Experimental determination of colloidal stabilization mechanism by AFM

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colloidal processing

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Experimental procedure:

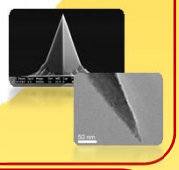
SiO_2 samples were prepared by sol-gel to obtain a highly dense and uniform SiO_2 **film [ref].**

Surface forces were measured using a Cervantes AFM System (Nanotec Electronica S.L., spain) operating in non-contact dynamic mode with amplitude modulation. A liquids cell was used for the measurements which were carried out at room temperature (23 ^{0}C) .

The samples were immersed for 1 h in the medium in order to allow the development of surface reactions and to obtain a stable surface.

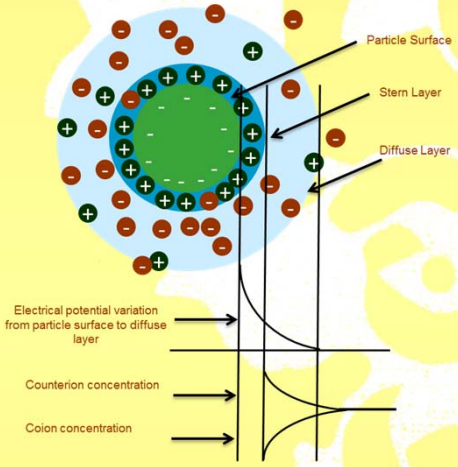
To carry out the study of the repulsive forces between the tip of the cantilever and the sample, **more than XX points per sample** were studied and 10 force measurements per point were carried out.

Technical Data	Nominal Value	Specified Range
Thickness /μm	4	3.0 - 5.0
Mean Width /μm	30	22.5 - 37.5
Length /μm	125	115 - 135
Force Constant /(N/m)	42	10 - 130
Resonance Frequency /kHz	330	204 - 497



DLVO theory.

Colloidal stability is related to particle-particle and particle-medium interactions. These interactions are a balance of attractive and repulsive forces. The surface of the oxides immersed in a polar media hydrates and then becomes charged depending on the pH. Immediately ion adsorption generate the Stern layer and, to maintain the electro-neutrality of the system, an ionic double layer is formed around the colloidal particles, as the counter-ions and co-ions (diffuse layer) arrange themselves around the particle to neutralize the surface charge.

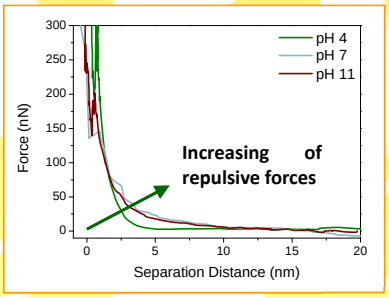


Objective of the work

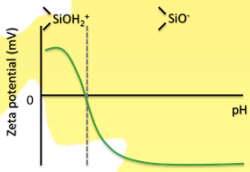
Verified the main principles of the stability of colloidal suspensions by the determination of forces acting in an aqueous medium between a SiO_2 surface and the cantilever tip of the AFM.

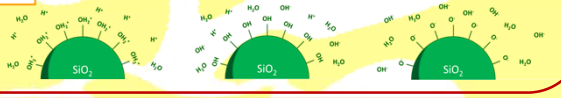
pH effect

The surfaces of the hydrated oxides are amphoteric therefore the pH of the media has a direct influence on the acid-base reaction that take place on them, changing their charge.



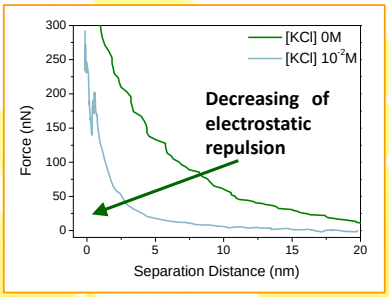
In the case of SiO_2 surfaces, repulsion forces at pH 7 and 11 are greater than pH 4, this is because increasing the pH value the negative charges increases to a maximum, developing higher repulsion forces between the tip and the surface.



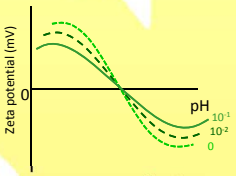


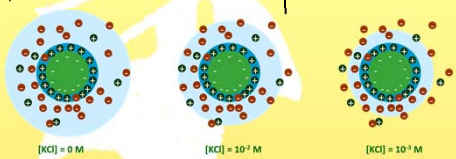
Salt concentration effect

The length of the double layer is determined by the value of the particle charge and the ionic strength of the medium. Increasing the salt concentration in the dispersion medium, particles experiment a more effective screening, making the double layer thinner and decreasing the absolute value of the zeta potential.

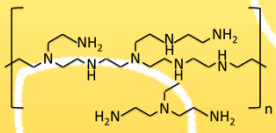


As can be seen in the figure, increasing the salt concentration of the medium decreases the repulsive forces. This is because to be the most effective screening make decreases the net charge of the Stern layer, reducing the repulsive forces.

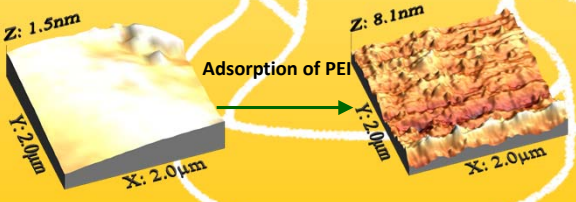




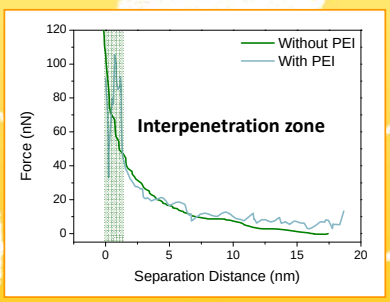
Effect of Polyethylenimine (PEI) addition



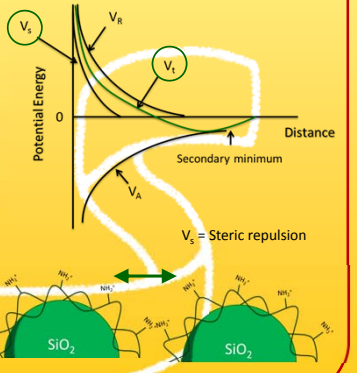
The adsorption of additives such as PEI increases the stability of the colloids, due to steric repulsion and to the charge of the side chains, that provide an electrostatic stabilization.



Topography of the SiO_2 surface without and with PEI



The inclusion of the PEI does not increase the repulsive forces but prevents contact between the tip and the surface to a few nm through steric mechanism. It can be seen that increasing the applied force the tip penetrates the adsorbed additive layer and reaches the contact.



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