

Structure and chemical stability of yttrium silica sol-gel microspheres

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INTRODUCTION: Biodegradable silica microspheres incorporating yttrium were investigated for possible use in the radio therapeutic treatment of special cancer tumors. The microspheres are designed to carry the radiation inside the cancer site, in order to provide a high and localized dose of beta radiation.

Sol-gel method allows at relative low temperatures obtaining materials of high purity and homogeneity with a controlled rate of biodegradability. By spray-drying method, microspheres with desired size can be obtained. Several yttrium silica microsphere batches were prepared in order to optimise the processing parameters. *In vitro* testing was focused on cations dissolution from microspheres immersed in Tris buffer solution at 37°C for up to 27 days. Structural characterization of the materials was done before and after immersion in the used solution.

METHODS: Silica microspheres of less than 50 µm of diameter containing yttrium were prepared by sol-gel and spray-drying methods. The obtained microspheres were thermal treated in order to control the biodegradation rate. The incorporation of yttrium in the microspheres was analyzed by Back Scattered Electron Imaging of Scanning Electron Microscope (BEI-SEM) equipped with Energy Dispersive X-ray Analysis (EDX). The chemical stability of the yttrium silicate microspheres have been investigated under *in vitro* conditions using Tris buffer solution with pH= 7.4, for up to 27 days. The yttrium and silica release behavior in the solution was analysed using Inductively Coupled Plasma Mass Spectrometry (ICP-MS) and UV-VIS spectrophotometer. The structural changes occurred during the immersion time have been evidenced by Fourier Transformed Infrared Spectroscopy (FT-IR).

RESULTS: BEI-SEM/EDXA analysis showed that yttrium was well and homogeneously encapsulated in some batches of the silica microspheres. The biodegradation results indicate that the silica release significantly decreased with the thermal treatment applied. The solution analysis points out a small release of yttrium from

the thermal treated samples in the immersion solution. The yttrium release depends not only on the thermal history of the samples but also on the incorporation of yttrium in the silica network.

The main vibrational modes of the Si-O-Si groups have been identified from the FT-IR spectra of the samples. The spectra exhibit a large band comprised between 1000 and 1200 cm⁻¹ which, together with the 796 cm⁻¹ band could be assigned to the asymmetric and symmetric stretching vibration mode of the Si-O-Si groups. The band located around 464 cm⁻¹ is attributed to Si-O-Si bending vibration. The stretching vibration of the Si-OH and NO³⁻ groups, located around 943 cm⁻¹ and 1385 cm⁻¹ disappear after the thermal treatment applied. The FT-IR spectra of the reacted microspheres revealed the structural changes occurred in the silica network during the immersion time. These changes depend on the type of the microspheres, indicating the influence of the processing conditions on the samples' structure and on the dissolution behavior of the microspheres in solution.

DISCUSSION & CONCLUSIONS: The biodegradation results reveal that the stability of the microspheres in the used solution depends on the thermal treatment applied as well as the incorporation of the yttrium in the silica network. The incorporation of yttrium in the microspheres strongly depends on the processing parameters. Using the optimal processing parameters yttrium can be well incorporated and stabilized in the silica microspheres, supporting the idea of using the sol-gel microspheres in radio therapeutic applications.

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