamine (PPD) (PPD) in black henna preparations

Year	Country	Analytical method	Source of henna samples and color	No.	No. containing PPD (%)	Concentration of PPD (% wt/wt)	Ref.
2011	United States	GC/MS	Not stated (market survey)	10	4 (40)	4.28–27.24	(146)
2011	Spain	HPCL	From patients, black	3	3 (100)	1.17–64	(1)
			Commercial, black	2	2 (100)	2.09–12.78	(1)
			Commercial, not black	9	0 (0)		(1)
2010	United Arab Emirates	HPLC	Henna salons, black	11	11 (100)	0.38–29.5 (> 6 in 6)	(145)
			Henna salons, red	14	5 (36)	0.005–0.23	(145)
2008	Turkey	IOEGC-MS	Cosmetic shops	35	30 (86)	0.25–7.04	(147)
2006	Korea	HPLC	Tattoo shops, colour?	15	3 (20)	0.25–2.35	(148)
2005	Spain	HPLC	Patient (who was also a tattoo artist), dark brown	1	1 (100)	23.5	(144)
2002	United States	HPLC	From patient, black	1	1 (100)	15.7	(110)
			Commercial samples (colour not mentioned)	3	0 (0)		(110)
2002	Denmark	HPLC	From patient, colour?	1	1 (100)	0.43	(149)
2002	Taiwan	MS	Commercial black henna	1	1 (100)	Not determined	(16)
			Natural henna powder	1	0 (0)		(16)
2001	Germany					On average, 6% PPD in henna preparations (cited in Ref. 47)	(122)

GC/MS, gas chromatography–mass spectrometry; HPLC, high-performance liquid chromatography; IOEGC-MS, ion-pair extraction and gas vhromatography–mass spectrometry; MS, mass spectrometry.

brown, chestnut, and red) and 25 'commercial' hennas (black, dark brown, chestnut, burgundy, red, golden blonde, and yellow) bought in various cosmetic shops in Turkey were investigated. The results are shown in Table 6 (147).

A large number of aromatic compounds were found in many hennas, both 'natural' and 'commercial'.

The highest maximum concentrations were found for PPD (7.04% wt/wt), *m*-phenylenediamine (2.16%), *o*-phenylenediamine (1.13%), *p*-nitroaniline (0.88%), aniline (0.85%), *m*-aminophenol (0.51%), *p*-aminophenol (0.37%), 3,4-toluenediamine (0.12%), *p*-chloroaniline (0.11%), *o*-aminophenol (0.10%), and *o*-toluidine (0.10%) (147). The total amounts of aromatic amines in 10 'natural hennas' varied from 12.73 mg/g (1.27% wt/wt) to 76.53 mg/g (7.65% wt/wt); the mean was 2.74%, and the median was 2.38%. In the 25 'commercial' hennas, the lowest concentration of aromatic amines was 1.85% wt/wt, and the highest was 7.36% wt/wt; the average amounted to 3.9% wt/wt, and the median concentration was 2.62% wt/wt (147).

PPD was present in 24 of 25 of the commercial samples. In the one without PPD, a high concentration of *m*-phenylenediamine was detected (2.0%). In all but one sample, the concentration of PPD was far higher than that of any of the other compounds. In the four 'natural' products that contained no PPD, high concentrations of *m*-phenylenediamine were found in three (0.92%, 2.16%, and 1.74%) and *o*-phenylenediamine in two (0.83% and 1.13%). In a further sample, neither PPD nor *m*-phenylenediamine was present, but *o*-phenylenediamine was identified (1.13%). Assuming that these analytical data (147) are correct, it is tentatively concluded that, in the great majority of black henna products, it is PPD that is added, but sometimes *m*-phenylenediamine or *o*-phenylenediamine are added. Whether *p*-aminophenol and *m*-aminophenol are actually added is unclear. The samples with higher concentrations of these aminophenols always contained high concentrations of PPD and/or *m*-phenylenediamine, so it may be more likely that they are either impurities or chemical reaction products. The same goes for *p*-nitroaniline and aniline, both of which are unlikely to have been actually added (DA Basketter, B Hefford, pers. comm. 2013).

Many patients with black tattoo reactions have positive patch test reactions to both PPD and one or both of the aminophenols (Tables 2–4). This is usually interpreted as cross-reactivity to PPD; however, the data in this analytical study suggest that primary sensitization to the aminophenols may sometimes occur in tattoos. Possibly, the multitude of – potentially allergenic – other aromatic amines present in black henna dyes (at least in the ones investigated in Turkey) in addition to PPD enhances its sensitizing capacity. These data may also explain why, in patients with allergic reactions to black henna tattoos, positive patch test reactions to PPD are not always found.

