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THE INFLUENCE OF pH ON THE STABILITY OF SiO_2 SUSPENSIONS

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Abstract. Nanomaterials are currently widely used due to the various processing possibilities for a wide range of applications. SiO_2 nanoparticles (*NPs*) attracted extraordinary attention in scientific research domain due to the posibility of design with specific tailored properties for targeted medical applications. Stöber method has been used since 1968 and with same minor modifications, is the most widely used method for synthesis nanometric SiO_2. Due to their geometry and size, the SiO_2 *NPs* are suitable for 3D printing technique (used in the case of medical applications, in bone tissue engineering), a very modern method for materials processing. For this purpose, the SiO_2 *NPs* are used in suspensions and it is very important to know the *NPs* surface loading, due to its major influence on their aggregation behavior. The currently used methods do not allow the accurate measurement of this property, this being estimated by corresponding the zeta potential. In this study we present the pH influence on the stability of the SiO_2 suspensions. The SiO_2 NPs were prepared by the classic Stöber method, with spherical uniform geometry and size of 120 nm. To determinate the zeta potential were prepared suspensions with 0.05 wt % SiO_2 in various pH solutions: 1.679, 4.00, 7.00, 10.00 and 12.45. In the case of basic pH the values of the zeta potentials were bigger then -30mV, indicating that analyzed suspensions present stability in this medium.

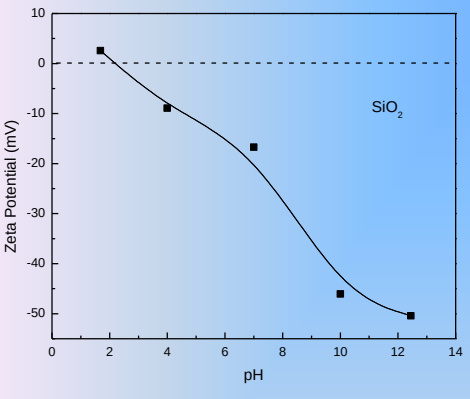
Experimental details

Synthesis of silica nanospheres.

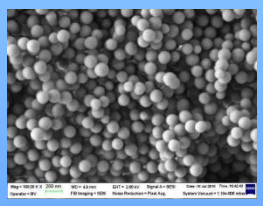
The synthesis of silica nanoparticles was made by chemical Stober method, using a mixture of 7 moles ethanol, 0.5 moles NH4OH and 7.5 moles H2O, homogenized through magnetic stirring and heated at 30°C, after that were drop wised added 0.14 moles tetraethyl orthosilicate. The mixture was then gellified at 80°C and the resulted powder was dried at 120°C for 24 hours. A white powder, containing silica nanoparticles, was obtained.

This method consists in polymerization of tetraethyl orthosilicate (*TEOS*) in a mixture of water and alcohol with low molar-mass, but also in the presence of ammonia, as catalyst. Polymerization is a process consisting of two stages: hydrolysis and condensation of *TEOS*, according to the reactions.

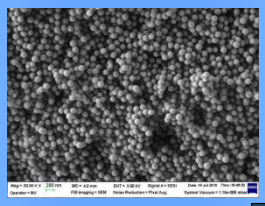
$$Si(OR)_4 + xH_2O \rightarrow (OH)_xSi(OR)_{4-x} + xROH \quad \text{Hydrolysis}$$
$$Si(OH)_4 \rightarrow SiO_2 + 2H_2O \quad \text{Condensation}$$



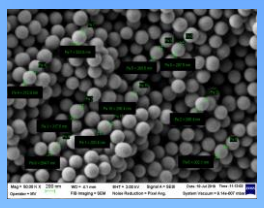
Zeta potential measurements as a function of pH of the solution



SEM images of SiO2 nanoparticles (x 100000)



SEM images of SiO2 nanoparticles (x 50000)

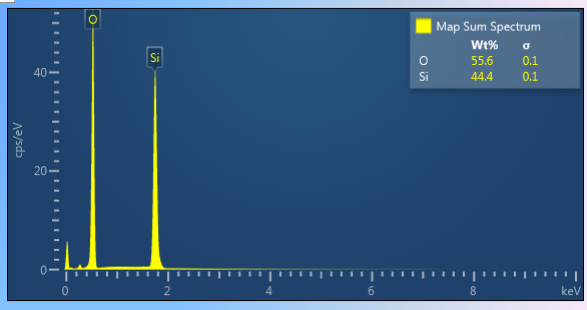


SEM images of SiO2 nanoparticles

Results and discussions

The Stober method has the advantage that it is a complex process but, in the same time, a controllable one. Thus, by modifying the synthesis parameters, the characteristics of the prepared nanoparticles, the composition, shape and the dimensions of the final product can be controlled. Because of this, it is easy to scaled-up for commercial and industrial applications.

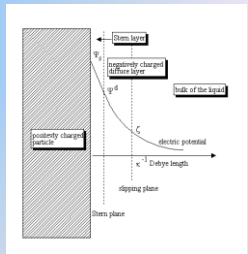
In this study, SiO2 nanoparticles were obtained by the classical sol-gel Stober method [9, 10], which involves the formation of SiO2 nanospheres by hydrolysis of alkyl silicates (tetraethyl orthosilicate) and subsequent condensation of silicic acid in alcoholic solutions, using ammonia as catalyst.



The EDS spectra images of SiO2 nanoparticles

To determinate the zeta potential were prepared suspensions with 0.05 wt % SiO_2 in various pH solutions: 1.679, 4.00, 7.00, 10.00 and 12.45..

In the case of basic pH the values of the zeta potentials were bigger then -30mV, indicating that analyzed suspensions present stability in this medium



Conclusions

- SiO2 nanoparticles were obtained by chemical synthesis (Stober) method;
- Compositional characterization by EDS confirmed the obtaining of pure silica;
- All the obtained particles have well-defined spherical shape and clearly separated from each other, with uniform dimensions (120nm);
- The isoelectric point (IEP) was determinated at 1.95 value for pH;
- SiO2 Zeta potential for pH below the isoelectric point are positive valueand for pH values above the IEP, the zeta potential values are negative, up to -50mV, indicating that analyzed suspensions present stability in alkaline medium.

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