



June 6-7, 2013

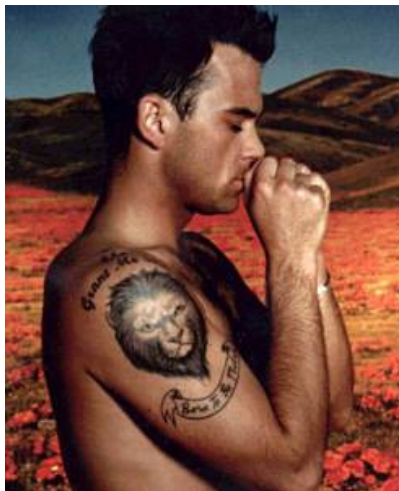
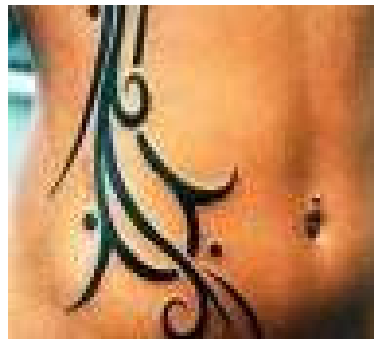
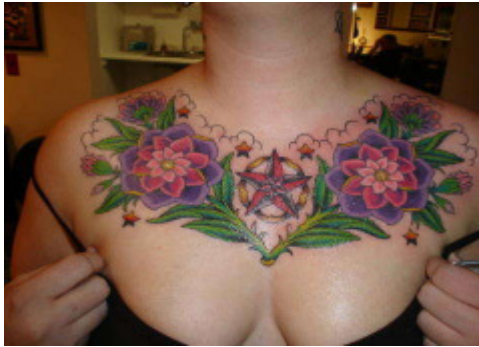


The Fate of Tattoo Pigments in the Skin

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University of Regensburg
Germany



Art...



... or medical problem ?

allergic, toxic, infections, ...

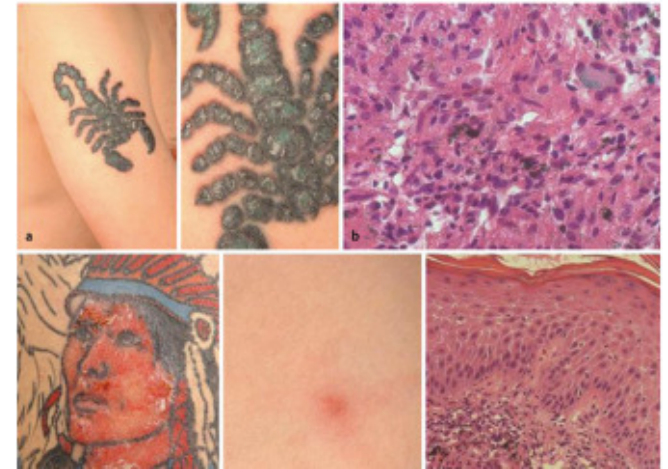


FIG.1 Acute allergic contact dermatitis on the tattoo site.

FIG.2 Erythema, edema and vesiculation on the tattoo site.

Images taken from different sources (Pubmed)

How many tattoos ?

(% of population)

USA	24 %	(80 Mio.)
Sweden	7 %	(0,6 Mio.)
United Kingdom	12 %	(7 Mio.)
Germany	9 %	(8 Mio.)
Germany	23 %	(Age: 15-29)

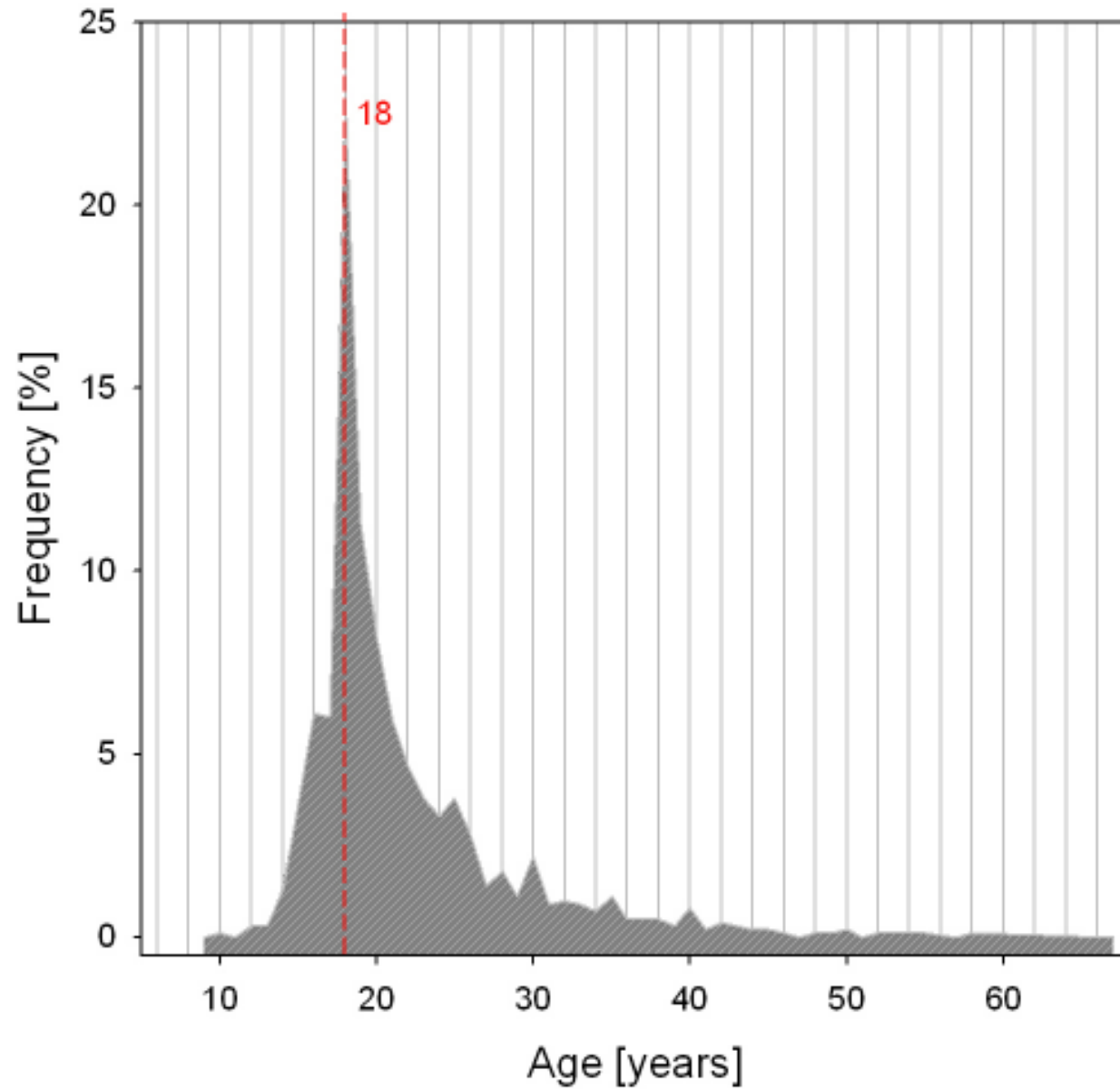
Tattoo Survey

40 questions, 3411 participants, Germany, Austria, Switzerland

	Study Population
Age (years), mean (SD)	29.3 (8.6)
Sex	
Male, n (%)	1402 (41.1%)
Female, n (%)	2009 (58.9%)
Type of tattoo color (n/a: n=6)	
black	1995 (58.7%)
mixed-colored	1410 (40.1 %)
Size of tattoo (n/a: n=2)	
small (< 300 cm ²)	1320 (38.8 %)
large (≥ 300 cm ²)	2089 (61.1 %)
Number of tattoos (n/a: n=6)	
single	1187 (34.9 %)
multiple	2224 (64.9 %)

Tattoo Survey

Age at first tattoo



Tattoo Survey

Problems

direct after tattooing

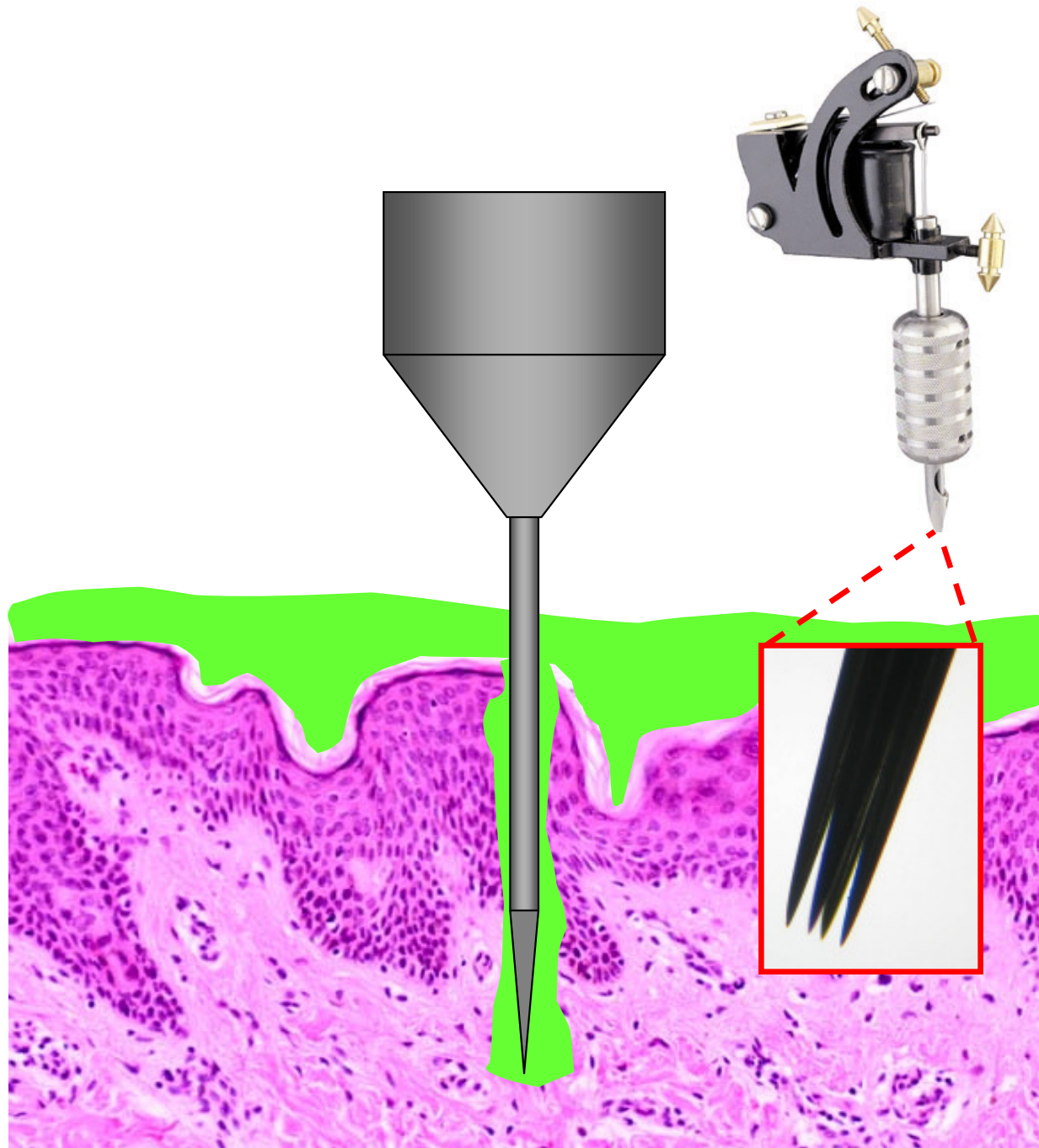
skin (68 %): crusts, itching, edema, bleeding, blisters, pus, ...

systemic (7 %): dizziness, headache, nausea, fever, fatigue, ague, ...

persistent (9 %)

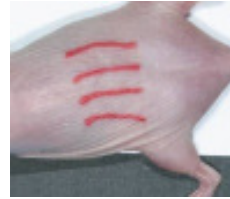
Scars, intermittent edema, light sensitive, itching, elevated skin, acne,
skin papules, numbness, psychic problems, ...

