

Tattoo Inks  
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The questions to be addressed are:

- what are the ingredients in tattoo inks
- toxicity of common ingredients in tattoo inks

**Summary**

Although there are definitely risks to tattooing they seem to be occurring infrequently. As a consequence of federal regulations affecting the permissive mercury levels the severity and frequency of skin reactions should decrease. Since the inks we tested and those tested by Timko<sup>1</sup> found no lead, mercury, or cadmium the more severe reactions of eczema, exfoliative dermatitis, swelling, and lichenoid reactions are probably going to become more uncommon. Aluminum and iron are still problematic with the long-term consequences not fully understood. Foreign body reactions and granulomas at the tattoo sites are going to continue as a natural consequence of placing foreign particular matter in the dermis.

**Tattoo Ink Ingredients**

The tattoo inks were purchased in Salt Lake City and represented as containing plant derived colors. I now have reason, based on what our laboratory found on analysis, to doubt that all of the colors are plant-based but surely some are.

The inks tested by USANA laboratories are Tribal Black, Battleship Grey, Steel Blue, Golden Yellow, Crimson Red, Grassy Green, and Deep Blue; all have less than 1ppm As, Pb, Hg, Cd.

All have a significant quantity of both Fe and Al, much greater than 1ppm. These findings now raise the question as to the toxicity of iron and aluminum. The manufacturer of all colors tested is Tommie's Supplies of Somers, Connecticut. We will try four more colors by other suppliers one of which is manufactured in China to see if there is any difference.

The absence of lead, mercury, and cadmium in any of our samples and those of Timko<sup>1</sup> (see APPENDIX B) is a significant finding, because these are classic elements of the color profiles used for centuries in tattoo inks. Presumably their absence is at least partially due to the enactment of the Food Drug and Cosmetic Act of 1976 which limited concentrations of lead to 10 ppm and mercury to 3 ppm in cosmetics<sup>2</sup> with the exception of skin whiteners wherein mercury cannot be at levels above 1 ppm<sup>3</sup>.

Schmidt et al. observed in a 2004 paper "Elemental analysis revealed multiple metallic components in the dyes; these materials may be responsible for persistent foreign body reactions even years after being placed in the skin. Silicon, aluminium, titanium and

copper were found in various yellow, green and red dyes. The composition of various dyes of the same colour from different sources was highly variable.”

The following are common pigments currently used in tattoo inks<sup>4, 5</sup>:

#### Black

- Iron Oxide ( $\text{Fe}_3\text{O}_4$ )
- Iron Oxide ( $\text{FeO}$ )
- Carbon
- Logwood; Logwood is a Heartwood extract from *haematoxylon campechianum* found in Central America and the West Indies.

#### Brown

- Ochre: ochre is composed of iron (ferric) oxides mixed with clay. Raw ochre is yellowish. When dehydrated through heating, ochre changes to a reddish brown color.

#### Red

- Cinnabar ( $\text{HgS}$ )
- Cadmium Red ( $\text{CdSe}$ )
- Iron Oxide ( $\text{Fe}_2\text{O}_3$ )
- Naphthol-AS-pigment
- Sienna (ferric hydrate)
- Sandalwood
- Brazilwood
- Organic pigments (aromatic azo compounds)

#### Orange

- disazo diarylide and/or disazo pyrazolone
- Cadmium seleno-sulfide

#### Flesh

- Ochres (iron oxides mixed with clay)

#### Yellow

- Cadmium Yellow ( $\text{CdS}$ ,  $\text{CdZnS}$ )
- Ochres
- Curcuma Yellow (Curcuma is derived from plants of the ginger family; aka tumeric or curcumin)
- Chrome Yellow ( $\text{PbCrO}_4$ , mixed with  $\text{PbS}$ )
- disazo diarylide

#### Green

- Chromium Oxide ( $\text{Cr}_2\text{O}_3$ ), Casalis Green or Anadomis Green
- Malachite [ $\text{Cu}_2(\text{CO}_3)(\text{OH})_2$ ]
- Ferrocyanides and Ferricyanides
- Lead Chromate

- Monoazo pigment: The monoazo compounds are neurotoxic.<sup>6</sup>
- Cu/Al phthalocyanine
- Cu phthalocyanine

### Purple

- Manganese, aluminum

### Blue

- Azure Blue
- Cobalt Blue (Cobalt aluminate)
- Cu-phthalocyanine pigments from minerals include copper (II) carbonate (azurite), sodium aluminum silicate (lapis lazuli), cadmium copper silicate (Egyptian blue), other cobalt aluminum oxides and chromium oxides. The safest blues and greens are copper salts, such as copper phthalocyanine. Copper phthalocyanine pigments have FDA approval for use in infant furniture and toys and contact lenses. The copper-based pigments are considerably safer or more stable than cobalt and ultramarine pigments.

