Bacteria-nanoparticle interaction based on functionalized surfaces

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Abstract
Silica nanoparticles were synthesized and functionalized with different chemical groups (hydroxyl, mercapto, isocyanate, carboxyl and amino) in order to understand how different functional groups favor the interaction between nanoparticles and the envelope of different bacteria. Obtained results showed that bacteria-nanoparticle interaction is driven by the nature of nanoparticles surface and that different types of bacteria envelope do not influence this mechanism.

Nanometric structures, functionalization, bacteria interaction.

Introduction
Nanoparticles are being used as one of the most promising strategies to prevent bacterial growth and development. Due to their unique physicochemical properties, nanomaterials are able to interact intimately with bacteria. Therefore, this mechanism of interaction has been still unknown.1-2 It is believed that it depends on the properties of the nanoparticles (such as size, aggregation state and functionalization of its surface) and also on the organization of the constituents of the bacterial cell envelope.3

Results and Discussion
Quantification of chemical groups present on the silica surface was determined by thermogravimetric analysis through distinct weight loss stages (Figure 1A). For SiO2-OH and SiO2-NH2 samples, the weight loss between 180 °C and 700 °C is ~ 4.2% and ~ 5.6%, respectively. The difference ~ 1.4% between these samples is related to the -NH2 group incorporated on the material surface. This is also valid for SiO2-NCO and SiO2-SH samples, which showed ~ 2.1% and ~ 4.2% of –NCO and –SH groups, respectively. For SiO2-COOH, taking into account that SiO2NPs-NH2 were used as precursor for the synthesis, the difference between the weight loss of SiO2-NH2 and SiO2-COOH is ~ 9.5% related to –COOH group. FTIR spectra (Figure 1B) confirms the functionalization success where bands attributed do different chemical groups can be identified. Incubation experiments (Figure 1C and 1D) with Staphylococcus aureus and Escherichia coli bacterium showed the following bactericidal efficiency trend: SiO2-OH > SiO2-COOH > SiO2-NH2 > SiO2-SH > SiO2-NCO. Bare nanoparticles and aliquots of nanoparticles incubated with bacteria were analyzed by scanning electron microscopy (SEM) and are presented in Figures 1E, 1F and 1G.

Conclusions
Bacteria-nanoparticle interaction is extremely dependent on the the nature of nanoparticles surface which can be tailored to obtain structures with high bactericidal efficacy. Similar behaviors were seen when different types of bacteria cell envelopes where compared.

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