Making a tattoo

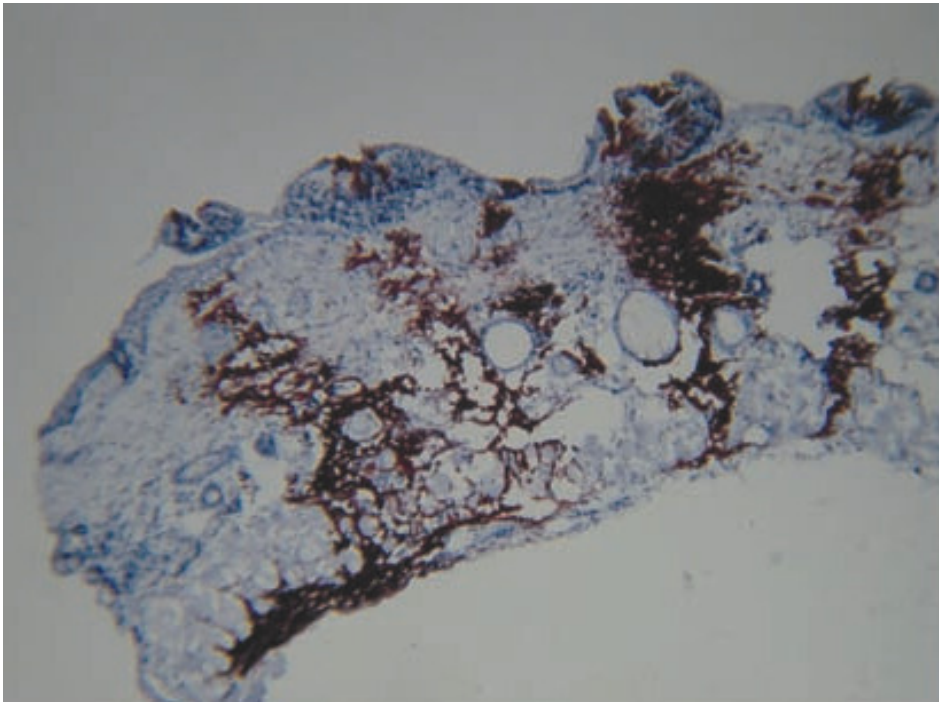


Making a tattoo

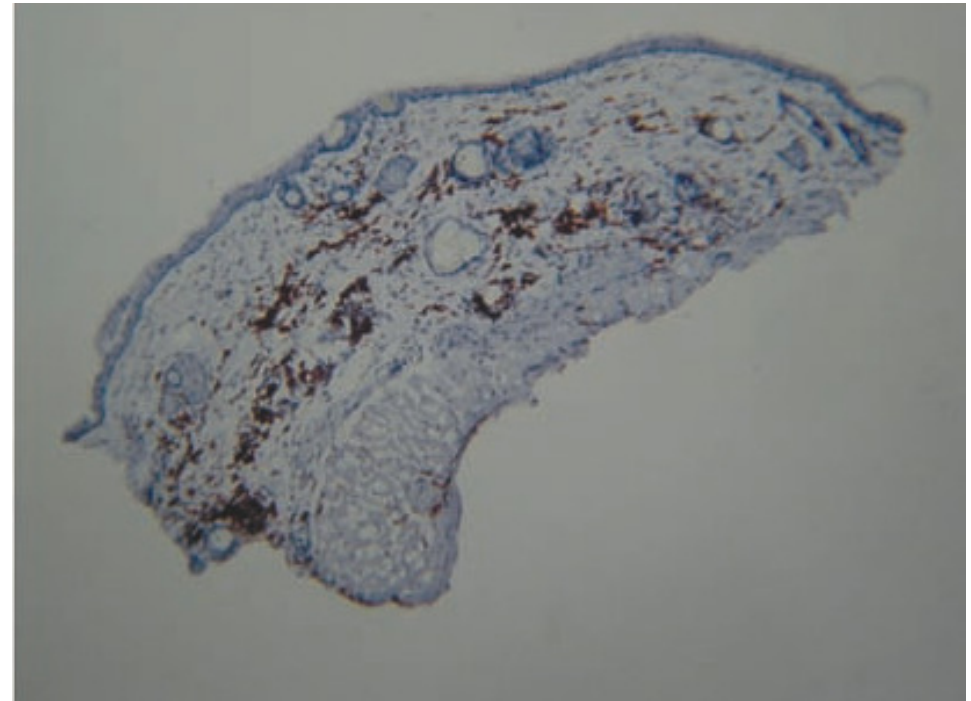
Mouse skin



1 day after tattooing



42 days after tattooing

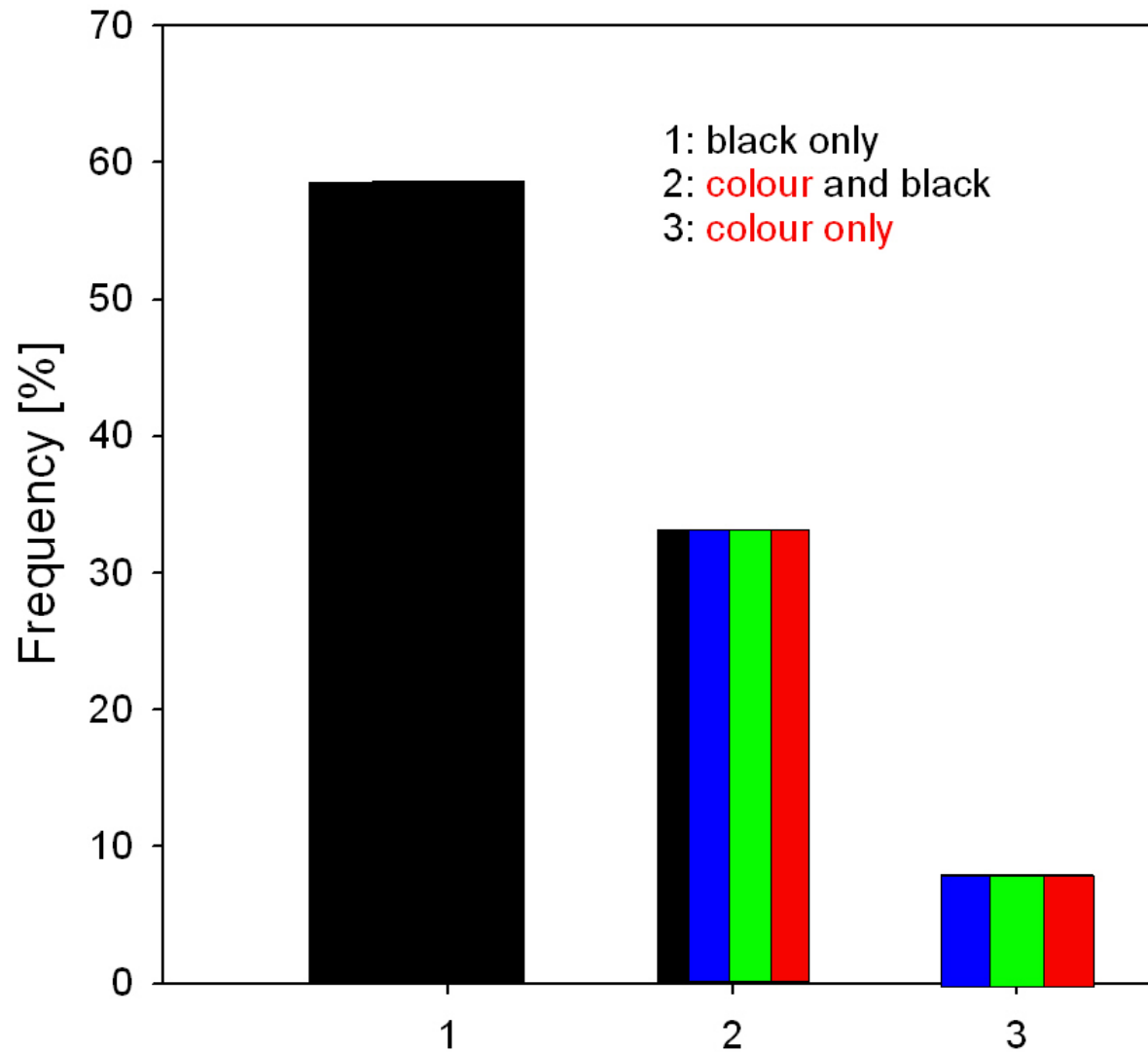


Tattooing of skin results in transportation and light-induced decomposition of tattoo pigments – a first quantification *in vivo* using a mouse model

Eva Engel¹, Rudolf Vasold², Francesco Santarelli¹, Tim Maisch¹, Neera V. Gopee³, Paul C. Howard³, Michael Landthaler¹ and Wolfgang Bäuml¹

