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How soluble are tattoo pigments? BfR develops new testing method

The German Federal Institute for Risk Assessment (BfR) has developed a new method that, for the first time, allows the solubility of tattoo pigments in the body to be assessed. Put simply, solubility describes how many individual molecules can be released from a tattoo pigment particle. Whilst the solid colour particles hardly react chemically with the body's cells, dissolved molecules can move much more freely and, for example, damage the genome or proteins, as well as trigger allergies. Solubility therefore plays a decisive role in determining whether or not tattoo pigments cause adverse reactions in the body.

Initial measurements using this method show that most of the ink particles examined are surprisingly stable within the body. They remain as solid particles beneath the skin and release hardly any molecules. This could explain why allergy tests for tattoo inks often yield negative results: too few molecules are released from the ink particles to have any effect. The fact that allergic reactions associated with tattoos do occur time and again in practice is therefore probably not due to the colour particles themselves, but possibly to accompanying substances, degradation products and impurities in the pigment or the tattoo ink. These substances dissolve much more easily and may therefore explain the reactions observed.

In future, the new method may help to assess tattoo pigments more systematically and identify problematic pigments. It is also universally applicable and can be used beyond the field of tattoo ink research to easily determine the solubility of many poorly soluble substances and thereby assess their health risks more accurately.

The method measures the extent to which colour pigments dissolve by analysing the varying 'colour intensity' of particles and individual molecules. To do this, the colour particles are first mixed with special solvents that are strong enough to dissolve even very small amounts from particles that are otherwise poorly soluble. Using an optical measurement technique – UV/VIS spectroscopy – it is possible to determine precisely how many molecules a pigment actually releases.

The values obtained can then be extrapolated to other environments. For example, it is possible to calculate the extent to which the substances dissolve in water or, indeed, in bodily fluids and cells. To do this, established models are used which describe how molecules distribute themselves differently depending on the medium. This makes it possible, with a reasonable amount of effort, to determine the maximum achievable dissolved amounts of the respective substances in the body – even if the tattoo pigments remain under the skin for years or decades.

The results show a clear pattern: most of the pigments examined hardly dissolve at all. They remain in large numbers as solid particles and release only minute amounts of individual molecules. This is significant for risk assessment, as biological processes such as allergies or effects on the genome are generally caused by dissolved molecules rather than by larger particles of a substance.

At the same time, the study's results suggest that the allergic reactions repeatedly observed in people with tattoos do not necessarily originate from the pigment itself. Industrially manufactured tattoo inks often contain additives and contaminations that dissolve much more easily than the molecules of the respective colour pigments. Furthermore, earlier studies show that pigments are also broken down into more soluble molecules by sunlight. These substances can be released in significant amounts and have a higher probability of triggering allergic symptoms than the pigment itself.

However, the low solubility of the colour pigments does not mean that they remain permanently in their original location beneath the skin. In fact, some of the particles are so small that they can be taken up by macrophages ('scavenger cells') and transported via the lymphatic system. These particles then migrate as solid granules – rather than as dissolved molecules – to neighbouring lymph nodes, where they are deposited and cause significant discolouration.

Link to the study

The full study has been published in English in the journal *ACS Measurement Science* and is available at the following address: <https://doi.org/10.1021/acsmeasuresciau.5c00214>

Further information on the BfR website about tattoos and allergies:

Questions and answers about tattoo inks

<https://www.bfr.bund.de/en/service/frequently-asked-questions/topic/frequently-asked-questions-about-tattoo-inks/>

Allergies: The most important questions and answers at a glance

<https://www.bfr.bund.de/en/service/frequently-asked-questions/topic/allergies-the-most-important-questions-and-answers-at-a-glance/>

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