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Poly(Methyl Methacrylate) Degradation Products and Its in vitro Cytotoxicity Evaluation in NIH3T3 Cells

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Abstract : Biosensors are used in many applications providing real-time monitoring to treat long-term conditions. Thus, understanding the physicochemical properties and biological side effects on the skin of polymers (e. g., poly(methyl methacrylate), PMMA) employed in the fabrication of wearable biosensors is crucial for the selection of manufacturing materials within this field. The PMMA (hydrophobic and thermoplastic polymer) is commonly employed as a coating material or substrate in the fabrication of wearable devices. The cytotoxicityof PMMA (including residual monomers or degradation products) on the skin, in terms of cells and tissue, is required to prevent possible adverse effects (cell death, skin reactions, sensitization) on human health. Within this work, accelerated aging of PMMA (Mw ~ 15000) through thermal and photochemical degradation was under-taken. The accelerated aging of PMMA was carried out by thermal (200°C, 1h) and photochemical degradation (UV-Vis, 8-15d) adapted employing ISO protocols (ISO-10993-12, ISO-4892-1:2016, ISO-877-1:2009, ISO-188: 2011). In addition, in vitro cytotoxicity evaluation of PMMA degradation products was performed using NIH3T3 fibroblast cells to assess the response of skin tissues (in terms of cell viability) exposed with polymers utilized to manufacture wearable biosensors, such as PMMA. The PMMA (Mw ~ 15000) before and after accelerated aging experiments was characterized by thermal gravimetric analysis (TGA), differential scanning calorimetric (DSC), powder X-ray diffractogram (PXRD), and scanning electron microscopy-energy dispersive spectroscopy (SEM-EDS) to determine and verify the successful degradation of this polymer under the specific conditions previously mention. The degradation products were characterized through nuclear magnetic resonance (NMR) to identify possible byproducts generated after the accelerated aging. Results demonstrated a percentage (%) weight loss between 1.5-2.2% (TGA thermographs) for PMMA after accelerated aging. The EDS elemental analysis reveals a 1.32 wt.% loss of carbon for PMMA after thermal degradation. These results might be associated with the amount (%) of PMMA degrade after the accelerated aging experiments. Furthermore, from the thermal degradation products was detected the presence of the monomer and methyl formate (low concentrations) and a low molecular weight radical (·COOCH3) in higher concentrations by NMR. In the photodegradation products, methyl formate was detected in higher concentrations. These results agree with the proposed thermal or photochemical degradation mechanisms found in the literature.1,2 Finally, significant cytotoxicity on the NIH3T3 cells was obtained for the thermal and photochemical degradation products. A decrease in cell viability by > 90% (stock solutions) was observed. It is proposed that the presence of byproducts (e.g. methyl formate or radicals such as $\cdot COOCH_3$) from the PMMA degradation might be responsible for the cytotoxicity observed in the NIH3T3 fibroblast cells. Additionally, experiments using skin models will be employed to compare with the NIH3T3 fibroblast cells model.

Keywords : biosensors, polymer, skin irritation, degradation products, cell viability
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