Tattoo Inks

Data based on survey



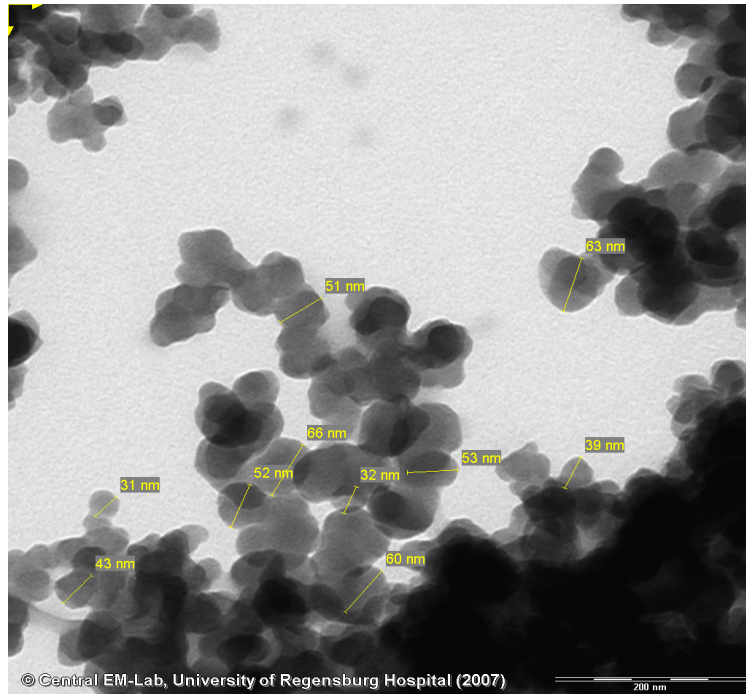
Tattoo inks - Color

Number	Trade name	Pigment	Chemical structure
1	Canary Yellow	P.Y.14	Disazo-Diarylide
2	17	P.Y.55	Disazo-Diarylide
3	Dunkelgelb Golden Luv	P.Y.83	Disazo-Diarylide
4	Zitronengelb	P.Y.74	M
5	Sunset Yellow	P.Y.150	Disazo-Diarylide
6	Orange, Navel Orange, Melon, I3	P.O.52	Quinacridone-Pyrazolone
7	Dunkelrot	P.R.49	NaphtholAS
8	I8	P.R.9	NaphtholAS
9	Red, Spanish Red, P8	P.R.22	NaphtholAS
10	Red Velvet	P.R.112	NaphtholAS
11	P1	P.R.170	NaphtholAS
12	Burgandy, I5, Magenta	P.R.122	Quinacridone
13	I6, Pur Purple, True Purple, P3	P.V.23	Dioxazine
14	Permanent Blue, Navy Blue	P.B.15	Cu-Phthalocyanine
15	Permanentgrün, Waldgrün, Forest Green, I4, Fezan Blue Green, Permanent Green, P2	P.G.7	Cu-Phthalocyanine
16	Avocado Green	PG	Cu/Al-Phthalocyanine

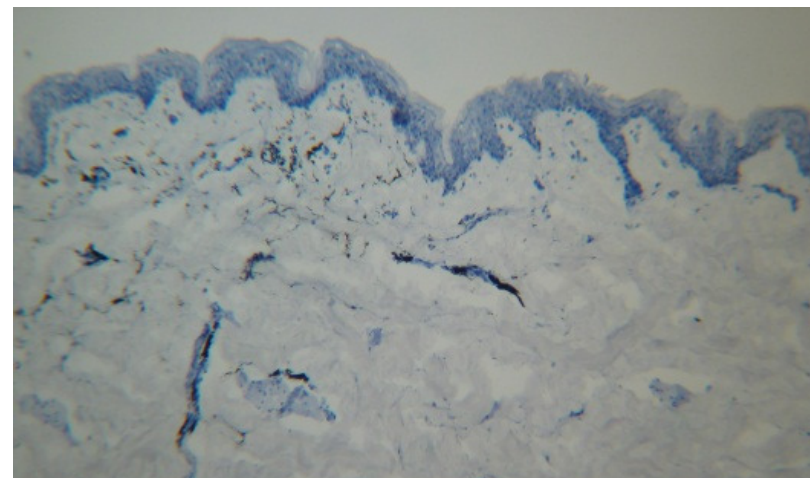
Pigments for Brilliant Solutions

Tattoo inks - Black

Prior to tattooing: nano-particles

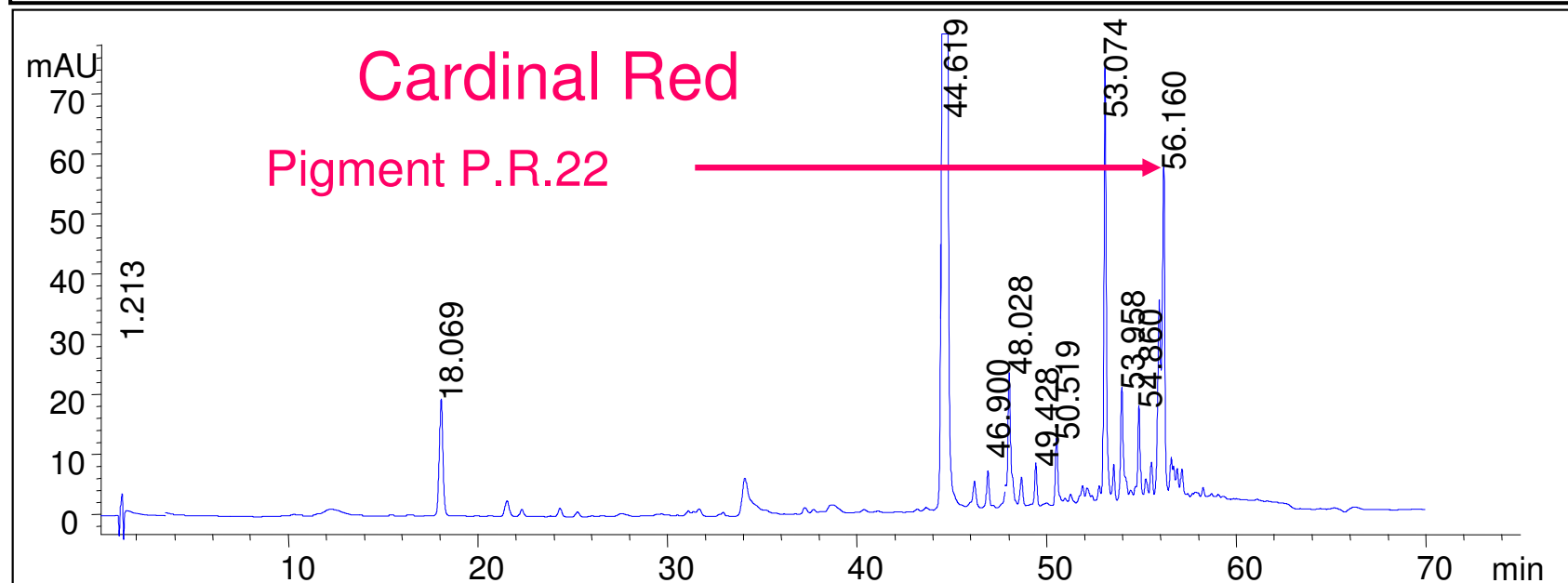
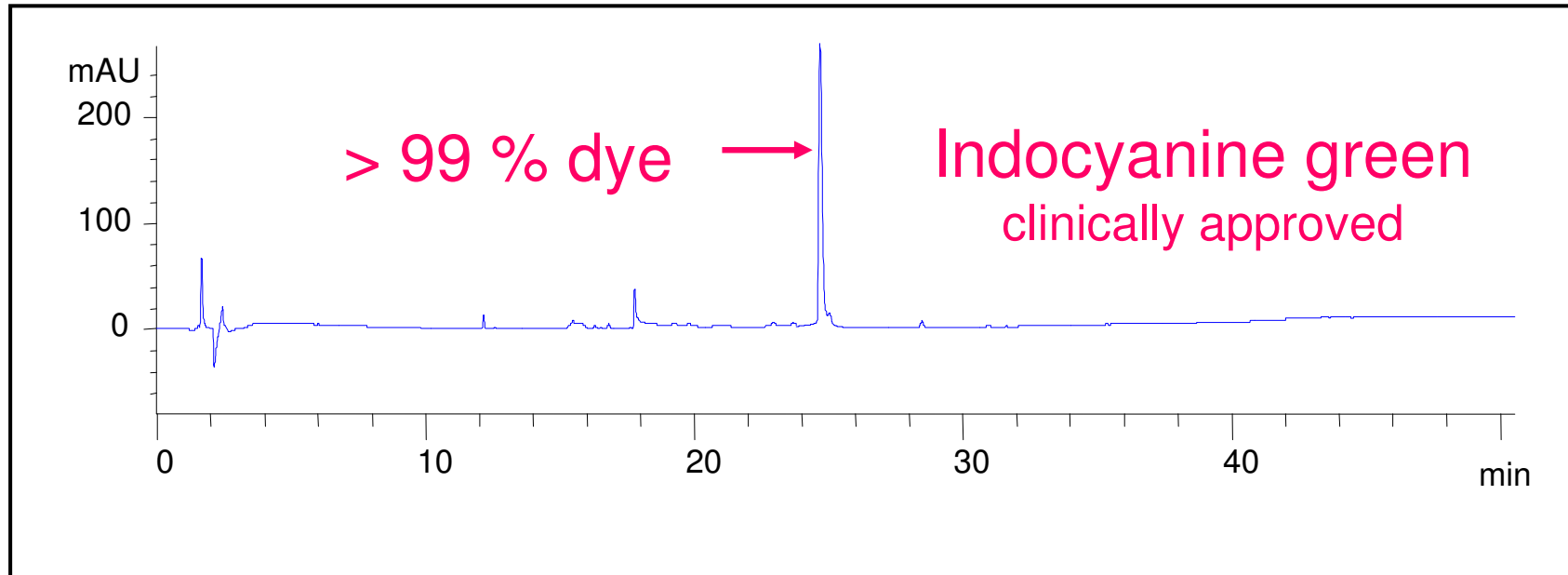


After tattooing:
nano- and micro-particles



Tattoo inks - Impurities

chemical analysis - HPLC



Tattoo inks - Impurities

Detected so far...

Table 1. Substances detected in tattoo inks

Compounds	References	Comments
Monoazopigment Disazodiarylide Naphthol-AS-pigment Quinacridone Dioxazine Cu-phthalocyanine Cu/Al-phthalocyanine-Br _x Cl _y	[11, 19]	pigment in color inks
Mercury Cadmium Cobalt Chrome	[62]	colored compounds in inks
Carbon black Iron	[13, 63, 64]	'color' of black, brown inks
Titanium dioxide Aluminium	[19, 63]	used for whitening of inks
Naphthol-AS 2-Methyl-5-nitroaniline 2-5-Dichloraniline 4-Nitro-toluene	[65]	synthesis educts and decomposition products of azo pigments
PAHs Phenol	[13]	residue of pyrolysis present in black inks
Dibutyl-phthalate Hexachloro-1,3-butadiene Metheneamine Dibenzofuran Benzophenone 9-Fluorenone 3,6-Dimethyl-1 heptyn-3-ol 1,6-Hexandiole, oleamide 7-Hexyl-2-oxepanone 1,1'Oxybis-2-propanol Carbitol cellosolve 1,2,3,4-Tetrahydro-1-phenyl-naphthalene	[12]	impurities in black inks

Dermatology

Case and Review

Dermatology
DOI: 10.1159/000346943

Received: December 23, 2012
Accepted: December 24, 2012
Published online: May 14, 2013

Adverse Reactions after Tattooing: Review of the Literature and Comparison to Results of a Survey

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Dermatology. 2013 May 14. [Epub ahead of print]

Tattoo inks - Impurities

Causing reactions: allergic, toxic, infections, tumor (?), ...