It has also been suggested that heavy metals (such as cobalt, mercury, nickel, chromium, lead, silver

Table 6. Aromatic amines in 10 'natural' and 25 'commercial' hennas (147)*

	Natural hennas (n = 10)		Commercial hennas (n = 25)	
Aromatic amine	Present in:	Concentrtion, μg/g (range)	Present in:	Concentration, μg/g (range)
p-Phenylenediamine	6 (60%)	8762–60 670	24 (96%)	2501–70 413
m-Phenylenediamine	8 (80%)	146–21 562	23 (92%)	25.63–20 052
o-Phenylenediamine	9 (90%)	98.21–11 300	21 (84%)	6.40–8256
p-Nitroaniline	6 (60%)	0.14–4680	20 (80%)	6.01–8810
Aniline	9 (90%)	1.13–186	21 (84%)	2.48–8470
m-Aminophenol	6 (60%)	1.28–2028	21 (84%)	88.12–5134
p-Aminophenol	9 (90%)	412–3689	23 (92%)	1.26–2754
3,4-Toluenediamine	6 (60%)	0.04–1230	13 (52%)	0.03–982
p-Chloroaniline	8 (80%)	0.23–22.14	18 (72%)	1.62–1114
o-Aminophenol	7 (70%)	42.13–634	22 (88%)	12.28–1034
o-Toluidine	4 (40%)	0.05–1.12	16 (64%)	1.28–1020
Ethylaniline	8 (80%)	8.13–86.14	16 (64%)	0.10–845
2,6-Toluenediamine	4 (40%)	0.33–1.42	18 (72%)	0.04–814
p-Toluidine	8 (80%)	3.42–78.54	18 (72%)	0.12–630
N-Methylaniline	8 (80%)	1.45–72.63	14 (56%)	7.14–214
Toluene-2,5-diamine	0	Not detected	11 (44%)	1.12–123
2-Aminobiphenyl	3 (30%)	4.58–7.43	13 (52%)	2.24–46.73
3-Aminobiphenyl	3 (30%)	2.45–5.14	13 (52%)	0.16–27.35
Toluene-2,4-diamine	4 (40%)	0.05–1.40	12 (48%)	0.06–24.32
2-Nitro-*p*-phenylenediamine	6 (60%)	0.02–2.14	7 (28%)	1.02–24.15
m-Toluidine	7 (70%)	0.76–17.84	16 (64%)	2.13–19.25
1-Naphthylamine	4 (40%)	0.04–12.17	10 (40%)	0.12–17.64
4-Chloro-*o*-phenylenediamine	3 (30%)	0.03–1.63	14 (56%)	0.02–13.46

*Aromatic amines with maximum concentrations of < 10 μg/g are not shown.

nitrate, iron oxide, and titanium dioxide), pyrogallol and substances such as ethyl cellulose and tartaric acid may be added to black henna (4). In 12 commercial and traditional henna samples, lead was found at concentrations ranging from 2.29 to 65.98 ppm, black henna paste containing the highest levels (150). Nickel and cobalt were identified in some henna samples available in Taiwan, but at very low concentrations (nickel, 2.94–3.95 ppm; cobalt, 2.96–3.54 ppm) (148).

Clinical picture

The first signs of allergic contact dermatitis caused by black henna tattoos develop within 1–3 days in those already sensitized, and within 4–14 days in patients who become sensitized by the tattoo. Most patients (about 80%) have the typical clinical picture of acute allergic contact dermatitis with erythema, oedema, papules, and vesicles; bullae are often observed (103). Although fierce, in most cases the dermatitis is limited to the site of the tattoo, and usually has a geometric pattern strictly mirroring the tattoo. Lichenoid contact dermatitis [which is well known to occur in PPD contact allergy (151)] is fairly frequent (3, 5, 16, 20, 71, 80); in one large case series, it was seen in 6 of 31 patients (3), and in another in 5 of 10 (16). Generalization of dermatitis may occur (12, 47, 57, 66, 68, 76, 82), and acute allergic contact dermatitis may, in some cases, be accompanied by systemic reactions, for example lymphadenopathy and fever (152); some patients had to be admitted to hospital (47). There are several case reports of (sometimes generalized) erythema multiforme-like contact dermatitis (47, 52, 54, 70, 79, 138), and there are single instances of urticaria and angioedema complicating contact allergy (101) and pustular allergic contact dermatitis (82). Secondary bacterial infections may be seen (153). It not infrequently takes several weeks before the eruption subsides, even with topical (and sometimes also oral) corticosteroid therapy (154). Post-inflammatory hypopigmentation is very frequent, especially in children (3, 45, 65, 71, 80, 103), often lasts for more than 6 months, and may be permanent; even depigmentation has been observed (59, 79). Hyperpigmentation, which occurs mostly in adolescents and adults, notably those with skin type III or IV, is also very frequent, and may last for more than 6 months in many of the patients (3, 66). Scarring

(hypertrophic or keloidal, usually not very convincing) has been observed in some cases (46, 50, 112, 134).

