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PEEK Substrates for Measurement of Contractile Cell Forces of Primary Cells

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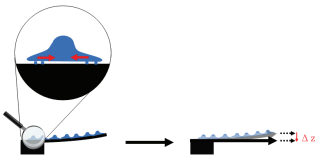
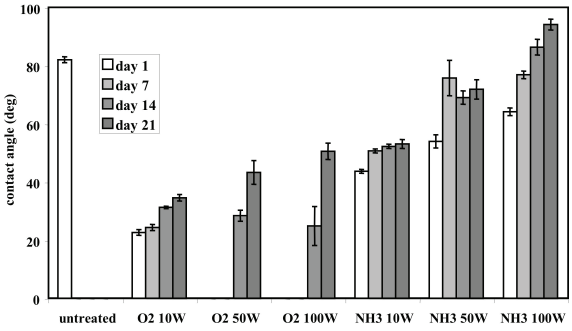
INTRODUCTION

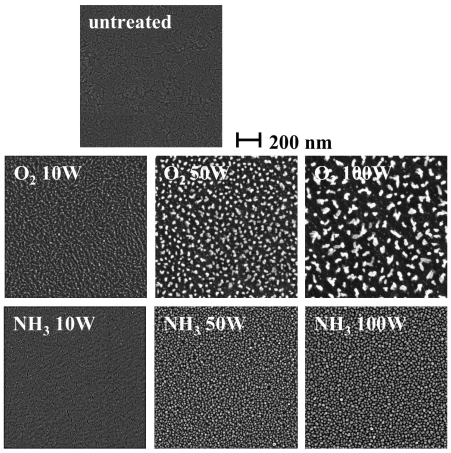


Polyetheretherketone (PEEK) gains increasing interest as biomaterial for trauma, orthopedic and spinal implants. Our aim is to measure cell forces on PEEK substrates that are relevant for medical applications. By functionalization and nano/micro-structuring of the substrate surface, we are going to improve medical implants. As one example, we have measured contractile cell forces (see poster J. Köser et al.). Another example is demonstrated measuring primary cell behaviour on plasma treated PEEK substrates. Starting from commercially available PEEK, substrate modifications by plamsa treatment have been developed. Since primary cells are especially relevant in biomaterials research, the effect of plasma treatment on two different cell types was studied: human adipose tissue-derived stem cells (ASC) and human dermal microvascular endothelial cells (HDMEC).

NANOSTRUCTURING OF PEEK SUBSTRATES BY PLASMA TREATMENT

contact angle measurements of nano-structured PEEK substrates

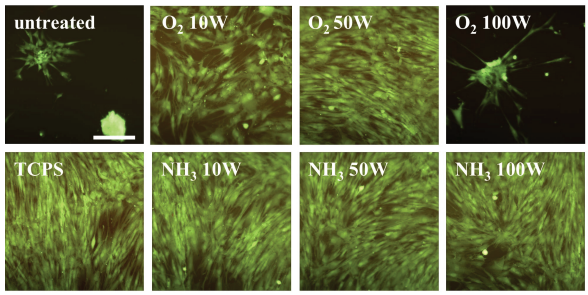




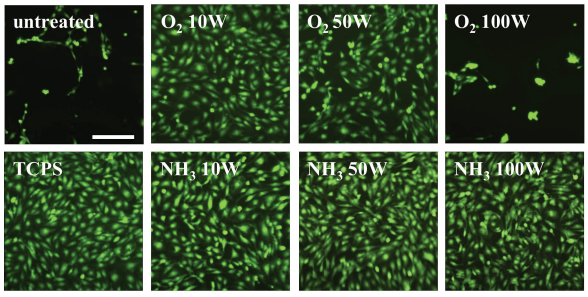
Besides a decrease in contact angle (see figure), both oxygen and ammonia plasma treatment induced highly reproducible nano-structures on the PEEK substrates (see figure). The pillar-like structures increased in size with applied power. Oxygen plasma is more effective in surface etching than ammonia plasma. The contact angle of plasma treated PEEK substrates increased during 21 days of dry storage (see figure). In general, higher etching rates resulted in larger contact angles. The contact angle of oxygen plasma treated substrates after 21 days stayed below 50°, compared to a contact angle of 82° for untreated PEEK surfaces. Ammonia plasma treated substrates resulted in contact angles of 50°, 70° and 92° for 10 W, 50 W and 100 W plasma intensity, respectively.

PRIMARY CELLS ON PLASMA TREATED PEEK SUBSTRATES

ASC



HDMEC



Two kinds of human primary cells were grown on the plasma treated PEEK substrates: ASC (human adipose tissue-derived stem cells) and HDMEC (human dermal microvascular endothelial cells). ASC were isolated from liposuction-derived tissue, HDMEC from juvenile foreskin. The cells were seeded on the PEEK substrates at passage 4, cultured for 48 h under standard conditions and stained with Calcein-AM. Both cell types did neither grow homogeneoulsy on untreated PEEK nor on strongly oxygen plasma treated PEEK substrates (100 W). Ammonia plasma and intermediate oxygen plasma treatment had a positive effect on cell attachment and proliferation. The treatment induced similar phenotypes as on tissue culture polystyrene (TCPS).
Scale bars correspond to 200 µm.

CONCLUSIONS AND OUTLOOK

Oxygen and ammonia plasma treatments of PEEK substrates has resulted in highly reproducible nano-structures. The size of the nano-structures was tailored varying the applied power during plasma treatment. Under identical process parameters (30sccm, 5min), oxygen was more erosive than ammonia.
Our results demonstrate that both primary cell types attached and spread appropriately on plasma-treated PEEK substrates. Ammonia plasma treatment is preferred because we have not found any negative effects on cell spreading so far.

Using nano-structured PEEK substrates, we are going to measure the contractile cell forces as a function of the nano-structure size, size distribution and density. In this way we take advantage from a physical method to improve nano-surface structuring of implant materials. Futhermore, we are going to focus on the characterization of the cell-substrate interaction.

ACKNOWLEDGEMENTS

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