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Micro/nanostructured conjugated polymer-based systems for the optical modulation of living cells activity

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Hybrid interfaces between micro/nanostructured materials and living cells are gaining increasing interest in biotechnology, given their huge application potential, spanning from local drug delivery to tissue engineering and from regenerative medicine and biosensing to neural computing.[1–3] Current platforms are commonly fabricated using different materials, ranging from metals and inorganic semiconductors to organic polymers.[4,5] Among the latter, conjugated polymers have attracted considerable interest due to their intrinsic optoelectrical properties in combination with compatibility with living tissues.[6,7] In particular, they bear the possibility to be employed as photoactive transducers at the interface with living systems to trigger the biological component simply by light, without any need for viral transfection.

Here, we realize smart biointerfaces between micro/nanostructured conjugated polymer-based systems and either plant or mammalian cells. The aim of our work is to study the cells response to micro/nanostructured semiconducting polymers alone and in combination with visible light excitation. Firstly, we characterize the bio/polymer interface through a combination of scanning electron microscopy and confocal imaging. Secondly, we study the cell physiological properties by means of fluorescence microscopy. Notably, we observed that optical excitation of semiconducting polymer beads both modulates the cytosolic calcium ions concentration in leaves guard cells and regulates the aperture size of stomata, the leaf pores which regulate the plant carbon dioxide uptake, oxygen release, and transpiration processes. Furthermore, we show that the combined action of conjugated polymer-based micro-pillar topography and visible light excitation leads to the modulation of neurons growth and orientation. The results support the possibility to employ light-responsive organic materials to regulate on demand the activity of cells, in a drug-free, touchless, repeatable, and spatio-temporally controlled manner.

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