Localized hypertrichosis has been reported (49, 88, 155, 156), both in patients with (49) and in those without (155, 156) an allergic tattoo reaction. One patient had rapidly progressive dyspnoea a few minutes after skin application of black henna dye, requiring prompt admission to a hospital emergency department (35). In another patient, contact allergy to PPD in a henna tattoo may have provoked Sweet syndrome (94).

Hand dermatitis from occupational exposure to black henna tattoo in tattoo artists appears to be rare, possibly because of the wearing of gloves. A 24-year-old female tattoo artist developed hand dermatitis from a tattoo paint containing 23.5% PPD (in the final mixture with water 12%) (144). A 24-year-old man, who had previously become sensitized by a henna tattoo and later experienced dermatitis from a hair dye, developed a painful bullous fingertip dermatitis after painting a friend with a temporary tattoo paint, which proved to contain 0.43% wt/wt PPD (149).

Consequences of sensitization to PPD in henna tattoos, cross-sensitization, and concomitant sensitization

Sensitization to PPD. Patients sensitized by PPD in henna tattoos may have serious allergic reactions when later dyeing their hair or eyebrows/lashes (71, 113, 120) with a permanent or semi-permanent dye (14, 36, 47, 55, 73, 113, 114, 74, 115–118, 121, 139, 157; Table 4). Dermatitis may affect the scalp, the face, the eyelids, the ears, the neck, and the trunk. The allergic reaction may be manifested by oozing vesicular dermatitis and massive oedema of the face. Sometimes, the eyes are completely shut. In rare cases, the reaction may be life-threatening, because of respiratory distress resulting from oedematous swelling (118). Children often have very serious reactions to hair dyes after being sensitized by black henna tattoo, and frequently need to be admitted to hospital (116).

Temporary tattoos may be a triggering factor for the development of contact allergy to hair dyes in individual patients (Table 4), but in the total group of patients with hair dye reactions, they appear not to be a significant risk factor (158). However, having had a henna tattoo is a main risk factor for severe allergic reactions to a hair dye (159).

Other sources of PPD (derivatives), which may need to be avoided, include leather, fur, textiles, nylon stockings, rubber, paints, photographic developers, and various industrial printing inks. The sensitization of children to PPD has important consequences for health and later career prospects. PPD-sensitized persons may experience problems working as printers, hairdressers, furriers, shoe shop assistants, chemistry workers, and in occupations in the leather, rubber and textile manufacturing industries. Moreover, jobs such as laboratory assistant, masseur, petrol pump attendant, and leather shop assistant, and working in the cellulose, plastic and paper manufacturing industries and agriculture, carry the risk of more or less intensive contact with PPD (152).

Cross-sensitization. Primary sensitization to PPD from black henna tattoos frequently leads to cross-reactions with a number of structurally related compounds, notably other hair dyes, azo dyes used in textiles, rubber chemicals (*N*-isopropyl-*N*′-phenyl-*p*-phenylenediamine, and black rubber mix), and benzocaine (Table 7).

Patients sensitized to PPD (from any source) may, according to other literature data, also cross-react (or possibly co-react) with a number of other substances; contact with these may, in some cases, cause later episodes of systemic contact dermatitis. These chemicals include the following (160, see also Table 7):