Dermatology

Case and Review

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Accepted: December 24, 2012
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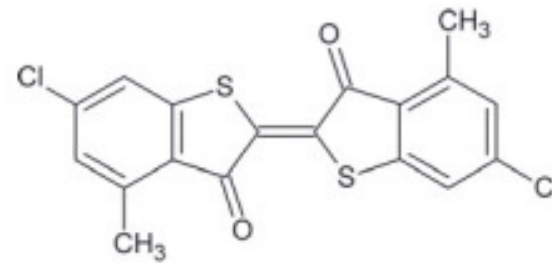


Tattoo inks - Impurities

Permanent-Makeup = Tattoo



PMU colorant: Longtime Liner®
Mainly iron oxides, however...



Pigment Red 181; CI 73360

Wenzel SM et al., Contact Dermatitis 2010; 63: 223-227

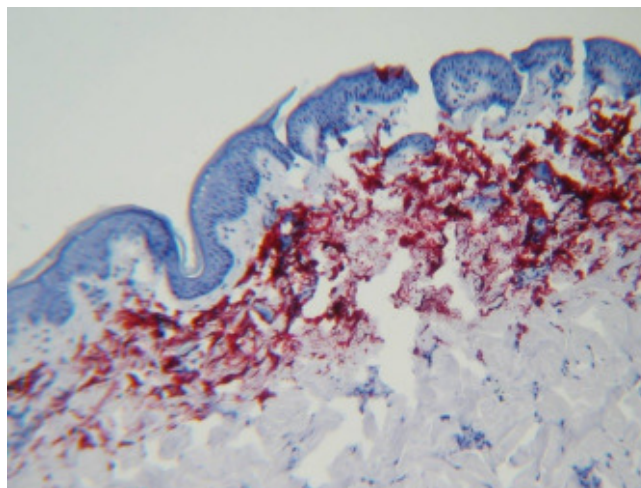
The Fate of Tattoo Pigments

Size of tattoos

	Study Population
Age (years), mean (SD)	29.3 (8.6)
Sex	
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The Fate of Tattoo Pigments

Determination of pigment concentration in the skin directly after tattooing
(extraction, chemical analysis, HPLC)



excised skin specimen

$\sim 1 \text{ mg/cm}^2$



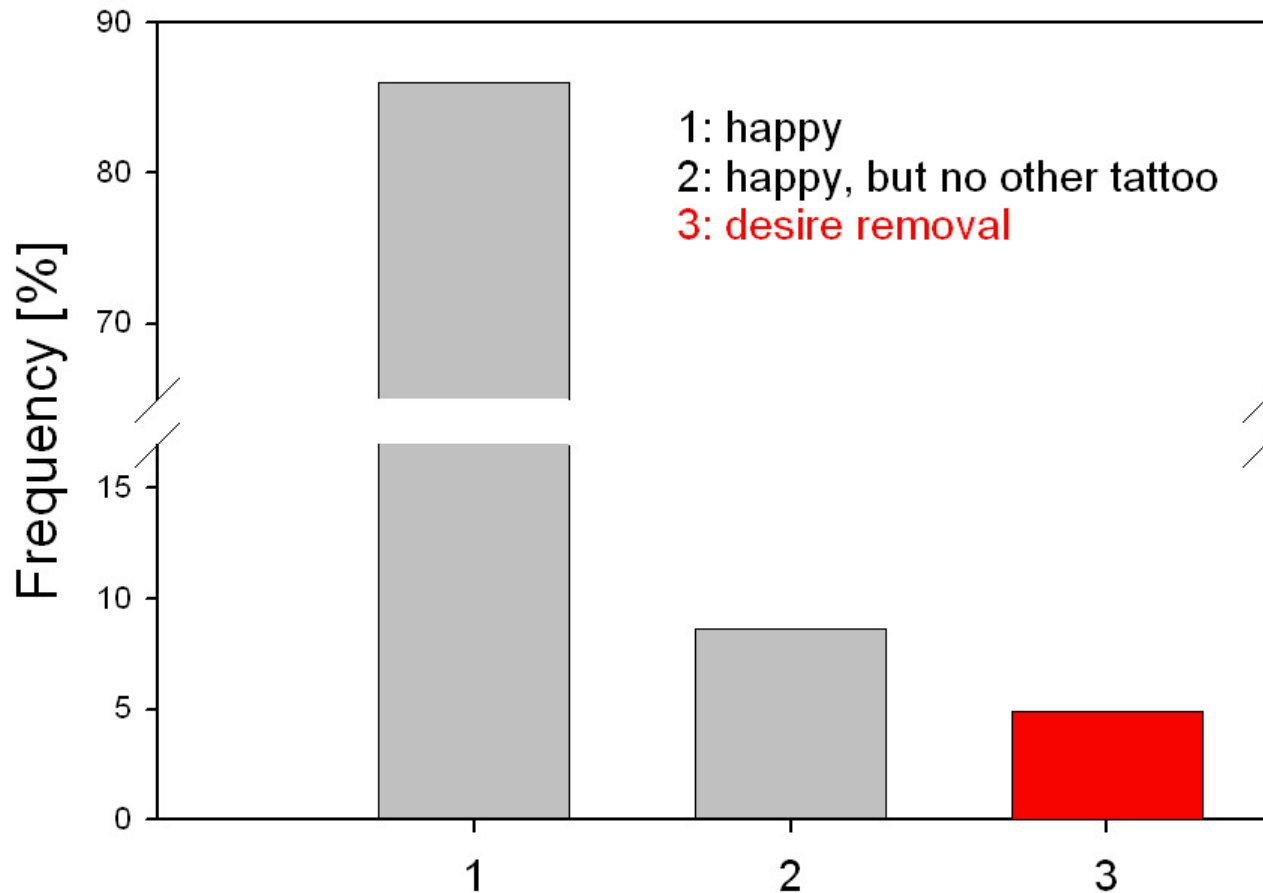
100 cm² Tattoo



The Fate of Tattoo Pigments

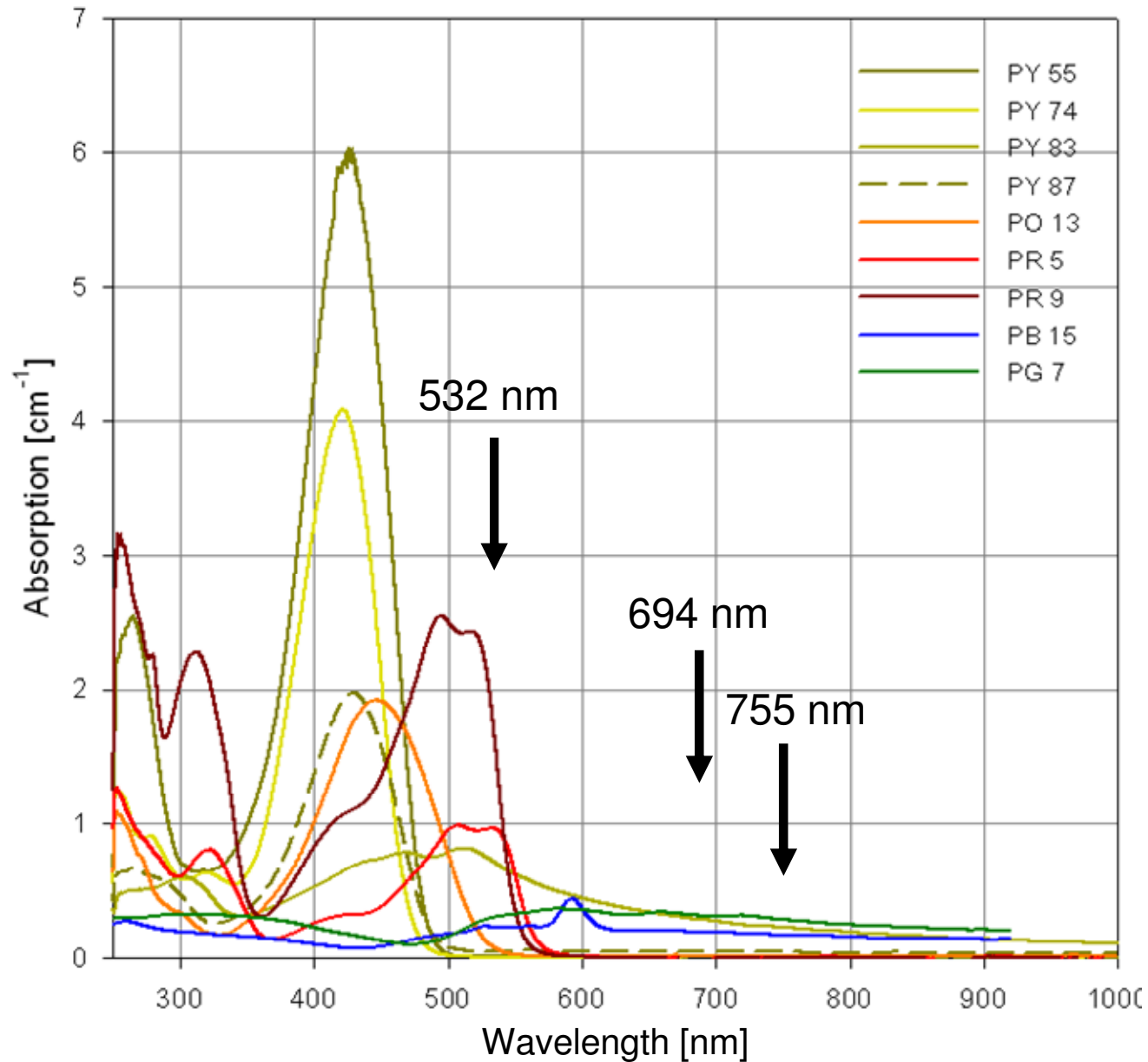
Tattoo removal with lasers

Germany 10 Mio. with tattoos → 0.5 Mio patients ?
USA 80 Mio. with tattoos → 4 Mio patients ?



