Radiation Technologies: Processes and Products

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Radiation Technologies: Processes and Products is an interdisciplinary group that uses the holistic approach as the key to conceptualize a research or a service. This interdisciplinarity, using Biology, Chemistry and Physics science, allows the study of a subject from various angles and methods unified by a common goal: the validation of methodologies to understand the subject of study.

The group *modus operandi* permits a constant connection with Industries, Universities and other Research groups applying its "way of knowing" in response to requested services, as a collaborator in a research project or in the transmission of knowledge. The group activities focus on the delineation, development, validation and application of technologies and processes in various fields, such as Environment, Food and Pharmaceutics. As a fundamental part of the validation studies, Risk Analysis is being applied as a process management tool either in production lines of studied products (*e.g.* food, devices and pharmaceuticals) or in environmental control (*e.g.* hospitals rooms and pharmaceutical industries).

In the scope of ITN mission the group is requested by the authorities or private industries to undertake a consultant role on sterilization and decontamination procedures mainly applying ionising radiation. The group also develops work with the National and International normalization, standardization and certification bodies (IPQ, CEN and ISO).

Being aware of society's current needs and the demand of Quality, Innovation and Development, the upgrading and renewal of facilities are being carried out in the scope of project REEQ/996/BIO/2005. In the course of this project, modelling tools (Monte Carlo simulations) have been applied to the pre-upgrading phase of ionizing radiation equipments (*e.g.* gamma experimental facility). Other domain of this project has been the design of a renewed layout of an existing building transforming it in an interdisciplinary laboratory with controlled environment in order to assist new applications for radiation technology, among others. These facilities, together with the inclusion of automation/robotic systems, in a further stage, have as main purpose to allow researchers of National and International Institutions and Industries to develop radiation technologies and/or to cope with the need of environmental control areas (clean areas) for their work.

The Group's main R&D activities are focused at employing ionising radiation technologies to new processes and applications in Agriculture, Food, Pharmaceutical, Wastewater Treatment and other areas. In order to improve our understanding of the Radiation effects in products integrated methodologies composed by Analytical Methods of Biology, Microbiology, Chemistry and Physics are being used. Molecular Biology new trends based on PCR technique are being developed as a diagnostic tool (*e. g.* potential pathogenic micro-organisms) and as well as fingerprinting methods to assess the bio-diversity profile of environmental samples.

Training and "know-how" diffusion are one of the main issues of this Group reflecting in the achievement of academic degrees (Graduation, M.Sc. and Ph.D.) and in the dissemination of obtained results in the scientific community (publications, workshops and conferences).

The financial support of the group is based on projects, sponsored by National (e.g. FCT, AdI) and International (e.g IAEA) science foundations and expertise services to Industrial Companies.

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Radiation Technology in Chemistry

R. Melo, J.P. Leal, J. Branco, Erzsebet Takacs[1], A. Bechior, S. Cabo Verde, M. L. Botelho

The radiolysis phenomenon caused by ionizing radiation (γ; β) applied to the environmental remediation of wastewater foreseen a promising treatment technology. The chemistry behind this process is essential to improve substantially our basic understanding of the radiation chemistry of recalcitrant compounds (reactions, pathways, and rates) in various systems. Gallic acid (GA) is a biorecalcitrant phenolic compound and could be considered as a model pollutant of the wastewater generated in the cork boiling process. The aim of the present research is the evaluation of γ and β radiation as emerging oxidation technologies. The evaluations of rate constants as well as the establishment of the partial contributions of the direct and radical reactions pathways to the global process are being studied. The studies performed in the Institute of Isotopes, Budapest showed that the GA is almost degraded (~86%), at 60 kGy, in the LINAC accelerator at 360 kGy/h. The HPLC measurements showed three main radiolytic products. The •OH and e^-_{aq} radicals attack were studied using pulse radiolysis technique. The spectral characteristics of the intermediates formed in •OH and e^-_{aq} reactions are different. Results are being analysed to better understand the degradation mechanism of such compound. Other Chemical field of study was the effects of gamma radiation on human haemoglobin structure evaluated by UV-VIS spectroscopy. Results pointed out to different degradation response of haemoglobin at lower dose rate (27 Gy/h) and at higher dose rate (270 Gy/h) which there was a decrease of the intensity against an increase of the haemo groups, respectively.

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Radiation Technology in Physics

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Monte Carlo methods and computational tools provide evidence not only in support of the assessment of dose distributions but also in shielding calculations in industrial processing facilities. Regarding this, MCNPX has been used to calculate the dose rate values of several positions in the Unit of Radiation Technologies (UTR), in order to carry out the effectiveness of the variance reduction techniques, concerning shielding verification. Simulated results were compared with ionizing chamber values (LMRI, ITN) and taking into account some disagreement in the results, the methodology is being developed, namely with an attempt of a better definition of the irradiator and chamber geometry. A study concerning the low dose effect on human mature red blood cells was done by means of necrosis and apoptosis induction. Due to exposure to gamma radiation (5, 10, 20 and 30 kGy) red blood cells show lactate dehydrogenase release in the medium. The % of specific lysis is time dependent – increases with time of incubation (until 72h), after that shows a significant ($P< 0.05$) decrease. In apoptosis, control values determination were higher than experimental levels, which means that red blood cells die by necrosis and the quantification was due to the presence of haemoglobin on medium.

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Radiation Technology in Microbiology

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The environmental persistence of infectious microorganisms is a current issue that questions the efficacy of available disinfection methods. In this scope two studies were developed. One, a research project, aimed to assess the inactivation response to common disinfectants (50 - 90% Ethanol and 1000 - 5000 ppm of Bleach) of two surrogates' models for human norovirus (murine norovirus – MNV and feline calicivirus – FCV). The virus infectivity was estimated using three different methods (Plaque assay, Tissue Culture 50% Infectivity Dose – $TCID_{50}$ and Quantitative Real-time PC–qRT-PCR) for comparison purposes. FCV (> 4 log titer decrease) point to be more sensitive than MNV (max 4 log titer decrease) to the assayed disinfectants. Based on the obtained results ethanol solutions point out to be more efficient (4 log decrease) than bleach (2 log decrease) in the inactivation of MNV. FCV was not detected when bleach solutions were used and a 5 log titer decrease was verified with ethanol treatment. qRT-PCR suggested to follow up the MNV inactivation response when compared with the plaque assay (ratio<2), the gold-standard method to measure virus infectivity. $TCID_{50}$ method point out to be a potential method to measure the inactivation of norovirus. The other study refers to a partnership between RTPPG and the company TradeLabor. This service pretended to evaluate the number of viable particles in several national health care services. The air bioburden ranged between $1 – 10^2$ ufc/m^3 and in the majority of cases the obtained values were not in consonance with the ISO room classification, suggesting that correction actions need to be made in the health routine disinfections procedures.

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