1 Hair dyes such as toluene-2,5-diamine sulfate, 2-nitro-*p*-phenylenediamine, *p*-aminophenol, *m*-aminophenol, and 4-amino-*m*-cresol.
2 Other dyes, including textile (azo and non-azo) dyes: Acid Yellow 36, *p*-aminoazobenzene (161), aniline, Bismark Brown R, 2,4-diaminoazobenzene, *p*-dimethylaminoazobenzene (161), Direct Orange 34, Disperse Black 1 (162), Disperse Black 2 (162), Disperse Blue 1 (162), Disperse Blue 3 (162), Disperse Blue 7 (162), Disperse Blue 35 (162), Disperse Blue 106, Disperse Blue 124, Disperse Blue 135, Disperse Orange 1, Disperse Orange 3, Disperse Orange 76 (= Disperse Orange 37, Serilene Yellow Brown) (162), Disperse Red 1 (162), Disperse Red 17 (162), Disperse Yellow 3, Disperse Yellow 4 (162), Disperse Yellow 9 (162), Disperse Yellow 39 (162), Naphthol AS (162), *o*-nitro-*p*-phenylenediamine, pyrogallol, and Serisol Blue 3 (unidentified chemical, 162). Patients sensitized to PPD may experience allergic contact dermatitis from wearing dark-coloured clothing (69, 98); simultaneous patch test reactions to PPD and textile dyes may be attributable either to cross-sensitivity proper (162), or to metabolic conversion of textile dyes in the skin to PPD or its metabolites. In addition to colouring synthetic fibres, azo compounds have been used in hair dyes, fur dyes, leather processing, printer's ink, and photographic products (162).

Table 7. Cross-reactions in patients sensitized to *p*-phenylenediamine (PPD) by black henna tattoos[a]

Cross-reacting compound	Synonyms	CAS	Refs
Acid Yellow 36	Metanil Yellow; CI 13065	587-98-4	(47)
p-Aminoazobenzene	Aniline Yellow; CI 11000	60-09-3	(69, 71, 77, 79, 83, 87, 116, 119)
4-Amino-*m*-cresol	4-Hydroxy-*o*-toluidine	2835-99-6	(116)
m-Aminophenol	1-Amino-3-hydroxybenzene; 3-aminophenol; CI 76545	591-27-5	(47, 73, 79, 113, 116, 118)
p-Aminophenol	1-Amino-4-hydroxybenzene; 4-aminophenol; CI 76550	123-30-8	(47, 71, 73, 79, 83, 87, 104, 113, 74, 118)
Aniline	Aminobenzene; CI 76000	62-53-3	(9)
Benzocaine	Ethyl *p*-aminobenzoate	94-09-7	(14, 47, 70, 73, 95, 105, 113, 116)
Bismark Brown R	Basic Brown 4; CI 21010	8005-78-5	(47, 69)
Black rubber mix	–	–	(55, 82, 87, 104)
Butacaine	3-Dibutylaminopropyl PABA	149-16-6	(104)
Butanilicaine	2-Butylamino-6′-chloro-*o*-acetotoluidide	3785-21-5	(104)
Butyl PABA	Butamben, butoform	94-25-7	(104)
2,4-Diaminoazobenzene	Solvent Orange 3; CI 11270:1	495-54-5	(55)
4,4′-Diaminodiphenylmethane	4,4′-Methylenedianiline	101-77-9	(59, 71, 77, 104)
Direct Orange 34	CI 40215	1325-54-8	(66, 98, 119)
Disperse Blue 106	CI 111935	68516-81-4	(104, 117)
Disperse Blue 124	–	15141-18-1	(35, 63, 104, 117)
Disperse Blue 106/124 mix	–	–	(47, 66)
Disperse Blue 135	Unknown chemical	–	(104)
Disperse Orange 1	CI 11080	2581-69-3	(55, 66, 87, 98, 104, 113, 119)
Disperse Orange 3	CI 11005	730-40-5	(47, 55, 59, 69, 71, 79, 83, 84, 87, 91, 104, 113, 116, 117)
Disperse Red 1	CI 11110; CI solvent red 14	2872-52-8	(55, 62, 66, 104, 117, 119)
Disperse Red 17	CI 11210	3179-89-3	(55, 113, 119)
Disperse Yellow 3	CI 11855	2832-40-8	(35, 47, 55, 57, 62, 63, 66, 70, 71, 77, 87, 104, 113, 117, 119)
Disperse Yellow 9	CI 10375	6373-73-5	(113)
Hydroquinone	1,4-Dihydroxybenzene	123-31-9	(47, 57, 113, 116)
N-Isopropyl-*N*′-phenyl-*p*-phenylenediamine	4-(Isopropylamino)diphenylamine	101-72-4	(14, 47, 66, 71, 73, 79, 81, 99, 104, 116, 120)
o-Nitro-*p*-phenylenediamine	4-Amino-2-nitroaniline; CI 76070	5307-14-2	(73, 83, 95, 74)
N-Phenyl-*p*-phenylenediamine	*p*-Aminodiphenylamine	101-54-2	(45)
Procainamide	*p*-Aminobenzoic diethylaminoethylamide	51-06-09	(104)
Procaine	2-Diethylaminoethyl-*p*-aminobenzoate	59-46-1	(95, 104)
Pyrogallol	1,2,3-Benzenetriol; CI 76515	87-66-1	(47, 116)
Sodium sulfadimidine	Sodium sulfamethazine	1981-58-4	(104)
Sodium sulfamerazine	–	127-58-2	(104)
Sulfaguanidine	–	57-67-0	(104)
Sulfanilamide	*p*-Aminobenzenesulfonamide	63-74-1	(104)
Toluene-2,5-diamine	*p*-Toluenediamine; CI 76042	95-70-5	(45, 47, 59, 71, 73, 77, 79, 83, 104, 113, 74, 116)
Toluene-2,5-diamine sulfate	*p*-Toluenediamine sulfate; CI 76043	615-50-9	(66, 87)

