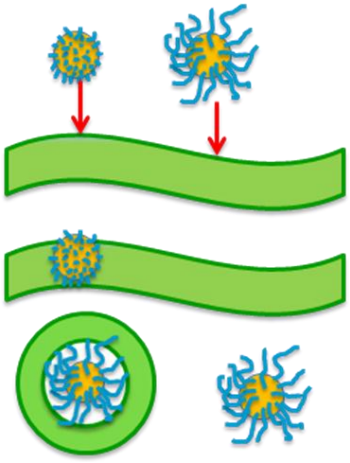
Project B2: Effect of polymer modification on nanoparticle – membrane interactions

Project leader: **Gradzielski (TUB)**
Co-supervisor: **Weikl (MPIKG)**
US partners: **Spontak (NCSU), Zauscher (DU)**

Outline. In the first period we studied the interaction of surface-modified silica nanoparticles (NPs) of different size with various phospholipid vesicle membranes. Depending on the state of the phospholipid membrane (gel/liquid) and size and type of silica NPs one observes adhesion to the outer side of the vesicles or incorporation into the vesicle interior. The first effect leads to a very pronounced increase of the colloidal stability of vesicle dispersions by orders of magnitude, while the latter has high relevance for questions of toxicity or the use of such particles for drug delivery. However, these investigations have all been done with "hard" silica NPs, under varying their charge conditions, and now their softness will be modified.

Research within the German group. In the continuation period the project will be extended by addressing the question how the softness of a NP affects its interactions with phospholipid membranes. For this purpose silica NPs will be modified with a more or less extended polymer shell. This will be achieved via surface polymerization by ATRP, which allows high variability in terms of the polymers attached (nonionic, cationic, anionic) and length of the polymer chains (DP = 10-150). This allows to control the "softness" and electrostatics, i.e., the range of the interaction potential of the NPs. They will be characterized comprehensively by means of static and dynamic light scattering (SLS, DLS), SAXS, and SANS. Then their interaction with phospholipid vesicle membranes (R = 50-200 nm, fluid/gel state) will be studied by scattering methods, fluorescence/FCS, and calorimetry (ITC, DSC), which allow for direct analysis of binding. Particularly interesting is the transport through the membrane and how it can be controlled via the polymeric shell of the NPs. Various scenarios, as depicted in the figure, can be envisioned, such as transport through the membrane, encapsulation, or adhesion at the outer surface. In order to learn about the dynamic aspects of these interactions these investigations will be done as a function of time, monitoring the systems over the s to weeks range. From this work systematic correlations between the elastic properties of the membrane and the surface properties of the NPs will be deduced, which will give a fundamental basis for understanding their properties as they are important for delivery systems and with respect to their potential toxicity.



Cartoon of possible ways of interaction between NPs and vesicle membranes, e.g. encapsulation or transport through the membrane.

Longer-term perspective. The kinetic aspects of the NP/membrane interactions will be in longer-term focus. Here we are especially interested in establishing relations between the surface structure of the nanoparticles, the membrane properties and how the transport through membranes is controlled by these parameters. The surface coverage of membranes by nanoparticles will also be studied by neutron spin-echo experiments (NSE).

Complementary work in US partner group. Additional structural information regarding the vesicle/NP systems will be obtained using the expertise of Spontak in electron microscopy, where cryo-TEM and tomography allow deducing unique additional structural features regarding the 3D-arrangement in these systems, which is of central importance for understanding these systems. The arrangement of our NPs on supported bilayers as a function of shell softness will be studied in cooperation with Zauscher, to yield a further understanding of these hybrid systems, also elucidating potential for applications.

Status of the project. This project is closely related to B1 (Weikl), but also to projects B3 (Grafmüller), B4 (Ballauff), and C4 (Lipowsky), where similar experimental questions are addressed. Curved interfaces play a role also in projects B5 (Schoen) and C3 (Dimova).