The Fate of Tattoo Pigments

Tattoo removal with lasers

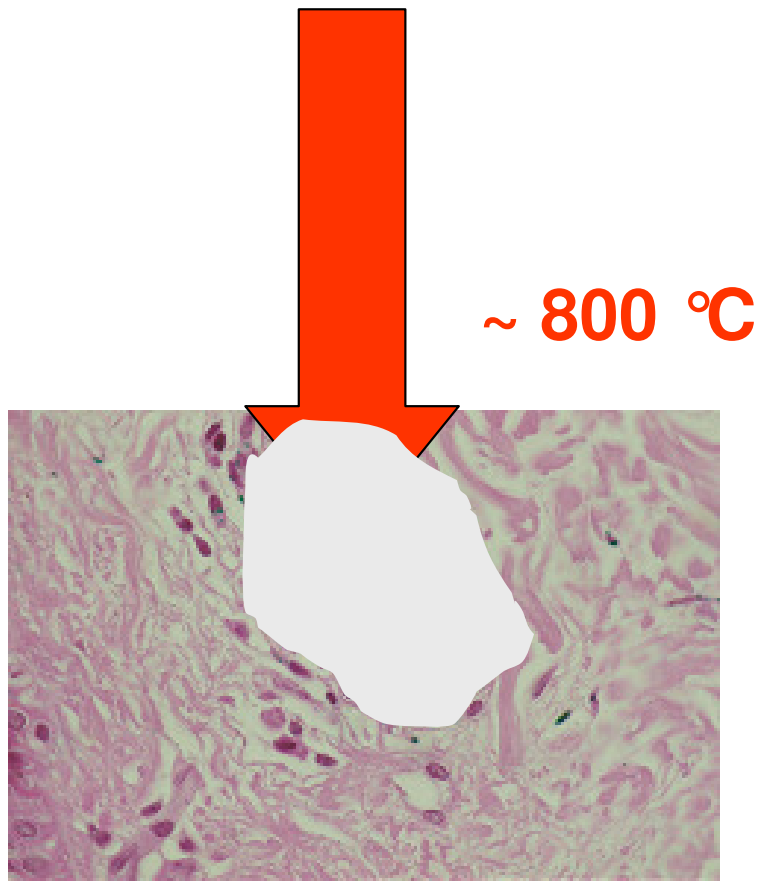


The Fate of Tattoo Pigments

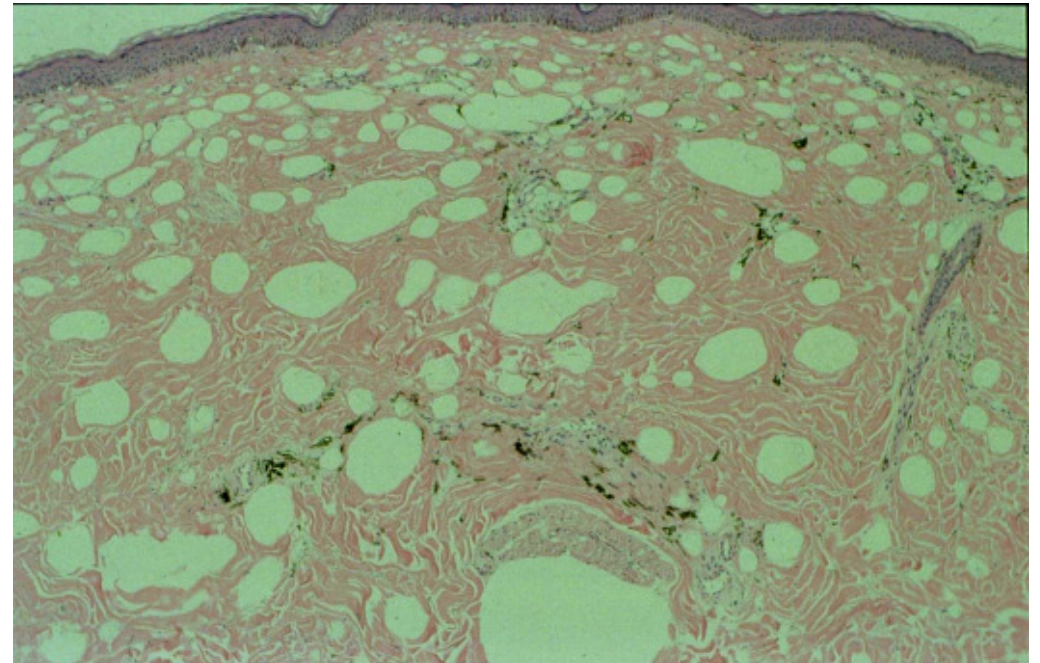
Tattoo removal with lasers

ultrashort pulse duration 10 ns

extremely high intensity 10^8 W/cm^2



ruby laser (694 nm)



The Fate of Tattoo Pigments

Tattoo removal with ruby laser



before laser therapy



5 min
after laser therapy



4 weeks
after laser therapy

The Fate of Tattoo Pigments

Tattoo removal with ruby laser

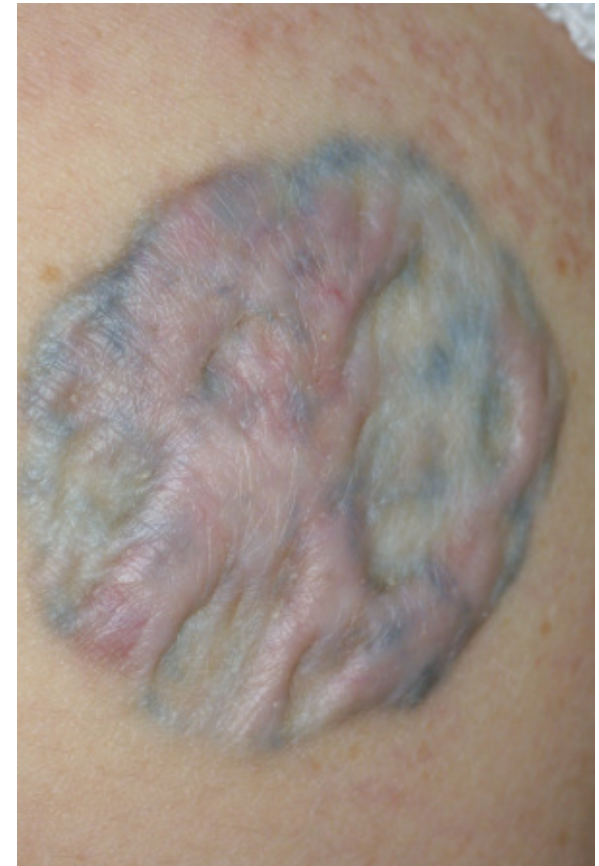
Needs a series of treatments !



The Fate of Tattoo Pigments

Tattoo removal with wrong device

Laser or IPL with ms pulses



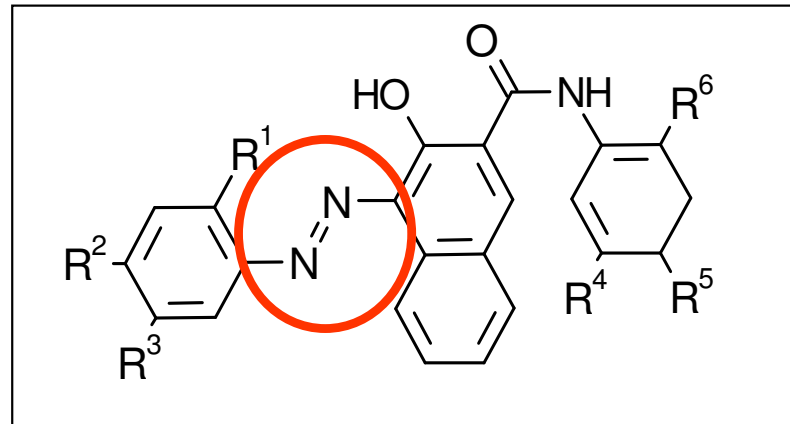
The Fate of Tattoo Pigments

Tattoo removal – decomposition of azo pigments

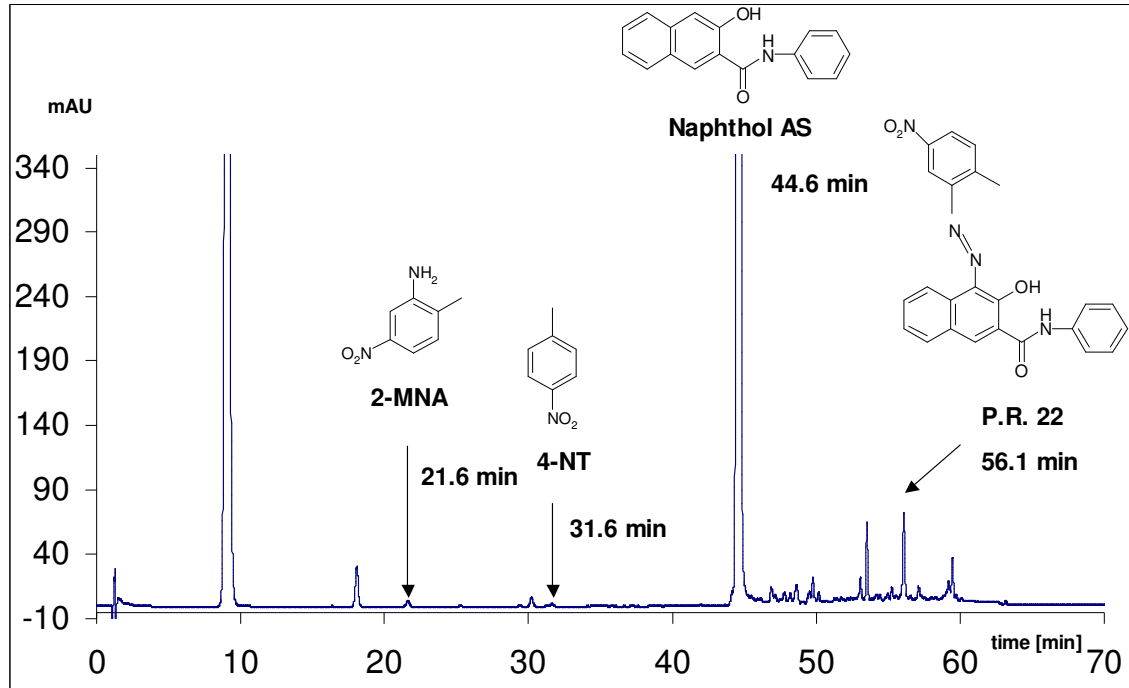
Laser irradiation: temperatures $\sim 800\text{ }^{\circ}\text{C}$