[a]Some reactions may have been co-reactions instead of cross-reactions proper; sensitization to PPD was not proved to be the result of exposition to black henna tattoos in all cases.

3 Oral drugs: sulfonamide antibiotics [including sodium sulfadimidine (veterinary drug), sodium sulfamerazine (veterinary drug), and sulfaguanidine (not used in humans)], glucose-lowering agents (sulfonyl urea derivatives), drugs to treat inflammatory bowel disease [mesalazine = 5-aminosalicylic acid (163)], hydrochlorothiazides [(164); ? not structurally related], dapsone, *p*-aminosalicylic acid, and celecoxib [(160); ? not structurally related].
4 Topical drugs such as PABA (sunscreen), PABA-derived anaesthetics such as benzocaine [localized dermatitis resulting from a nerve block (113)], procaine, butylPABA, butacaine, butanilicaine, and procainamide; parabens [preservatives (70, 165)], hydroquinone (skin-lightening agent, stabilizer in cosmetics), and sulfanilamide.
5 PPD derivatives used in rubber such as *N*-isopropyl-*N*′-phenyl-*p*-phenylenediamine, 4,4′-diaminodiphenylmethane, *N*-phenyl-*p*-phenylenediamine, and chemicals present in black rubber mix.

Concomitant sensitization. In many studies, patients have shown positive patch test reactions to other, not PPD-related, allergens. Mostly, these may be purely coincidental and be unrelated to the tattoo. Examples include reactions to nickel (16, 18, 57, 119), cobalt, neomycin, formaldehyde, methylisothiazolinone + methylchloroisothiazolinone, thiomersal, ethyl mercury, ammonium persulfate, cocamidopropyl betaine, hydrogen peroxide, sodium benzoate, sodium thiosulfatoaurate, turpentine, and tixocortol pivalate (Tables 2–4). In one investigation, nickel was found in 11 and cobalt in five of 15 henna samples analysed for the presence of heavy metals (148). However, the amounts were very low (nickel, 2.94–3.95 ppm; cobalt, 2.96–3.54 ppm), and it can be doubted whether these are immunologically relevant, although the authors stipulated that it is hard to completely rule out the possibility of heavy metals playing a role in inducing tattoo contact dermatitis (148).

However, the strong immunological response to high concentrations of PPD might also result in concomitant sensitization to other chemicals that come into contact with the skin during the tattooing process, such as lawsone in henna (14), natural henna powder (16–18), colophonium [an adhesive in a stick-on rubber stencil attached to the skin to apply designs more easily (105, 118)], thiuram mix [rubber gloves, stick-on rubber stencil for outlining the tattoo (16, 35, 47, 57, 70, 100, 113, 116, 117)], and hidden ingredients of the tattoo materials, such as fragrances in essential oils [positive patch test reactions to fragrance mixes or *Myroxylon pereirae* (5, 47, 113, 118)].

In two studies, type I natural latex rubber allergy has been shown (35, 117). This may be merely a coincidence, or be related to gloves worn by the tattoo artist or the tacky material used for outlining the tattoo (117).

Diagnosis

The diagnosis is easy to suspect on the basis of the clinical picture, and can be confirmed by a positive patch test reaction to PPD. Usually, these patients have strong contact allergies to PPD, with strong to extreme bullous patch test reactions to the usual test concentration of 1% pet. (166).

Therefore, it has been recommended to start patch testing with a concentration of 0.01%, which can elicit a sufficiently positive reaction in a highly sensitized individual. If the result is negative at the first reading, the concentration of PPD can then be stepped up to 0.1%, or even 1%, to ensure that an allergic contact dermatitis caused by PPD is not missed (154, 167). German investigators suggest, for patch testing with PPD in children and adolescents with a history of allergic reactions to henna tattoos or hair dyes, that testing begin with $\leq 0.05\%$, with 10-fold increases to a maximum of 1% or 0.5% in children aged < 12 years (47). According to some authors, however, such patients need not be patch tested at all, and PPD allergy can be assumed to be present (168). Be that as it may, when patch testing is not performed, the frequently occurring cross-reactions go unnoticed, which may have future consequences for avoidance of substances or choice of profession.

