

Modification of polysulfone by means of UV irradiation and H₂O₂ plasma treatment

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INTRODUCTION: Polysulfone is frequently used as a material for filtration membranes (eg., for haemodialysis) and medical implants of various types. The hydrophobic character of polysulfone surface, resulting from its chemical structure, is the reason of membrane fouling with proteins, but this effect can be diminished by making the surface more hydrophilic. The effect of the irradiation of polysulfone with the UV light absorbed by the polymer and the effect of plasma H₂O₂ treatment was studied. The interactions of the cells with polysulfone and modified polysulfone samples were monitored.

METHODS: Materials: polysulfone (PSU) (Aldrich, M_n = 16000); the samples were prepared in the form of homogeneous films or composites consisting of monofilament polypropylene (PP) mesh (Bard) covered with PSU thin layer (PPSU/PP). The spectra of PSU samples were recorded with 8452A Hewlett Packard (UV-VIS), EQUINOX 55, Bruker (FTIR), FTIR Excalibur (ATR) and Renishaw 2000 (RS) spectrophotometers. SEM observations of the polysulfone surface were performed with JSM-5410 Jeol instrument. Contact angles of water on the investigated samples were measured using the sessile drop technique with a Krüss DSA 10 apparatus. The samples were irradiated with the UV light absorbed by the polymer (λ = 254 nm) with the aid of ASH 400 medium pressure mercury lamp (PSU/irr) and subjected to plasma H₂O₂ etching in a Sterrad 100 system (PSU/pl). The samples were immersed in a bovine serum albumin solution and the evaluation of protein adsorption was done with a spectrophotometric method at 280 nm. Cells: human osteoblastic line HFOB 1.19, human fibroblastic line HS-5, human macrophagous line KMA. Cell cultures were run in an incubator in the atmosphere of 5%CO₂/95% air. The viability of the cells was determined using the method based on MTT (Sigma) dye metabolism in living cells mitochondria. The concentrations of collagen type I and IL-1β were evaluated by means of ELISA tests (DSLabs Inc., USA).

RESULTS: The modified surfaces present a much rougher morphology than the initial PSU films, which was observed in SEM micrographs. The decrease of sulfone end ether bands connected with the degradation of polysulfone as well as the formation of carbonyl and hydroxyl groups and polyphenyl structures was confirmed by spectroscopic measurements carried out for UV irradiated samples. The amount of bovine serum albumin adsorbed on the modified surfaces was lower than that taken off from the original films. The contact angle of water on the investigated samples visibly decreased after UV irradiation and plasma treatment (e.g., PSU: 82°, PSU/irr: 44°, PSU/pl: 63°).

The viability of fibroblasts and osteoblasts cultured with the modified samples was lower than in the presence of the unmodified ones (e.g., osteoblasts - PSU: 82%, PSU/irr: 60%, PSU/pl: 66%; fibroblasts - PSU: 78%, PSU/irr: 65%, PSU/pl: 75%) while macrophages were unaffected by irradiated PSU (PSU: 84%, PSU/irr: 86%, PSU/pl: 92%). The level of cell's activation was estimated by the determination of the amount of collagen type I secreted by fibroblasts and osteoblasts as well as IL-1β by fibroblasts. The yield of collagen type I production by living osteoblasts and fibroblasts was enhanced after the UV and plasma modification of the surface. The level of IL-1β is low (100-140 pg/ml for PSU samples, 125 pg/ml for fibroblasts cultured without polymer sample).

DISCUSSION & CONCLUSIONS: The irradiation of polysulfone with the light absorbed by the polymer (254 nm) and the etching with H₂O₂ plasma change the polymer surface making it more hydrophilic due to the introduction of polar groups containing oxygen (carbonyl, hydroxyl). These modifications resulted in the diminished ability to absorb albumin and the decrease of the contact angles of water. The cellular response to the various samples is differentiated and depending on the kind of the cells, but the biocompatibility of the investigated samples is satisfactory.

