Synthesis, characterization and activation of metal oxide nanoparticles

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Metal and metal oxide nanoparticles (NPs) are commonly used in various industrial processes and are employed in commercial products such as sun-creams and paints. Therefore, the assessment of pharmacokinetic (PK) properties of NPs and potential toxicological effects due to long term exposure has recently become a challenge for the scientific community. Positron Emission Tomography (PET) is a powerful tool for the (non-invasive) pharmacokinetic characterization of new chemical entities, although a positron emitter has to be introduced in the chemical structure prior to image acquisition.

The objectives in this project are:

1- To develop a new strategy for the introduction of a positron emitter in the core of metal oxide NPs.
2- To characterize NPs before and after irradiation to evaluate the effects of activation in the physico-chemical and radiological properties.

Aluminium oxide NPs incorporating oxygen-18 were synthesized by reacting an aluminium salt ($Al_2(SO_4)_3{\cdot}16H_2O$[1] or anhydrous $AlCl_3$) with a base (Urea/reflux or NH_3(g)/Room temperature) in enriched water ($[^{18}O]H_2O$). The resulting NPs were bombarded with high energy (18 MeV) protons in an IBA 18/9 cyclotron to produce (*in situ*) ^{18}F (nuclear reaction $^{18}O(p, n)^{18}F$). After irradiation, the decay curves derived from positron annihilation were determined in a PET-CT camera (eXplore Vista-CT, GE Healthcare) and the number and relative amounts of positron emitters in the samples were calculated by adjustment of multi-exponential equations. NPs were also characterized by TEM, DLS, Raman Spectroscopy[2], and XRD before and after bombardment to assess the effect of irradiation on physico-chemical properties.

In general terms, no significant differences were observed between samples before and after irradiation, regarding particle size and chemical composition. However, variations in morphism were observed when $Al_2(SO_4)_3{\cdot}16H_2O$ was used as aluminium salt and Urea was used as a base. Regarding the radiochemical characterization, ^{18}F and ^{13}N (produced from the undesired nuclear reaction $^{16}O(p,\alpha)^{13}N$) were found in all samples, the most favourable case being when anhydrous $AlCl_3$ and NH_3 were used as starting aluminium salt and base, respectively (86% ^{13}N / 14% ^{18}F). Further experiments to improve the production of ^{18}F are being currently carried out.

Metal oxide NPs containing ^{18}O could be synthesized by reaction of aluminium salts with a base in $[^{18}O]H_2O$. Activation of such NPs with high energy protons led to the formation of ^{18}F and ^{13}N. The irradiation process did not introduce significant changes in particle size and crystal structure in most cases.

[1] Yüksel Sarikaya et al. J. European Cer. Soc., **22**, (2002)1905-10