In most cases, it is not necessary to test the henna preparation itself (which is usually not available), and this should actually be discouraged, because of the risk of very strong reactions and possibly active sensitization, owing to the high PPD content. When available, pure, unadulterated henna (10 mg of powder in 100 ml of water or ethanol) and lawsone (1% water, 1%, 5% or 10% pet.) should be tested. They are usually negative, and henna can then be used as an alternative, especially for hair dyeing (154).

In nearly all cases, the allergen in black henna tattoos was PPD (or similar dyes that cross-react with PPD and are identified by a positive patch test reaction to PPD); in one report, the incriminated chemicals were essential oils ['pink oil' and cedarwood oil; presence in the tattoo not verified (169)]. In some cases, the patch test reaction to PPD was negative (or PPD was not tested), and the actual allergen remained unknown.

Other henna products containing PPD

The application of black henna as a dye for eyebrows and eyelashes led to periocular dermatitis and blepharoconjunctivitis in a PPD-allergic woman (170). Dyeing hair with black henna resulted in allergic contact dermatitis of the scalp and face, with upper airway obstruction, in a 15-year-old girl; patch tests were not performed (171). A 38-year-old woman developed a severe angioedema of her eyelids, face, scalp and tongue within hours of using a commercial product of henna, which she applied on her hair; she proved to be allergic to PPD and both natural and commercial henna (19, 36). A 44-year-old woman was aware of her allergy to permanent hair dyes, but her dermatologist approved of her use of natural dyes, such as henna. A commercial henna dye caused allergic contact dermatitis within 24 hr (172). A 57-year-old man developed a painful, blistering skin reaction on his forearm within hours of application of a henna dye that he was planning to use to dye his hair as a sort of patch test (173).

The size of the problem

Reports of sensitization to tattoos. In the English-language literature, over 140 patients sensitized by tattoos have been reported (Table 2). Although most were single case reports or presented 2 or 3 patients, there were also case series of 5 patients (5, 60, 79), 7 patients (16), 10 patients (67), and even 31 tattoo-sensitized patients (3, albeit with few clinical data). Ten Taiwanese patients with tattoo reactions (of whom 7 were sensitized by the tattoo itself) were seen in a 7-month-period in 2000 in a single dermatology clinic (16). Ten tattoo-sensitized patients were seen in one hospital during 6 months in Bangalore, India (67). Not infrequently, siblings were reported to have developed allergic reactions from a tattoo that had been applied at the same time (47, 66, 79, 99, 109).

Forty published cases had allergic contact dermatitis caused by tattoos resulting from previous sensitization, mostly from previous tattoo applications (Table 3), and reports of > 30 people with (often fierce) reactions to other PPD-containing products, notably hair dyes, were found in the English-language literature (Table 4). Six children with severe allergic reactions to hair dyes after sensitization to black henna tattoos were diagnosed within 2 years (2003 and 2004) in two hospital clinics that, on a yearly basis, see $\sim 5\%$ of the suspected contact dermatitis patients in Denmark (116). Another 6 patients with hair dye allergy after sensitization by black henna tattoos were seen over a 2-year-period in one hospital in Toronto, Canada (74).

Routine testing with PPD and the proportion caused by tattoos. In a multicentre European study, the weighted average prevalence of positive patch test reactions to PPD was 4.6% in 21 515 routinely tested contact dermatitis patients (174). Of these, 4.8% (weighted average) were caused by previous black henna tattoos (range 0–15.2%, median prevalence 3.9%); in most centres, the proportion caused by tattoos was low, except in the Scandinavian countries (174). In a group of 39 patients reacting to PPD seen in Gran Canaria between 2005 and 2009, in 8 (21%) the source of sensitization was identified as black henna tattoos. In the age group of 10–20 years, almost all were sensitized from the tattoos (175). In 2004, at the St John's Institute of Dermatology, London, UK, 66 of 634 routinely tested patients had positive patch test reactions to PPD 1% pet. (176). Of these 66, 6 (9.1%) had been sensitized to PPD from a black henna tattoo (women, 11.1%; men, 4.8%). Prior to 2004, henna tattoos as a cause of PPD sensitization were exceptional (167, 176). In Ottawa, Canada, 2.2% of 134 reactions to PPD were attributed to previous tattoos in 1997–2009 (177).