Azo pigments

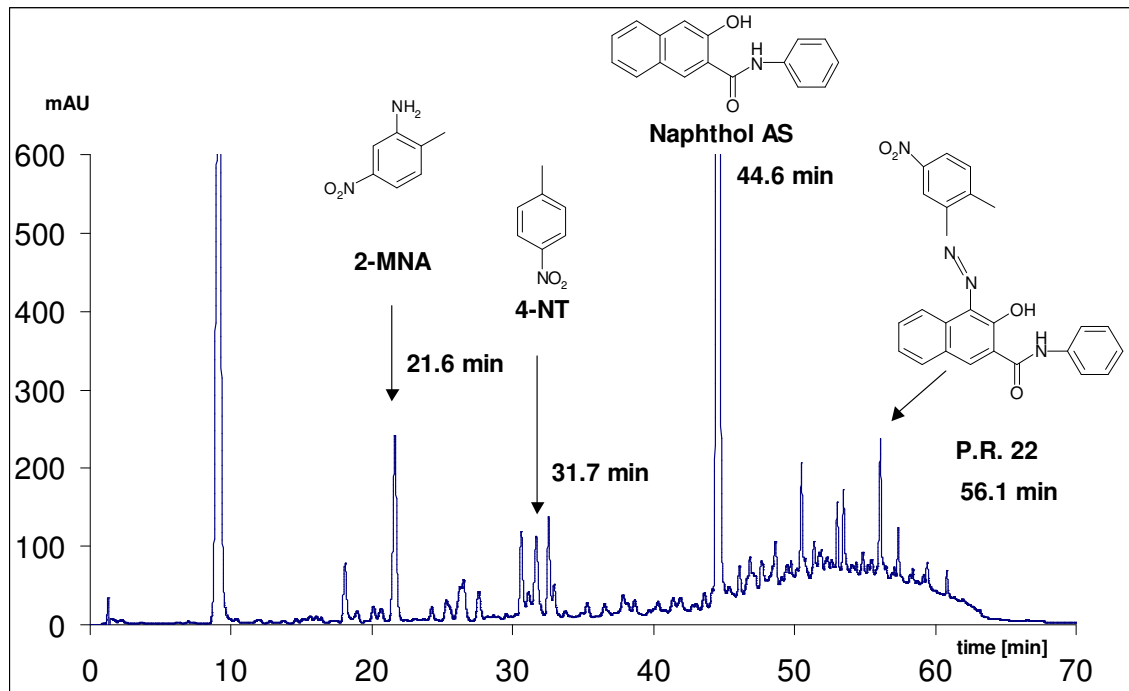
food industry: no temperatures above $200\text{ }^{\circ}\text{C}$



The Fate of Tattoo Pigments



P.R.22
before
laser irradiation

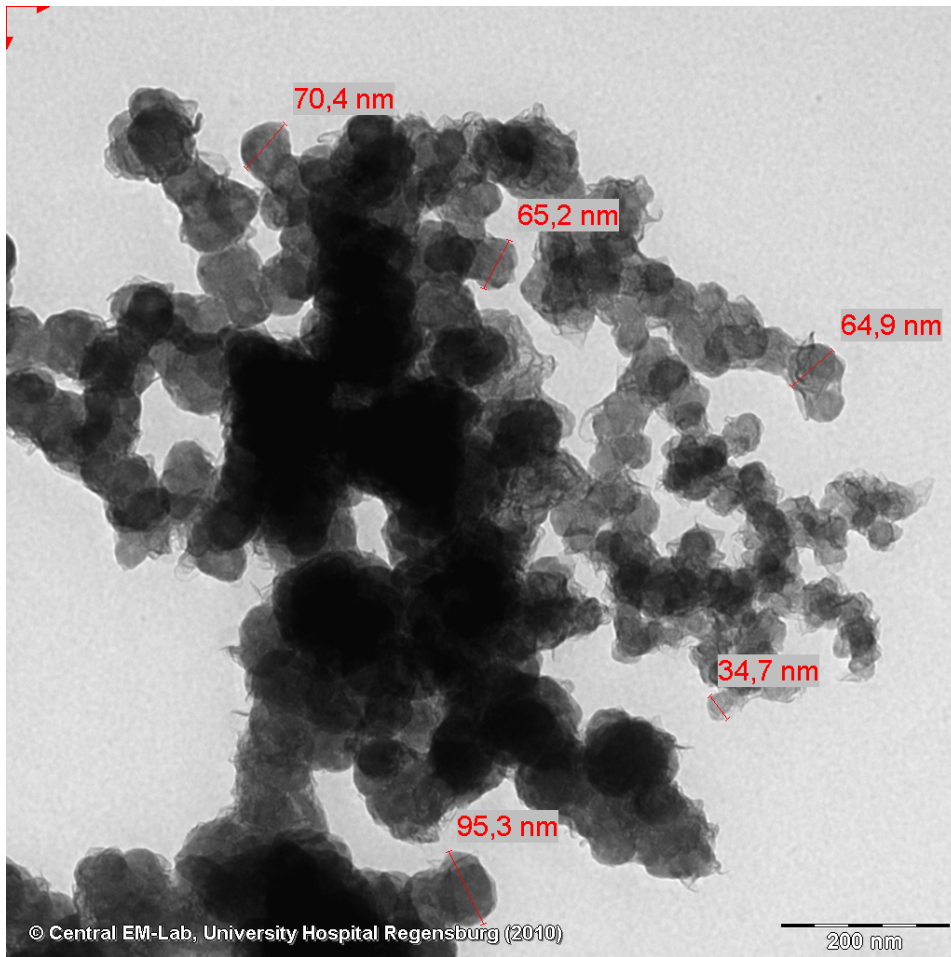


after
laser irradiation

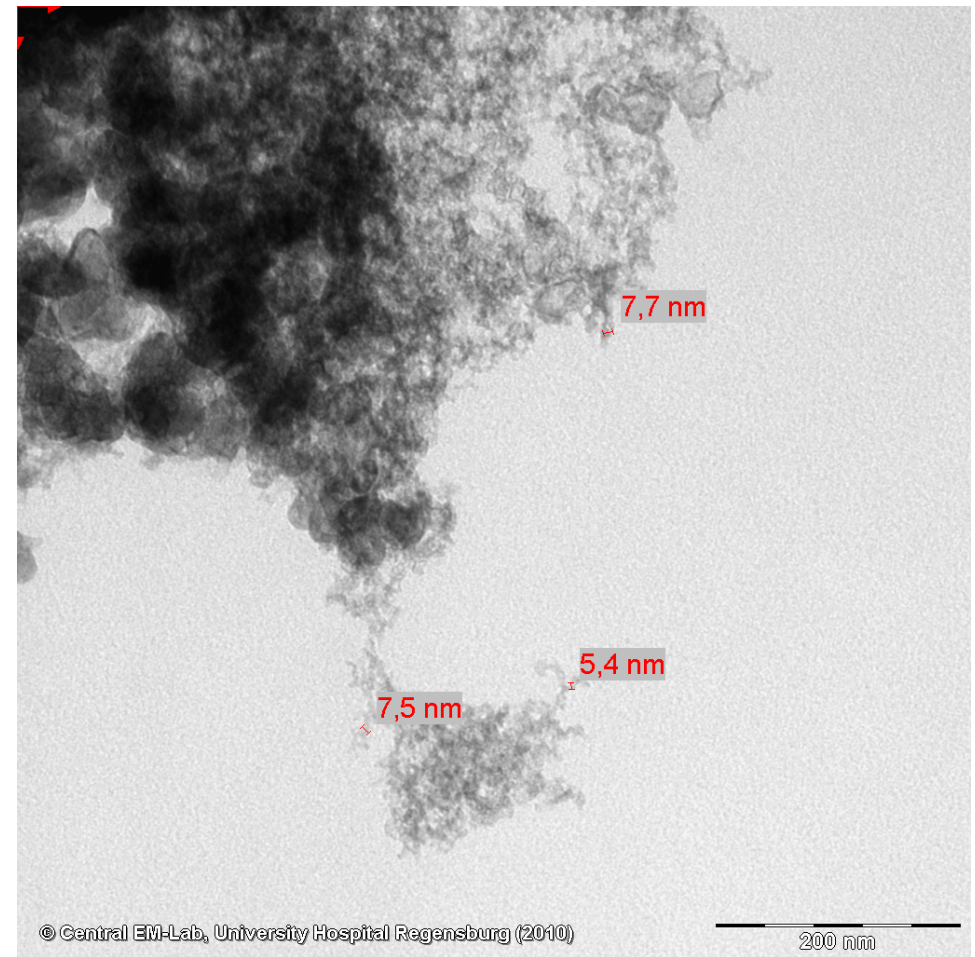
The Fate of Tattoo Pigments

Tattoo removal – break down of carbon black particles

Before



after laser



Mean diameter of particles

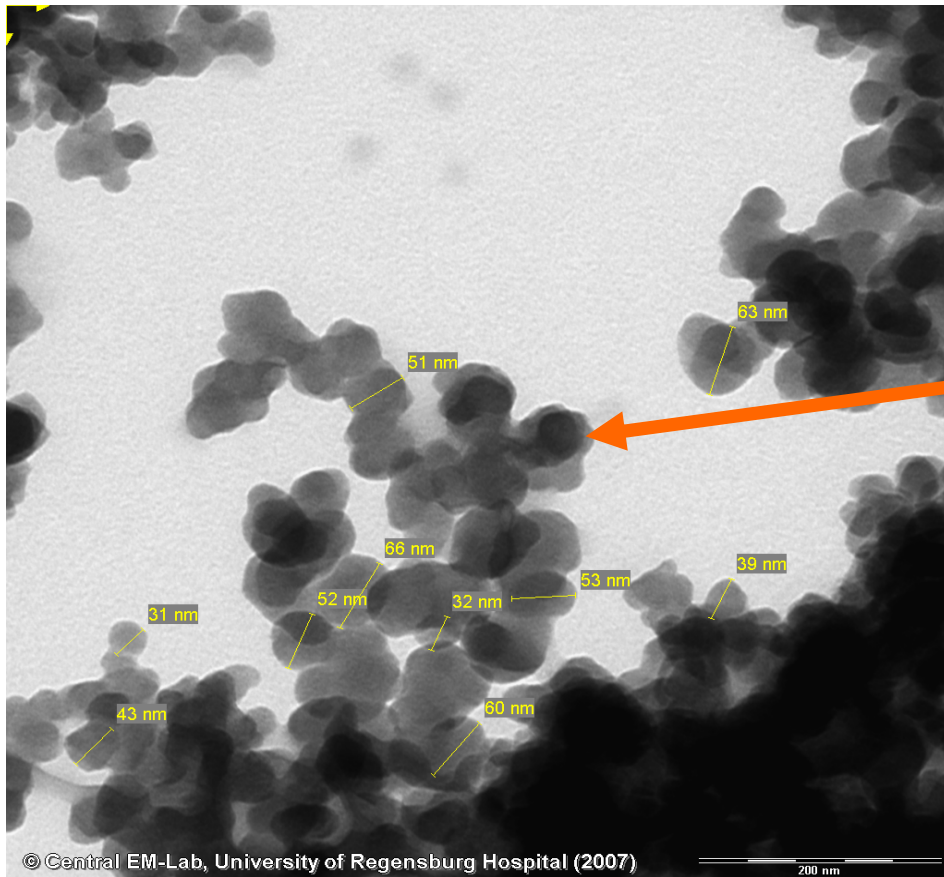
~ 50 nm

~ 6 nm

The Fate of Tattoo Pigments

What about black tattoo inks ?

