Geometric Control of Cell Behavior by Biomolecule Nanodistribution

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Many dynamic interactions within the cell microenvironment modulate cell behavior and cell fate. However, the pathways and mechanisms behind cell–cell or cell–extracellular matrix interactions remain understudied, as they occur at a nanoscale level.

Recent progress in nanotechnology allows for mimicking of the microenvironment at nanoscale in vitro; electron-beam lithography (EBL) is currently the most promising technique. Although this nanopatterning technique can generate nanostructures of good quality and resolution, it has resulted, thus far, in the production of only simple shapes (e.g., rectangles) over a relatively small area (100 × 100 μm), leaving its potential in biological applications unfulfilled.

Here, we used EBL for cell-interaction studies by coating cell-culture-relevant material with electron-conductive indium tin oxide, which formed nanopatterns of complex nanohexagonal structures over a large area (500 × 500 μm). We confirmed the potential of EBL for use in cell-interaction studies by analyzing specific cell responses toward differentially distributed nanohexagons spaced at 1000, 500, and 250 nm.

We found that our optimized technique of EBL with HaloTags enabled the investigation of broad changes to a cell-culture-relevant surface and can provide an understanding of cellular signaling mechanisms at a single-molecule level [1].
Figure 1: Quick overview how the combination of geometrical shape control of hexagonal nanopatterns and the use of Halo tags combines into a nanopositioned biomolecule of different size to control the behavior of cells.

[1] Jakub Pospíšil, Miloš Hrabovský, Dáša Bohačiaková, Zuzana Hovádková, Miroslav Jurásek, Jarmila Mlčoušková, Kamil Paruch, Šárka Nevolová, Jiri Damborsky, Aleš Hampl, and Josef Jaros, Geometric Control of Cell Behavior by Biomolecule Nanodistribution, ACS Biomaterials Science & Engineering 2022 8 (11), 4789-4806, DOI: 10.1021/acsbiomater.2c00650