How many people have had black henna tattoos?. The numbers of people who have ever had a black henna tattoo may be considerable. In a questionnaire study performed in 2008–2009 in Copenhagen, Denmark, 48.1% of 473 hairdressing apprentices (mean age 17.5 years; median 17.0 years; nearly 97% female) had previously had black henna tattoos. In a control group from the general population ($n = 1277$), the proportion was 31% (396/1277) (178). In a previous 2007 study by the same group among hairdressers and the general population in Copenhagen, Denmark, 39.4% of trained hairdressers aged 18–24 years and 33.3% of Danish adult women in the general population aged 18–24 years had had a temporary tattoo (179). Among men and women of all ages (56% women, 44% men, age 18–70 years), 6.3% had had a temporary black tattoo, with decreasing percentages in older age groups (179).

In a UK questionnaire study of 4000 randomly selected individuals (45% response rate) from 2008, it was shown that 7% of adult respondents and 14% of their children (age not defined) had had a temporary tattoo (180). In a 2010 Danish study on 889 men and women in the Odense Adolescence Cohort Study aged 28–30 years (501 women and 388 men), 161 (18.1%) had had a temporary tattoo (21.2% women, 14.2% men) (181). It was found that the exposure to black henna tattoos in the general Danish population is increasing, especially in the younger age groups and in women, in spite of messages from both dermatologists, the media and

regulatory organs concerning the risk of allergic reactions to these (179, 182).

How many people with a black henna tattoo become sensitized?

Of 180 hairdresser apprentices (mean age 17.5 years, median 17.0 years, nearly 97% female) who had previously had black henna tattoos, not one (0%) reported a reaction to them; in the control group, however, 10 of 396 (2.5%) of those having had a tattoo stated that they had suffered from a reaction at the tattoo site (178). In an earlier study of the same group of investigators, of 171 hairdressers having had a tattoo, 6 (3.5%) reported an allergic reaction; in the general population, 5 of 215 people (2.3%) had had a tattoo reaction (179).

The published information on allergic reactions to tattoos and their sequelae is, without any doubt, only the tip of the iceberg. Many cases of *de novo* tattoo sensitization may go unnoticed, when, later, no re-exposure to tattoos, hair dyes or other products containing PPD or cross-reacting substances sufficient to cause allergic contact dermatitis takes place. The relationship between a localized allergic reaction and the tattoo is quite obvious to its owner; probably, only those with acute and severe reactions will visit a doctor, and most will be unlikely to be referred to a dermatologist. Only a fraction of those seen by dermatologists will be reported in the literature, and the published numbers will decrease as such reactions become common knowledge. Even among patients who experience severe allergic reactions to hair dye, only 10–30% will be seen by a doctor, and even fewer by a dermatologist (158, 183).

Thus, taking all of the data together, it seems safe to assume that allergic reactions to black henna tattoos are frequent.

Non-allergic side-effects of black henna tattoos

Local cutaneous reactions. There have been some reports of the appearance of localized hypertrichosis after black henna tattoos without allergic reactions to the tattoo (155, 156). In all of these cases, the hypertrichosis occurred rapidly, between 5[b] and 20 days, when the tattoo was fading away, was asymptomatic, and resolved spontaneously within 3–4 months. It has been speculated that one – or the combination of several – of the additive substances contained in the commercial henna paste may play a role in inducing transient hair growth (49). One case of cutaneous mercury deposition after the application of henna dye containing red pigment with a painful cutaneous granuloma and abscess in a 13-year-old has been presented; the subcutaneous tissue with the mercury materials had to be removed surgically (184). In an 8-year-old girl from India, depigmented spots at the tattoo site were seen 3 days after its application. Prior to this, the tattoo had been partially removed because of extreme itching, but no dermatitis developed. The depigmentation was ascribed to PPD; patch tests were not performed (185). A 'second-degree chemical burn' developed in a black henna tattoo, where the skin had started blistering a few hours after application; patch tests were not performed (186).

Systemic side-effects. The mixing of henna with PPD has been practised for several decades in certain African countries, notably the Sudan (187). Many cases of toxicity from the black powder used for body painting, some fatal, were noted in Sudan in the early 1980s (188). The initial symptoms are massive oedema of the face, lips, glottis, pharynx, neck, and bronchi, occurring within hours of application of the dye mix to the skin, and sometimes requiring emergency tracheostomy for respiratory obstruction. The symptoms may then progress on the second day to anuria and acute renal failure. Dialysis has helped some patients, but others have died from renal tubular necrosis (188). Ingestion of the mix or PPD alone, either accidentally (in children), deliberate (suicidal), or homicidal, leads to similar clinical presentations with, additionally, rhabdomyolysis. Many patients die within 24 hr (189, 190). Pulmonary oedema was thought to have been caused by painting the feet with a henna mixture probably containing PPD in 1 patient (191). Cutaneous vasculitis and crescentic, rapidly progressive glomerulonephritis has been ascribed to the chronic use of henna mixed with PPD for dyeing of the hair (192). Lead has been found in commercial and traditional henna samples in concentrations ranging from 2.29 to 65.98 ppm; the highest levels were found in black henna paste (150). According to the authors, the cumulative effects of prolonged lead exposure may be of concern, especially in children (150).