### Violet

- Manganese Violet (manganese ammonium pyrophosphate)
- Various aluminum salts
- Quinacridone
- Dioxazine/carbazole

### White

- Lead White (Lead carbonate)
- Titanium Dioxide (TiO<sub>2</sub>)
- Barium Sulfate (BaSO<sub>4</sub>)
- Zinc Oxide (ZnO)

The ubiquitous presence of aluminum in all of the colors tested leads to the conclusion that the colors in most tattoo inks, including the ones that we acquired, are aluminum lakes. An aluminum Lake is a color extended on aluminum oxide by adsorption or co-precipitation. Because lakes are not soluble in water they are used when it's important to keep colors from bleeding, running, or mixing with another color, rendering them ideal for tattoo inks. Generally, lakes are not as colorfast as many inorganic dyes but their colors are more brilliant giving an aesthetically pleasing tattoo and a satisfied customer.

### **Toxicology**

Dyes and their mordants (Cd, Hg, Fe, and Al) travel from the skin through the lymph system and are deposited in the lymph nodes<sup>7,8</sup>. The long-term systemic health consequences on the individual of the metal carriers found in tattoo links is not known.

**Note:** *A mordant is a substance used to set dyes on fabrics or tissue sections by forming a coordination complex with the dye which then attaches to the fabric or tissue. It may be used for dyeing fabrics, or for intensifying stains in cell or tissue preparations. A*

*mordant is always a polyvalent metal ion. The resulting coordination complex of dye and ion is colloidal.*

Schmitzl, in his 2004 paper concludes that “The tattoo dyes currently in use contain a number of components which cannot be regarded as "tissue inert". Chronic foreign body reactions can be expected even after many years<sup>4</sup>.”

Among other observable conditions resulting from tattoo inks are eczematous hypersensitivity reactions and photosensitivity reactions. Eczematous hypersensitivity reactions are characterized by localized eczematous eruptions and/or exfoliative dermatitis with the reaction most commonly associated with red pigments especially mercury sulfide.

The photosensitive reactions are most commonly caused by sunlight exposure of the yellow (cadmium sulfide) tattoo pigments. Edema and erythema develop upon exposure to sunlight. Since cadmium sulfide is the light-sensitive material used in photoelectric cells; therefore, the reaction is believed to be phototoxic. No good data on this theory exists.

Chromium and green tattoo pigment is associated with eczematous reactions at the site of the pigment, eczema of the hands, and generalized eczematous reactions.

Given the significant amounts of aluminum found in the inks we purchased and the aluminum compounds reported in the references above, it is not surprising to find that skin pathologies, including granulomas<sup>9</sup>, are commonly seen around tattoos. These granulomas produce foreign body reactions with numerous pigment filled giant cells in the ring of lymphocytes with inflammation, erythema, and edema. Although Mercury is most commonly associated with granulomatous tattoo reactions, there have been reported reactions involving chromium and cobalt<sup>10</sup>.

As is the case with granulomatous, lichenoid reactions to the tattoo dyes involves, in most cases, Mercury. Typically hyperkeratotic lichen planus are usually found in the red portion of the tattoo<sup>11, 12</sup> although there has been a report of a generalized lichen planus reaction in a patient with lichenoid reaction<sup>13</sup>.

**Note:** *A lichenoid is a discrete flat papule or an aggregate of papules giving a patterned configuration resembling lichen growing on rocks.*

**Note:** *lichen planus is an eruption of flat-topped, shiny, violaceous (purple) papules on flexor surfaces*



An interesting and unexpected complication of tattooing is reported to be painful MRI for those who have tattoos containing ferromagnetic compounds such as iron oxide<sup>14</sup>. The pain levels can get so high that it requires the cessation of the procedure.

