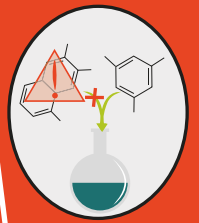




Safe(r) silver nanowires



A BETTER ALTERNATIVE TO INDIUM?

Indium is being intensively used in touch screens but has serious disadvantages. Thus, silver seems to be a promising alternative:

Indium

- ✗ High mechanical fragility
- ✗ Availability uncertain in future

VS.

Silver

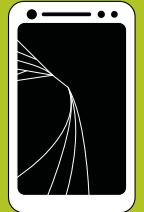


- ✓ Flexible network
- ✓ Lower cost and large availability
- ✓ Fewer toxicity concerns

DAMAGED SCREENS

The use of silver nanowires in touch screens can be a good alternative to indium based materials.

But the impact of these nanowires has to be evaluated on our skin. Is silver released when touch screens are damaged?

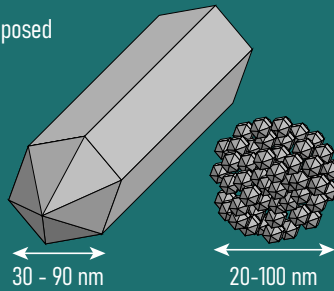


SILVER NANOWIRES OR NANOPARTICLES?

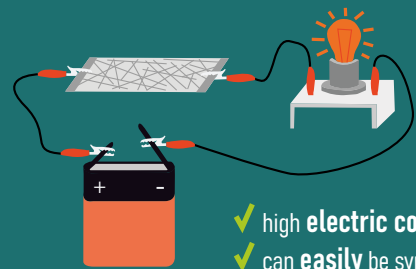
Silver can be toxic. However, silver nanowires (NWs) are less likely than nanoparticles (NPs) to release Ag⁺:

Silver NWs are a cristallized structure as opposed to silver NPs with a more amorphous nature.

Silver NWs are the most stable.



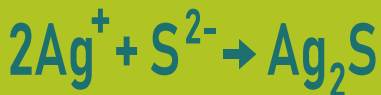
PROPERTIES OF SILVER NANOWIRES



- ✓ high electric conductivity
- ✓ can easily be synthesized
- ✓ transparent

SULFIDATION TO PREVENT TOXICITY

Sulfidation of silver nanowires drastically reduces the solubility of Ag. This process occurs naturally:



This prevents the release of Ag⁺ and limits the toxicity.



OBJECTIVES

Developing a new strategy to manufacture safer silver nanowires:

- ❑ Chemical protection against Ag⁺
Sulfidation appears to be a promising strategy but it must not alter silver conductivity.
- ❑ Physical protection against Ag⁺
Developing silver nanowires and test their toxicity (linked to their diameter) on keratinocytes.

SOME RESULTS OF THE PROJECT

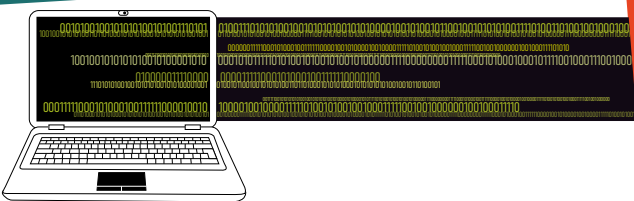
Silver nanowire toxicity on keratinocytes

Functionality after sulfidation

To check if sulfidation does not alter NWs conductivity, chemical modeling has been performed.

Information

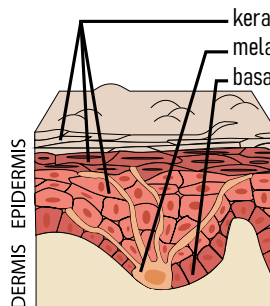
Chemical modeling helps solving chemical issues. Computer programs use theoretical chemistry to predict the behaviour of substances. Thus, the structure and the properties of molecules can be calculated.



Silver sulfidation leads to Ag₂S ionic conductivity, which may participate in electrical conductivity. This needs to be confirmed on an experimental basis.

Keratinocyte = skin's cell

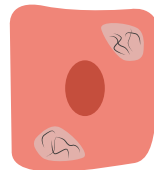
Keratinocytes are a major component of skin epidermis, they multiply near the basal lamina, then differentiate and migrate to the surface.



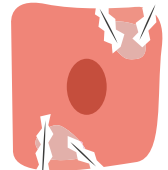
At the surface, cells are not alive, they are called squame.

Two types of silver nanowires (NWs) have been compared:

30 nm wide nanowires



90 nm wide nanowires



Whereas 30 nm wide NWs are crumpled within vesicles, 90 nm wide NWs keep their needle shape, puncturing cells, they are thus, more toxic.

It appears that the use of 30 nm NWs causes less concerns.

Sulfidation is likely to reduce the release of Ag⁺. It does not seem to alter conductivity but further experiments have to be performed to confirm it.

Moreover, it appears that thin NWs cause less damaged to the keratinocytes.

LIFE CYCLE STAGES STUDIED

