The use of a library of industrial materials to determine the nature of substrate-dependent performance of primary adherent human cells

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Statement of Purpose: One of the current challenges in biomaterials design for tissue engineering is to simultaneously control the properties of the biomaterials and to determine the critical parameters of the biomaterials for a given cell type. We developed a library of industrial materials with defined specifications.[1] The library can be applied to any adherent cell type for determining structure-function relationships between material properties and biological performance.

Materials and Methods: The library consisted of 16 commercial industrial materials. The physical properties of all materials were fully characterized by water contact angle (WCA) measurements, profilometry, Fourier transform infrared spectroscopy (FTIR), secondary ion mass spectroscopy (SIMS), streaming potential measurements and determination of Young's moduli. The library was then applied to human primary renal proximal tubule cells (HPTCs) and human umbilical vein endothelial cells (HUVECs).[1] Cell proliferation on different materials of the library was determined by 4',6'-diamidino-2-phenylindole (DAPI) staining and followed by high content screening using the ImageXpress Micro System (Molecular Devices, Singapore). Cell differentiation was assayed by functional assays and immunostaining.

Results and Discussion: The materials covered a broad range with regard to each of the properties analyzed. For instance, the materials displayed WCA between 0° (too small to be measurable) to ~ 160°. We evaluated cell growth on the different materials by counting cell numbers on day seven after seeding (Fig. 1a, b). The results revealed that substrate stiffness was the major determinant of cell performance. The ability to grow and differentiate on stiff or more compliant materials was cell type-dependent, but cell performance of the tested cells was consistently best on tissue-culture polystyrene, cover glass and Thermanox© (consisting of a polyester film).[1] These were the stiffest materials. The functional assays and immunostaining data showed that properly differentiated endothelia and epithelia were formed on the stiffest materials.[1]

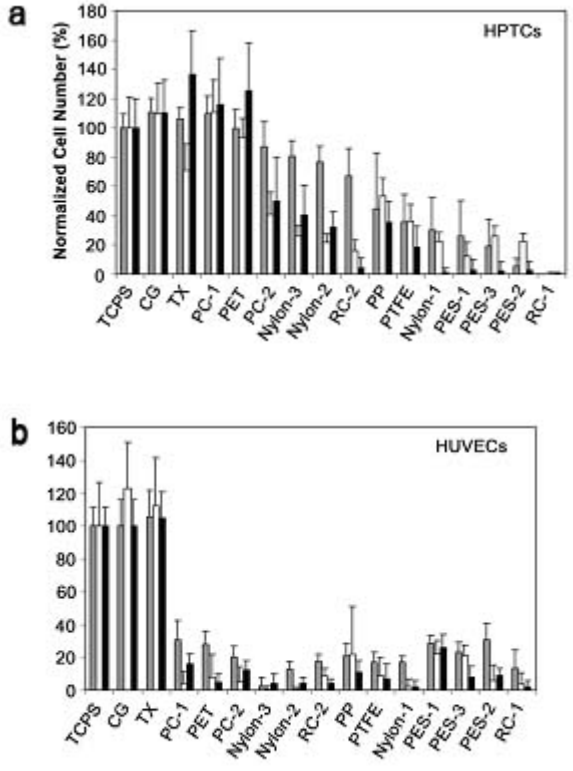

Fig.1 Cell numbers (a) HPTCs and (b) HUVECs on the different materials of the library. Three batches of each cell type were analyzed (grey, white and black bars). The cell numbers were counted on day seven after seeding and three replicates per cell batch and material were analyzed. The bars show the mean ± standard deviation. The mean cell numbers obtained on TCPS were set to 100% and the other data were normalized to these values (separately for each batch). (Reproduced from Ref 1)

Conclusions: Our results give new insights into the biomaterial requirements of primary human cells, help to understand current problems and are potentially useful for the development of improved biomaterials. The materials of the library can be easily accessed by the scientific community to determine the biomaterial requirements of any adherent cell type of interest.

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References: 1. M. Ni, P.K. Zimmermann, K. Kandasamy, W. Lai, Y. Li, M.F. Leong, A.C.A. Wan, D. Zink, Biomaterials, 33 (2012) 353-364.