Simply Carbon black (soot) ?



PAH

absorbed to the surface of nanoparticles

and
dibutyl-phthalate
hexachloro-1,3-butadiene
etc.

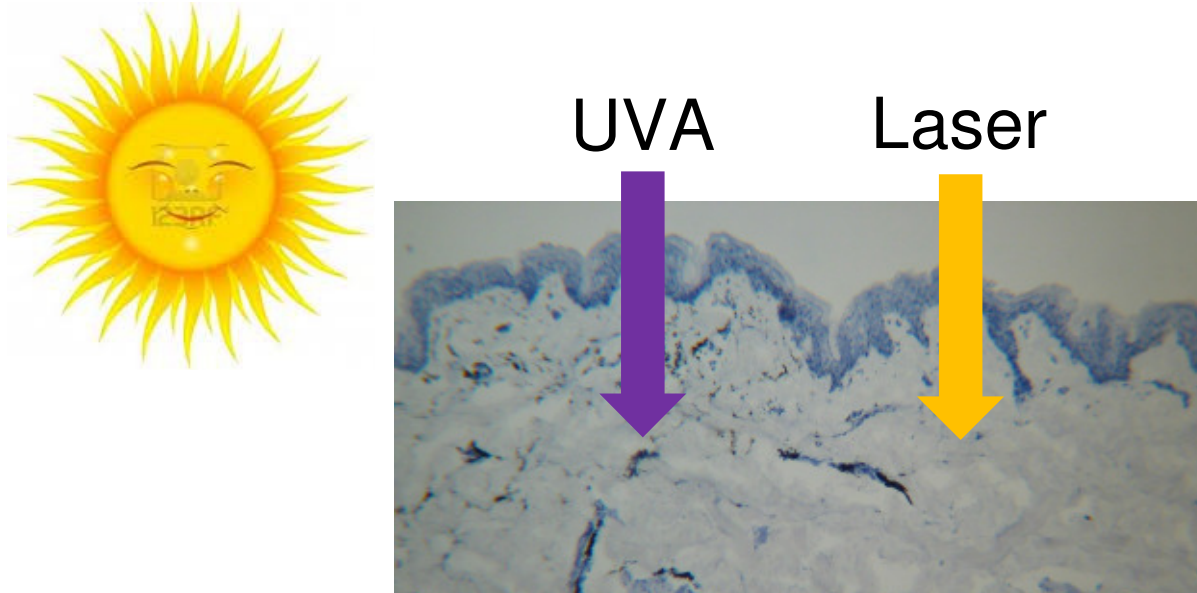
Polycyclic Aromatic Hydrocarbons (PAH)

Up to 200 µg/g (total amount of PAH)

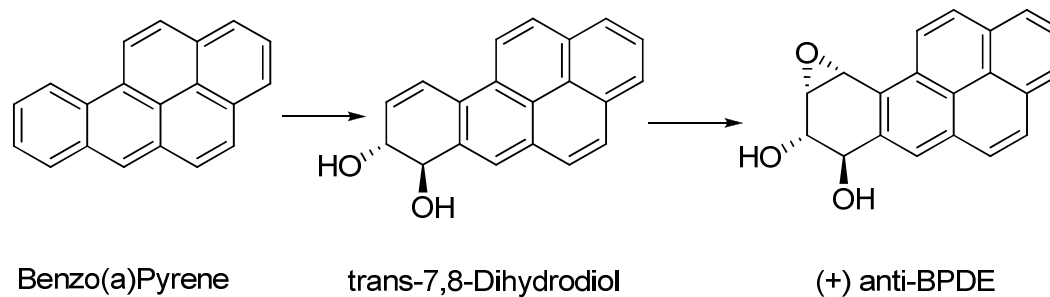


PAHs found in black tattoo inks				
PAHs*	mean value extracted [µg/g]	mean daily dietary intake (38) [µg/person]	carcinogenicity US-EPA (23)	Toxicity TEF (25)
phenanthrene (12)	24.5 ± 6.0	1.54	D	0.001
acenaphthylene (8)	14.5 ± 5.5	0.13	D	0.001
benzo[b]fluoranthene (2)	4.5 ± 4.3	0.04	B2	0.1
pyrene (12)	4.4 ± 0.8	0.35	D	0.001
anthracene (8)	3.3 ± 0.8	0.07	D	0.01
fluoranthene (14)	2.8 ± 1.0	0.35	D	0.001
chrysene (4)	1.7 ± 0.8	0.11	B2	0.01
benz[a]anthracene (6)	1.6 ± 0.2	0.05	B2	0.1
benzo[ghi]perylene (3)	1.2 ± 1.5	0.05	D	0.01
Indeno[1,2,3-cd]pyrene (2)	1.1 ± 1.0	0.03	B2	0.1
acenaphthene (8)	0.9 ± 0.3	0.98	-**	0.001
fluorene (6)	0.9 ± 0.2	0.59	D	0.001
benzo[k]fluoranthene (2)	0.4 ± 0.2	0.01	B2	0.1
benzo[a]pyrene (4)	0.3 ± 0.2	0.04	B2	1.0
naphthalene (7)	0.3 ± 0.1	-**	C	0.001
dibenzo[a,h]anthracene (1)	0.1 ± 0.1	0	B2	1.0

The Fate of Tattoo Pigments



Formation of mutagenic diolepoxide



Irradiation of black tattoo inks (in solution)

UVA radiation:

diolepoxide detected

QS-Laser radiation (532 nm)

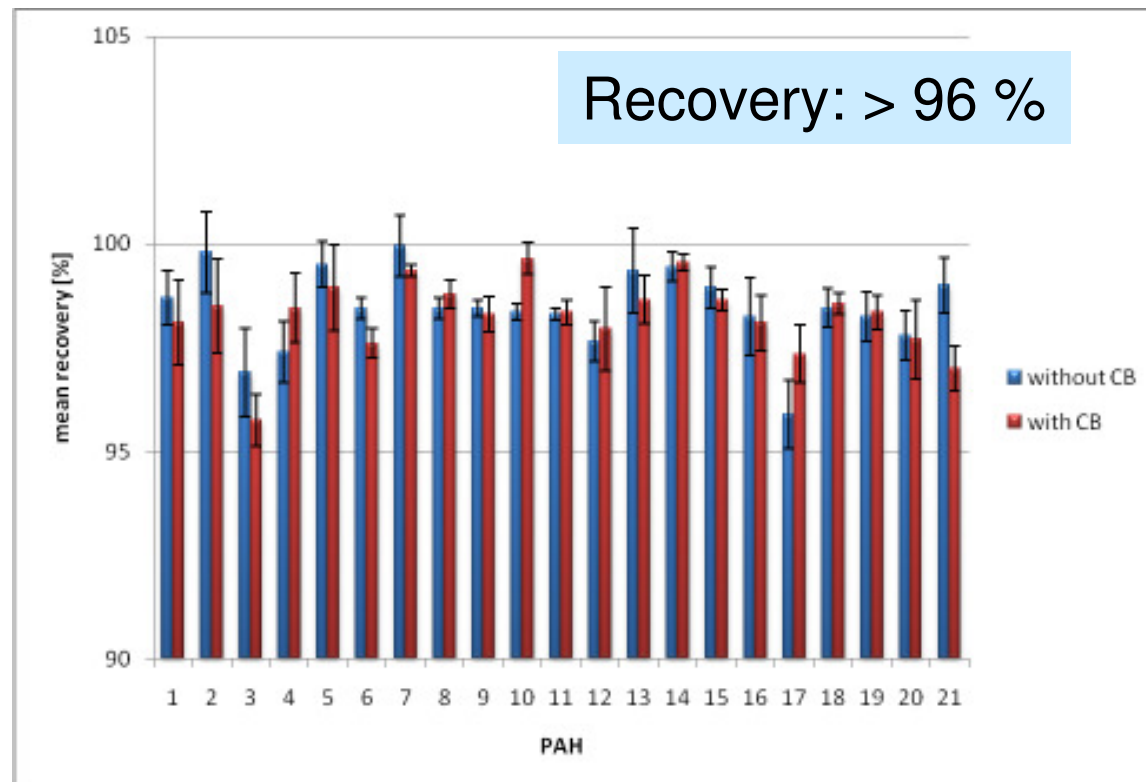
None

The Fate of Tattoo Pigments

16 tattooed skin samples and corresponding regional lymph nodes



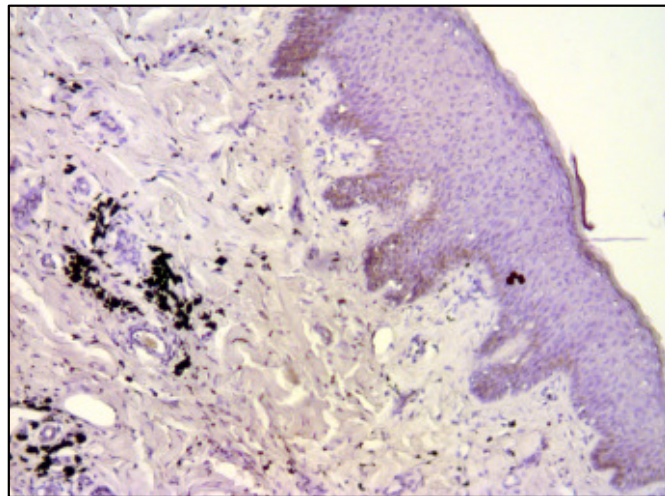
Extraction and quantification of 20 PAH and phenol at the same time