#### Reference List

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2. Timko AL, Miller CH, Johnson FB, Ross E. In vitro quantitative chemical analysis of tattoo pigments. Arch Dermatol 2001;137(2):143-147.
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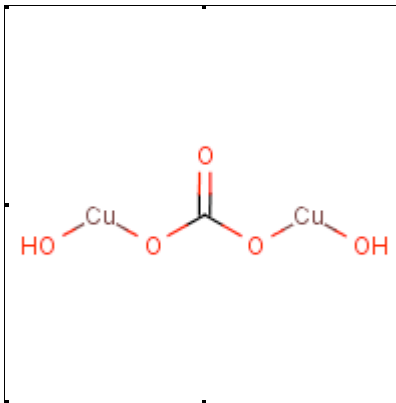
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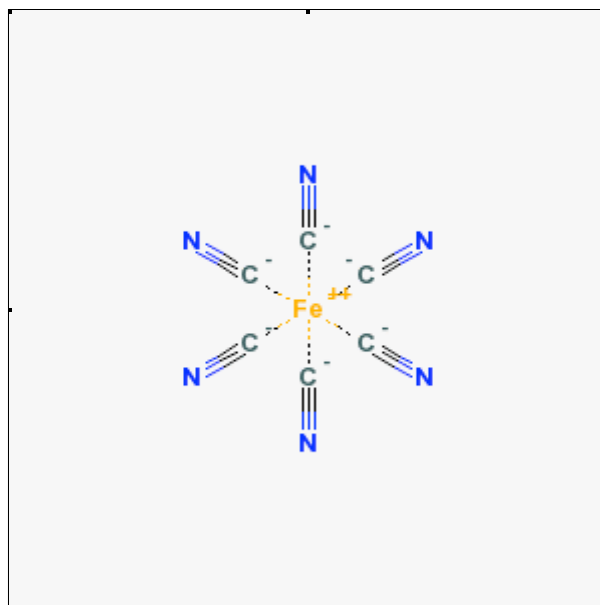
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13. Taaffe A, Wyatt EH. The red tattoo and lichen planus. *Int J Dermatol* 1980;19(7):394-396.
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## APPENDIX A

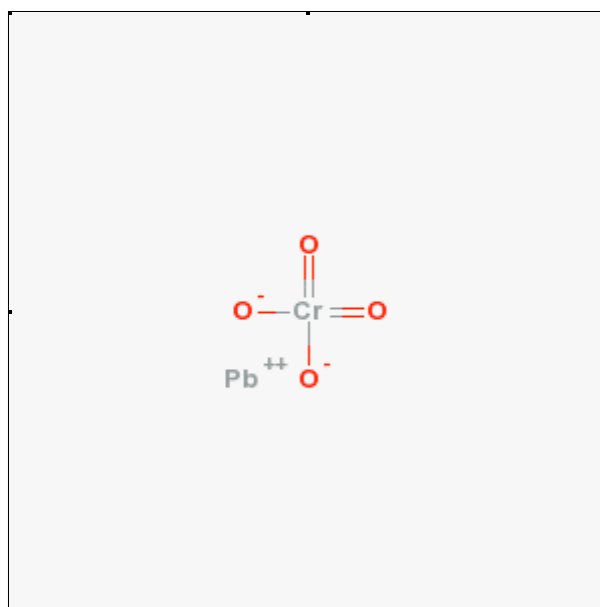
### Chemical Structures of Some Tattoo Pigments



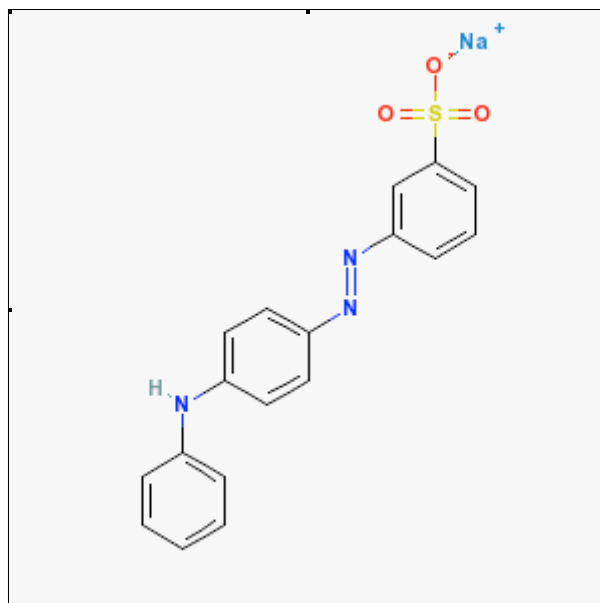
Malachite  $[\text{Cu}_2(\text{CO}_3)(\text{OH})_2]$



