Nanostrukturierte Materialien: Gesundheit, Exposition, Materialeigenschaften

APQ: Adsorption of lipids on the surface of differently modified nanoparticles

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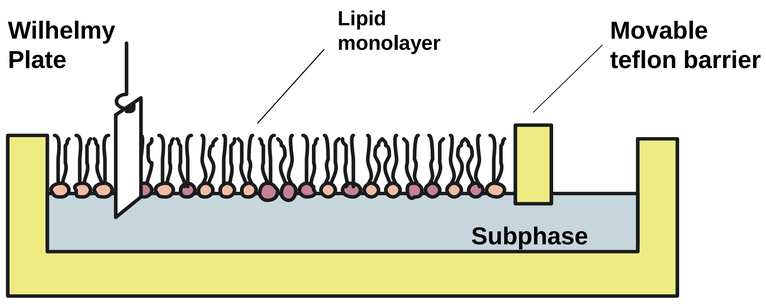
Introduction

To characterize the effect of nanoparticles (NPs) in biological systems, it is important to examine their interactions with various biomolecules including proteins and lipids. When being inhaled or introduced into the blood stream the surface of the NPs changes due to the adsorption of various biomolecules. This aquired corona may substantially change the NPs behaviour in biological systems. Therefore, the aim of this work was to characterize the adsorption behaviour of four different lipids on the surface of Ag-, ZrO_2 and SiO_2 –NPs with different surface modifications. First, the amount of lipids on the surface was determined by phosphate analysis and the lipid corona on the nanoparticles was made visible by Atomic Force Spectroscopy (AFM) and Transmission Electron Microscopy (TEM). Additionally, it was examined whether the lipid corona is stable or whether lipids are being released easily upon compression and expansion, which also mimicks the breathing process using a Wilhelmy film balance.

Method: Wilhelmy Film Balance



- A film balance is used to study the properties of amphiphilic monolayers such as lipids
- Amphiphilic substances (e.g. lipid-covered NPs) are spread on an aqueos subphase
- The molecules on the subphase can be compressed or expanded with a moveable teflon barrier
- The change in surface pressure upon compression/expansion is measured with a Wilhelmy plate

Applications:
- Monolayers of lipids as a simplified model of cell membranes
- Analysis of adsorption/desorption processes from different surfaces such as NPs
- Influence of different substances (e.g. NPs) on the phase transition of lipids

Results

Phosphate Analysis

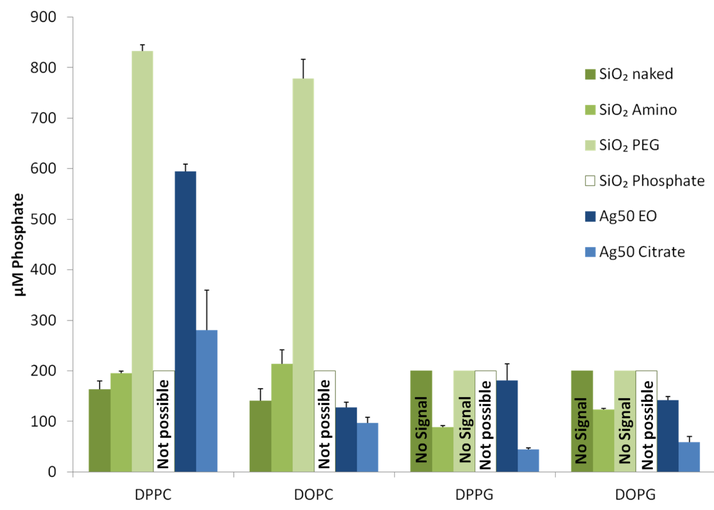


Figure 1 Amount of lipid phosphate detected on surface of NPs
NPs (1,25 µg/mL) were incubated for 12 h at 60 °C with the different lipids. After centrifugation and further washing steps the samples were incinerated with perchloric acid to turn lipid phosphate into inorganic phosphate which was subsequently detected.