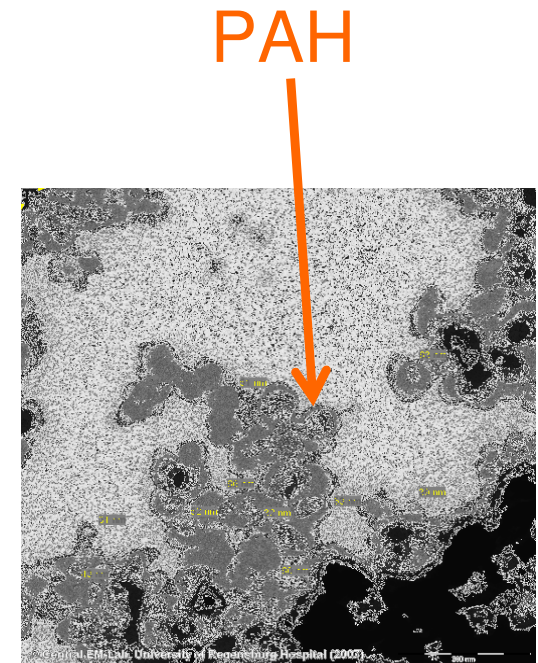
The Fate of Tattoo Pigments

16 tattooed skin samples

PAH: 0 - 0.57 $\mu\text{g}/\text{cm}^2$ skin



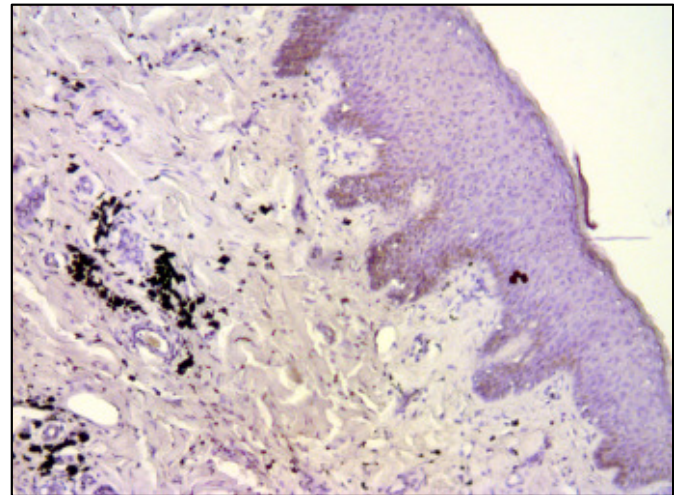
Tattoo	Concentration of PAH $\mu\text{g}/\text{cm}^2$
# 1	0.08
# 2	0.57
# 3	n.d.
# 4	0.41
# 5	0.19
# 6	0.40
# 7	0.18
# 8	0.07
# 9	n.d.
#10	0.12
#11	0.08
#12	0.22
#13	n.d.
#14	n.d.
#15	0.14
#16	0.16



The Fate of Tattoo Pigments

16 tattooed skin samples

Up to 200 μg of Carbon black per cm^2 skin



Tattooing: 1 mg/cm^2
Up to 80 % of tattoo colorants disappeared

Tattoo	Concentration CB $\mu\text{g}/\text{cm}^2$
#5	152.0 \pm 49.7
#6	194.9 \pm 21.1
#7	157.0 \pm 67.8
#8	89.4 \pm 38.1
#9	82.8 \pm 22.1
#10	105.3 \pm 52.5
#11	94.3 \pm 31.5
#12	42.1 \pm 32.4
#13	157.3 \pm 20.6
#14	167.4 \pm 72.1
#15	167.5 \pm 29.3
#16	87.6 \pm 20.2

The Fate of Tattoo Pigments

transportation of inks in the body

Tattooing of skin results in transportation and light-induced decomposition of tattoo pigments – a first quantification *in vivo* using a mouse model

Eva Engel¹, Rudolf Vasold², Francesco Santarelli¹, Tim Maisch¹, Neera V. Gopee³, Paul C. Howard³, Michael Landthaler¹ and Wolfgang Bäuml¹

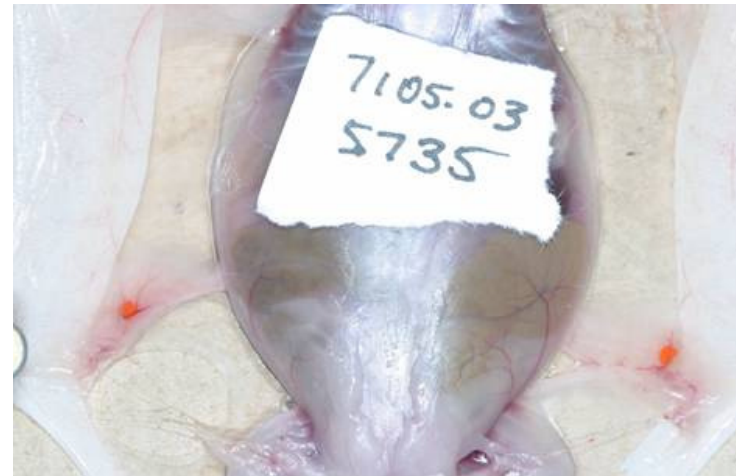
¹Department of Dermatology, University of Regensburg, Regensburg, Germany;

²Department of Organic Chemistry, University of Regensburg, Regensburg, Germany;

³National Toxicology Program Center for Phototoxicology, National Center for Toxicological Research, US Food & Drug Administration, Jefferson, AR, USA

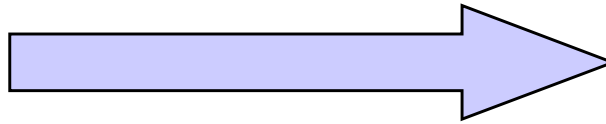
Quantification six weeks after tattooing:

~ 30 % of injected colorants is transported away from skin after tattooing

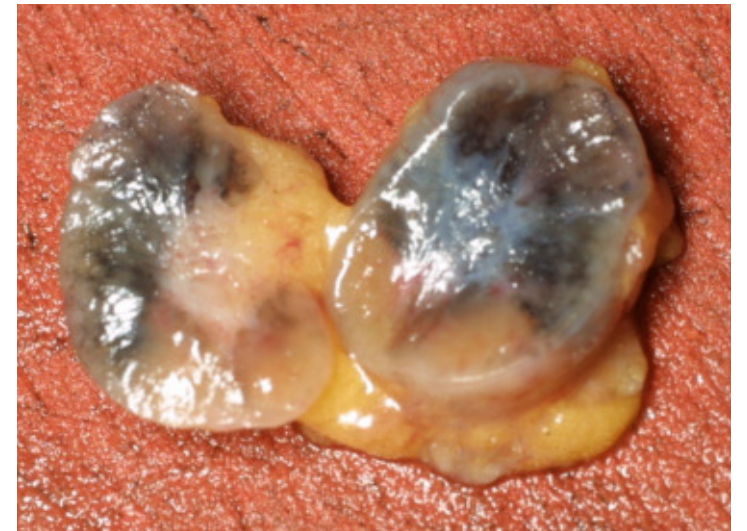
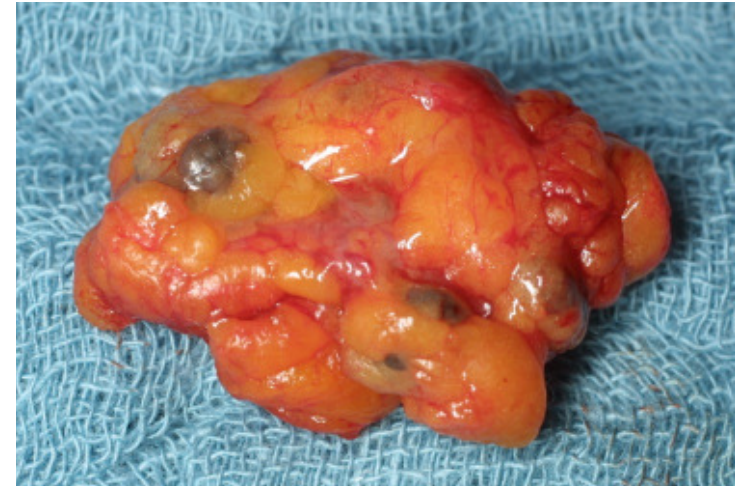


The Fate of Tattoo Pigments

transportation of inks in the body



Human body



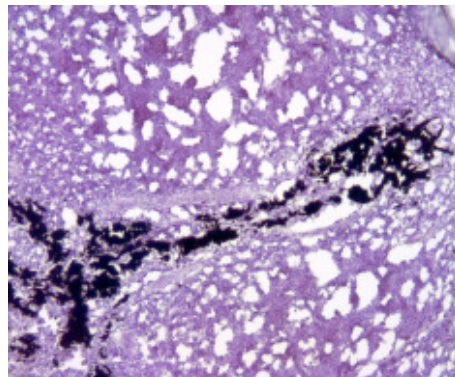
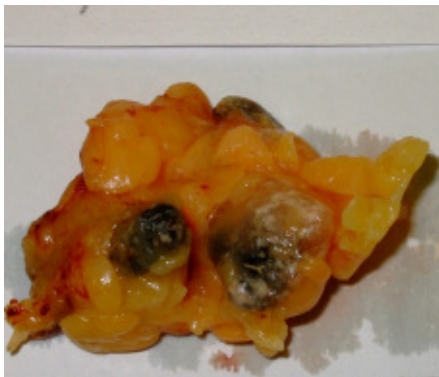
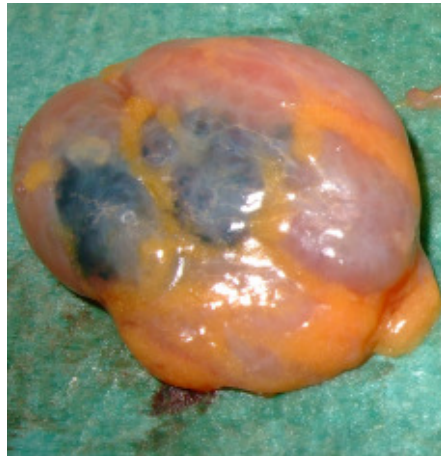
The Fate of Tattoo Pigments

transportation of inks in the body

16 lymph nodes

Up to 17 mg of Carbon black per gram lymph node

Up to 11.8 μg PAH per gram lymph node



Lymph node	Concentration of CB [mg/LN]	Concentration of CB [mg/g]	Lymph node sample	Conc. PAH [μg /LN]	Conc. PAH [μg /g]
#1	0.80	13.30	# 1	0.02	0.05
#2	0.51	12.75	# 2	1.88	11.75
#3	0.06	1.20	# 3	n.d.	n.d.
#4	0.26	6.50	# 4	0.20	0.87
#5	0.64	12.80	# 5	0.39	2.29
#6	0.09	4.50	# 6	0.44	2.93
#7	0.01	0.11	# 7	0.52	3.06
#8	0.59	7.37	# 8	n.d.	n.d.
#9	0.19	4.75	# 9	n.d.	n.d.
#10	0.39	2.78	# 10	0.10	0.17
#11	0.08	4.00	# 11	0.74	10.57
#12	0.34	17.00	# 12	0.61	10.16
#13	0.05	1.67	# 13	n.d.	n.d.
#14	0.14	7.00	# 14	n.d.	n.d.
#15	1.45	12.08	# 15	0.10	0.43
#16	0.32	2.66	# 16	0.46	2.19

Some recommendations and ideas

- Inks without hazard impurities
- Remaining risk of adverse reactions
- Research regarding transportation processes in human body
→ Animal studies
- Interaction of UV or laser radiation with tattoo inks in skin
→ Animal studies
- High number of tattooed people: Need for epidemiologic studies