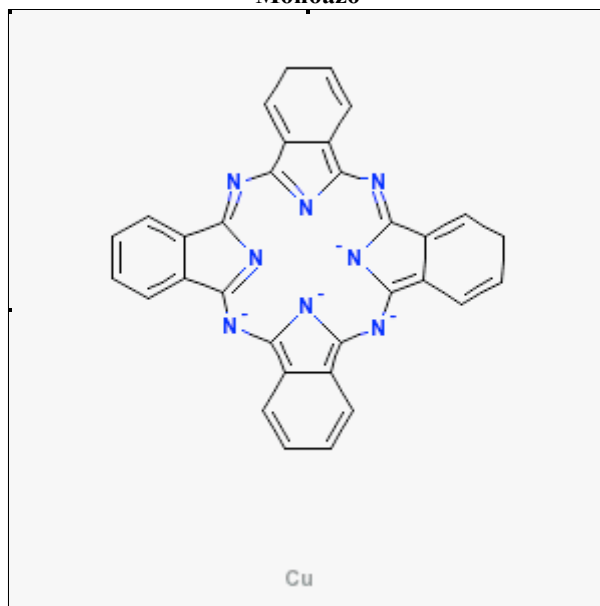
Ferricyanides



Lead Chromate

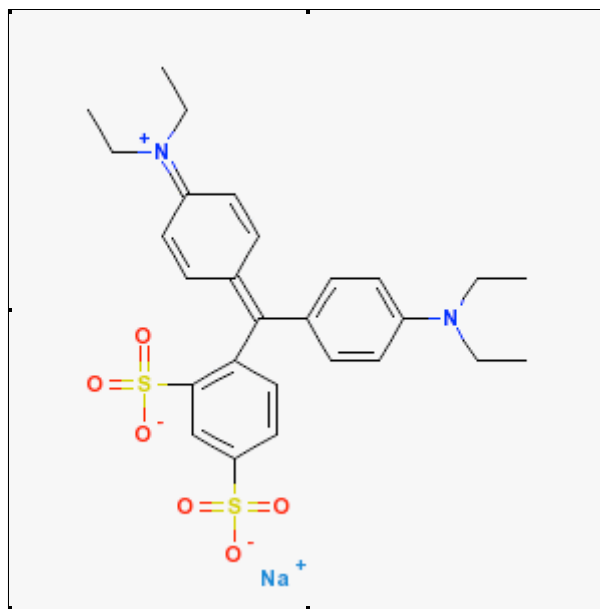


**Monoazo**

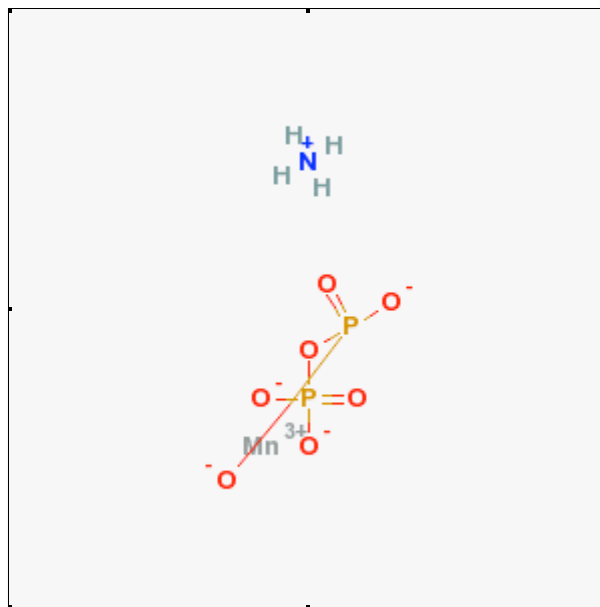


**Cu phthalocyanine**

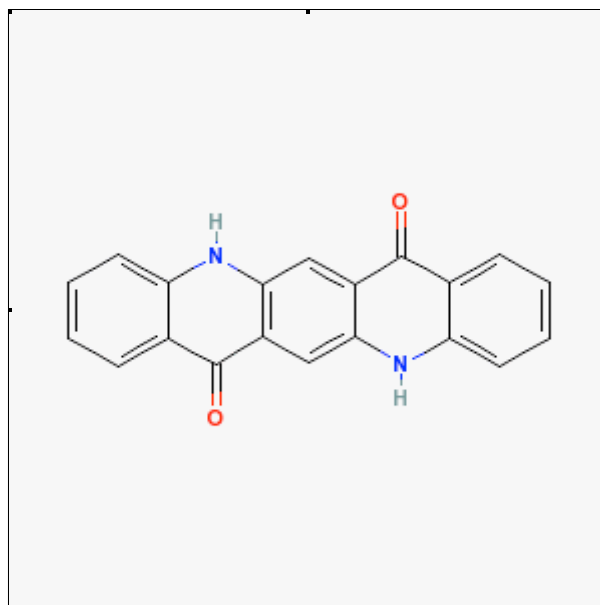




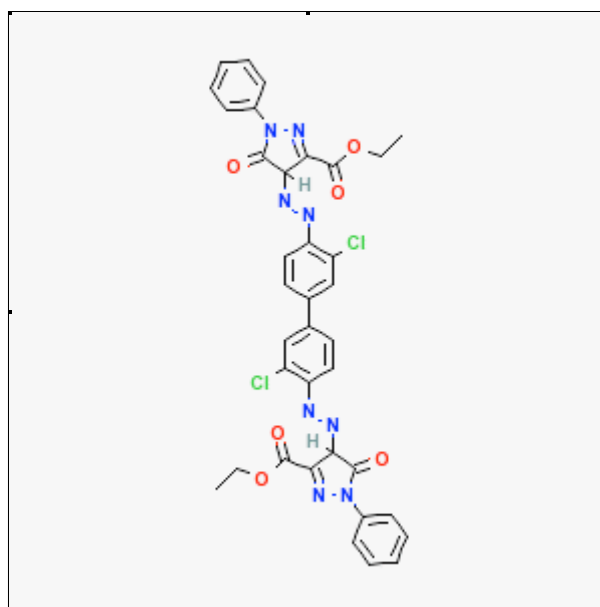
Azure Blue



Magnesium ammonium pyrophosphate



Quinacridone



Pyrazolone (diazo)

APPENDIX B<sup>1</sup>

**Table 1. Percentage of Elemental Composition of Tattoo Pigments Obtained by X-ray Diffraction\***

Stock No.	Color	Element†										
		Titanium (22)	Aluminum (13)	Silica (14)	Copper (29)	Chromium (24)	Iron (26)	Chlorine (17)	Sulfur (16)	Carbon (6)	Oxygen (8)	Magnesium (12)
8001	Black	...	0.25	...	...	...	85.95	...	0.29	...	13.51	...
8007	White	98.55	1.45	...	...	...	...	...	...	...	...	...
8016	Fire red	...	26.21	...	...	...	...	9.68	10.76	23.29	30.06	...
8022	Flesh No.1 (tan)	74.27	1.75	...	...	...	23.98	...	...	...	...	...
8031	Indian brown	41.98	0.76	...	...	...	57.26	...	...	...	...	...
9001	Crimson red	...	...	17.2	...	...	...	...	...	49.36	22.25	11.19
9002	Devil's red	27.65	2.6	0.53	...	...	...	...	...	51.67	17.55	...
9008	Lotus (red)	40.17	3.2	...	...	...	...	...	...	17.71	38.92	...
9009	Venetian brown	...	0.38	1.73	...	...	79.85	...	...	...	18.04	...
9014	Florida orange	...	...	...	...	...	...	...	...	84.35	15.65	...
9017	Lemonyellow	53.06	1.86	...	...	...	...	...	...	23.9	21.18	...
9022	White	96.41	3.59	...	...	...	...	...	...	...	...	...