Transmission Electron Microscopy

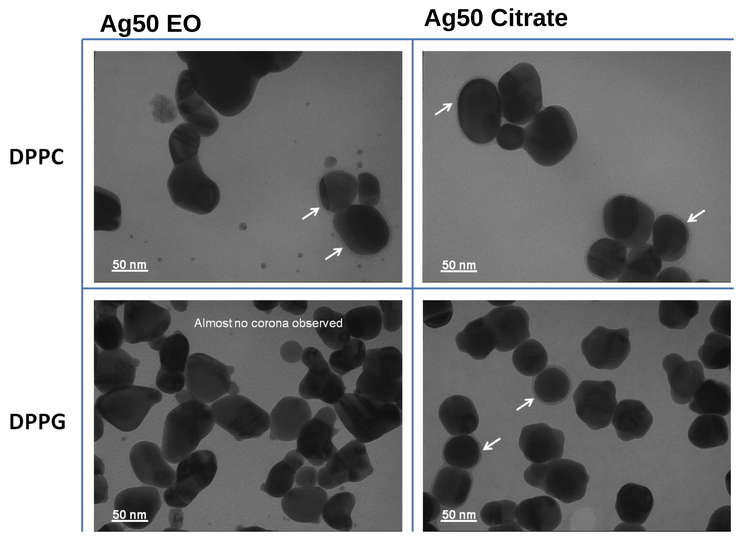


Figure 2 Lipid corona on Ag50 EO and Ag50 Citrate
NPs (1,25 µg/mL) were incubated for 12 h at 60 °C with the different lipids. After centrifugation and further washing steps the resulting samples were subjected to TEM.

- **ZrO_2 Modifications**
  - Phosphate analysis and TEM pictures not possible
- **Ag Modifications**
  - Incomplete corona on surface
  - Interaction higher for Ag50 EO than for Ag50 Citrate
  - DPPC interacts stronger than DOPC, DPPG and DOPG
- **SiO_2 Modifications**
  - Only weak interaction with lipids
  - SiO_2 PEG may interact strongly with DPPC and DOPC
  - Only SiO_2 Amino interacts with DOPG and DPPG
  - Phosphate analysis not possible for SiO_2 Phosphate

Film Balance Measurements

Figure 3 Surface pressure-area (π-A) isotherms of SiO_2 naked and SiO_2 Phosphate with DPPC
NPs (1,25 µg/mL) were incubated with DPPC for 12 h at 60 °C. After centrifugation and washing, the pellets were spread on a buffered subphase and the compression was started.

Figure 4 Surface pressure-area (π-A) isotherms of ZrO_2 Modifications with DPPC
NPs (1,25 µg/mL) were incubated with DPPC for 12 h at 60 °C. After centrifugation and washing, the pellets were spread on a buffered subphase and the compression-expansion cycle was started.

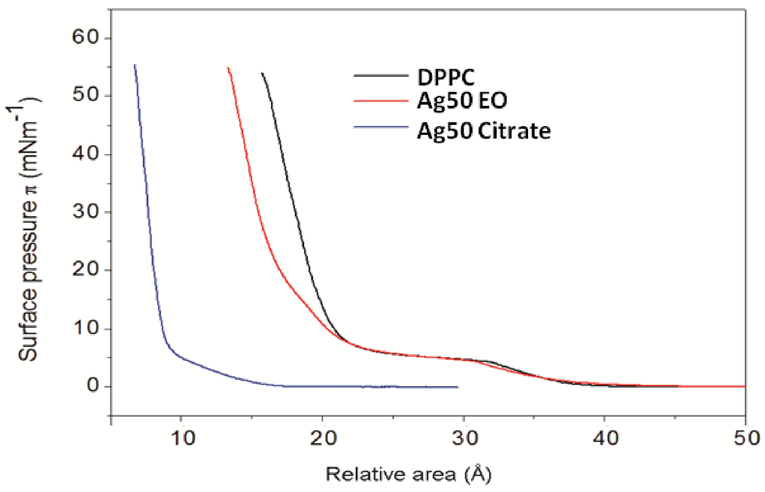


Figure 5 Surface pressure-area (π-A) isotherms of Ag50 EO and Ag50 Citrate with DPPC
NPs (1,25 µg/mL) were incubated with DPPC for 12 h at 60 °C. After centrifugation and washing, the pellets were spread on a buffered subphase and the compression was started.

Conclusion The tested nanomaterials only gain an incomplete, mostly weak lipid corona when incubated with different lipids. When being submitted to a modelled breathing process on the film balance SiO_2 naked,SiO_2 Phosphate, Ag50 EO and ZrO_2 Amino even loose their incomplete corona. The other NPs tested loose their corona only partly and NPs are still present on the subphase disturbing the normal phase behaviour of DPPC.

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