On post-irradiation oxidation of Vitamin E-stabilized UHMWPE.

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Introduction.
Ultra high molecular weight polyethylene (UHMWPE) has been the material of choice for bearing components of total joint arthroplasty for the past 30 years. According to the ASTM regulation 648-07, the UHMWPE for orthopaedics does not contain any stabilizer and therefore it can oxidize very easily. Sterilization with high energy radiation in the presence of air is well known to be the main cause of oxidative degradation of orthopaedic UHMWPE. The irradiation process with high energy radiation (gamma radiation or e-beam) produces, at the end of sterilization, an amount of macroradicals proportional to the absorbed dose and, in the presence of oxygen, the oxidation process starts at low temperature. It has been shown in this process, called post-irradiation oxidation (1), all the oxidation products (hydroperoxides, ketones, acids, alcohols) are formed without thermal decompositions of hydroperoxides. Aim of this work is to evaluate the role of Vitamin E as a stabilizer in the post-irradiation oxidation process.

Materials and Methods.
Commercially available grade GUR 1020 UHMWPE slabs with and without Vitamin E were micromotmed to 180 µm thick films in air, at room temperature (Polycuts Microtome, Reichert-Jung, Germany). The films were irradiated to 60 kGy with e-beam in inert atmosphere at room temperature (Bioster, Seriate Italy) and stored in liquid nitrogen in the dark until analyses were performed. Then the films were stored at RT in dark. The FTIR measurements were run on a Spectrum 100 spectrometer (Perkin-Elmer, Shelton, Connecticut, USA). All spectra were run in the transmission mode with a 4 cm⁻¹ resolution and 16 scans per spectrum. The peak at 2020 cm⁻¹, a combination band associated with the twisting of CH₂, was used as an internal standard, since it can be regarded as unaffected by minor changes in the polymer structure. At the peak at 2020 cm⁻¹, all the spectra were normalised at an absorption of 0.05, correlating to a film thickness of ca. 100 µm. All the absorbance values were measured on spectral subtractions (irradiated - original). Ketones, free and bonded hydroperoxides were analyzed by means of their absorption bands at 1718, 3550 and 3420 cm⁻¹ respectively.

Results.
Figure 1a and b show the build-up of hydroperoxides and ketones respectively as a function of the ageing time at RT for films irradiated in air at 60 kGy. Figure 2 shows the rate of ketones formation. The rate of formation of hydroperoxides follows the same behavior.

Discussion.
The rate of hydroperoxides and ketones formation is very high after the irradiation process and then it decreases in the first 100 hours. The rate is proportional to the vitamin E concentration.

References.

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