9023	Black	...	...	...	...	...	87.98	...	...	...	12.02	...
9024	Permanentgreen	...	0.89	...	13.32	...	...	51.55	...	34.24	...	...
9025	Emerald green	5.45	0.49	...	...	72.66	...	4.15	...	...	17.25	...
9026	Pine green	44.34	4.08	...	8.27	...	...	6.71	...	14.64	21.96	...
9029	Parrotgreen	58.57	2.51	...	...	...	...	4.61	...	17.12	17.19	...
9036	Sky blue	37.95	1.9	...	11.06	...	...	2.16	...	35.41	11.52	...
9061	Blue green	...	1.14	...	14.46	...	...	52.24	...	32.16	...	...
9090	Cerise (red)	51.51	2.18	...	...	...	15.34	...	...	9.81	21.16	...
9091	Yukon white	94.98	5.02	...	...	...	...	...	...	...	...	...
9092	Mistygreen	51.5	2.51	...	...	...	...	3.59	...	18.43	23.97	...
9093	Misty blue	94.82	4.13	...	...	...	...	1.05	...	...	...	...
9094	Tulip yellow	27.29	2.29	0.22	...	...	...	2.29	0.3	37.3	30.31	...
9095	Peony (pink)	63.77	2.38	...	...	...	...	...	...	13.85	20	...
9096	New blue	50.93	2.36	...	8.54	...	...	1.39	...	18.21	18.57	...
9097	Blush (orange)	58.06	2.25	...	...	...	...	2.87	...	14.39	22.43	...
9098	Wild violet	65.29	2.88	...	...	...	...	...	...	9.56	22.27	...
9099	Tulip red	...	0.19	13.4	...	...	...	...	...	52.29	25.12	9
Not applicable	India ink	...	...	...	...	...	...	...	...	92.19	7.81	...

\* The numeric values in the table represent the elemental percentage in the composition of the pigment. Ellipses indicate absence. † The parenthical number below the element represents its atomic number.