Monitor of X-ray Activation of TiO_2 Nanoparticles for CT26 Cells Therapy by SR-FTIR

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Cancer treatment utilizing photo-catalytic process have been realized and practiced since the mid of 1980s. Most authors use TiO_2 nanoparticles with ultraviolet (UV) irradiation to enhanced cancer therapy because they believe that TiO_2 is biocompatible and with high degree of photoactivated cytotoxicity. However, using UV light source for cancer therapy presents several drawbacks due to its low penetration and incapability to be focused. Therefore, X-ray irradiation with higher penetration, could be a promising candidate to allow the treatment of deeper organs without requiring optical fibers or additional surgery. In this study, the photocatalytic reaction by UV and X-ray irradiation was evaluated by the photodegradation of methylene blue (MB) in solution with anatase TiO_2 nanoparticles measured by ultraviolet-visible spectroscopy. The cell damage was evaluated by the synchrotron radiation Fourier-transform infrared (SR-FTIR) spectroscopy using CT26 cell line to estimate the therapeutical effect. SR-FTIR with high coherence and ultra-high brilliance from synchrotron radiation photon source, provides high spatial resolution and signal to noise ratio to screen various biological studies including investigation of cell membranes, proteins and nucleic acids, as well as tissues engineering. Understanding the degree of damage by the radiation is quite important for therapeutical applicatio

The photodegradation ratio C/C_0 was derived from the normalized 664 nm peak heights as shown in Figure 1. The comparison between the X-ray and UV irradiation results cannot be used for a full quantitative assessment because of the different source characteristics. Qualitatively speaking, however, we can estimate that X-rays are at least as affective as UV light.

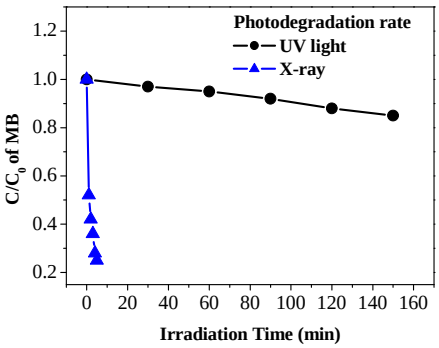

Figure 1. The photodegradation ratio C/C_0 (C = remaining methylene blue concentration; C0 = initial concentration) derived from the normalized 664 nm peak heights.

In order to understand the chemical nature of the conditioned investigated, control and UV or x-ray irradiated cells were analyzed by SR-FTIR. CT26 cell under different treatments exhibited significant spectra variation in the range of 1800 to1000 cm^{-1}, as shown in the Figure 2. The frequencies of the maximum of the Amide I peaks also shifts toward to lower energy after both treatments . The most striking UV or x-ray-induced spectral variation is the appearance of a new peak at ~1730 cm^{-1} but totally absent for non-irradiated specimens. The C=O bound presented in the spectra could be associated with the CT26 cells damaged after irradiation.

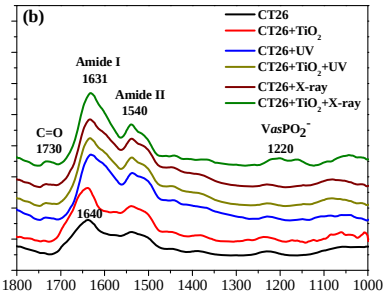

Figure 2. Synchrotron radiation FTIR spectra of CT 26 cells in the range 1800-1000 cm-1 for different treatments.

Figure 3 shows the intensity ratio between the 1540 and 1730 cm-1 features related to the carbonyl group and to protein amide II. These results corroborate the conclusion that X-rays do affect the cell+TiO_2 system in a way similar to UV irradiation. The ratio was in fact higher for X-ray irradiation than for UV irradiation. Furthermore, the absence of C=O bound peak in the spectrum of CT26 cells treated with TiO_2 nanoparticles could be also give us chemical insight of cytotoxicity.

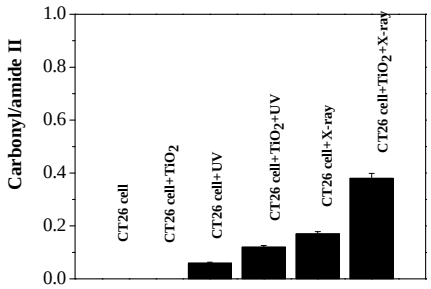

Figure 3. Carbonyl/amide II ratio of CT26 cells for different treatments.