Legislation

In the United States, henna is allowed as a colour additive for hair dyes, but not for direct application to the skin, such as in mehndi body decoration (4). In the EU, lawsone is considered to be not suitable for use as a non-oxidizing colouring agent for hair dyeing and, by extension, is not suitable for any other cosmetic use. PPD in cosmetics is permitted both in the EU and the

[b] Five days appears to be a very short time for new and more hairs to appear; one may speculate that previously inconspicuous hairs have attained some colour from PPD in the tattoo.

United States in hair colours only (maximum 2% in the EU, no limits in the United States), and is not allowed for dyeing eyelashes or eyebrows, or direct application to the skin. US legislation does not allow the importation of temporary tattoos that contain PPD or are not properly labelled. Thus, the use of black henna is illegal. Similar directives exist in, for example, Canada, New Zealand, and Australia (193).

At present, in most countries, there is no regulatory statute on the practice of application of henna tattoos by tattoo artists. Surveillance of the distribution of henna products and the sites where tattoos are applied (beaches, markets, fairs, and amusement parks) is difficult, especially in countries where no pertinent legislation exists.

Conclusion

Red henna is the dried and powdered leaf of *L. inermis*. Henna has been used as a dye for the skin, hair and nails for over 4000 years, and as an expression of body art, especially in Islamic and Hindu cultures in the Arab, African and Indian world. Body painting with red henna is generally safe, with few reports of allergic contact dermatitis caused by it and/or its active ingredient lawsone (2-hydroxy-1,4-naphthoquinone, CI 75480, Natural Orange 6). Type I allergy is equally rare, and is mainly an occupational hazard in hairdressers, in whom it may cause symptoms such as sneezing, conjunctivitis, running nose, dry cough, dyspnoea, swelling of the face, or generalized urticaria. Lawsone is a potent oxidant of G6PD-deficient cells; topical application of henna may therefore cause life-threatening haemolysis in children with G6PD deficiency, signs and symptoms of which may include pallor, lethargy, vomiting, jaundice, anaemia, tachycardia, poor peripheral perfusion, shock, and even death.

Black henna is the combination of red henna and the dye PPD. Temporary black henna tattoos have become very popular among children, adolescents and young adults in western countries in the last 15 years. They are usually applied in holiday resort areas, in attraction parks, at festivals and at fairs by street artisan tattoo artists, but black henna preparations for tattooing are also available as do-it-yourself kits and ready-to-use henna paste, or are made by patients themselves. Among the general Danish and UK populations, 6–7% have ever had a black henna tattoo, with far higher percentages (up to 33%) in women aged 18–24 years. An estimated minimum of 2.5% will become sensitized to PPD in the tattoo; PPD is an extreme sensitizer, and is often present in the tattoo at high concentrations. Over 140 cases of allergic contact dermatitis caused by black henna tattoos have been reported in the English-language literature since 1997, which is without any doubt only the tip of the iceberg. Allergic reactions are usually limited to the tattoo site, but generalization may occur. It often takes several weeks for the dermatitis to subside, despite topical and sometimes oral corticosteroid therapy. Long-lasting pigment alterations are observed frequently.

Once sensitized, the patients may experience allergic contact dermatitis from the use of hair dyes containing PPD or related chemicals. Such reactions are often fierce, especially in children, and many of them need to be hospitalized. In addition, many of those sensitized to PPD have cross-reactions to other hair dyes, dyes used in textiles, local anaesthetics, and rubber chemicals, contact with which needs to be avoided. The sensitization of children to PPD may have important consequences for health and later career prospects.

With the increasing use of black henna tattoos and the absence of legal control of henna tattooing practices, future cases of sensitization to PPD are inevitable. Temporary black henna tattooing should be controlled by health authority legislation to minimize the extent of the problem. Prevention requires the regular provision of information to Western consumers, especially young people and their parents, by health authorities and scientific associations, and by individual specialists in dermatology, allergology, and paediatrics. Black henna tattoos are hazardous for one's health and constitute an important public health problem, and their use should be strongly discouraged.

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