The main objective of the project is to find the correlations between molecular structures of conjugated surface-grafted polymer brushes and their unique electrical and optical properties. Surface-grafted polymer brush is an organized system of macromolecules attached by one end to the grafting surface. Due to high grafting density of the chains they get extended perpendicularly to the surface making the whole system looking like a brush. Conjugated polymer brushes consist of macromolecules containing the system of conjugated double bonds in the main chain, which is responsible for their semiconductive properties. After appropriate chemical modification (so-called doping) such polymer become highly conductive almost as high as common metals. This is why such polymers are also often described as “synthetic metals”.
Conjugated polymers were obtained for the first time in 70s’ in XX century (Nobel prize in 2000) but only in the recent years they have attracted special attention due to their numerous applications e.g., in photovoltaic cells, organic light emitting diods (OLEDs) and nanoelectronics, which develops quickly following the trend of miniaturization. In most of the mentioned applications, ultrathin polymer layers (thickness in nanometers range) are very desired and especially demanding are nanowires, which enable directional conductivity. Conjugated polymer brushes are very promising candidates for fabricationg such structure and they fundamental properties are going to be studied within the current project.
Conjugated polymers are commonly synthesized using so-called step-growth polymerization, which is not compatible with the surface-initiated polymerization used for fabrication of polymer brushes. This is why we have recently introduced a novel approach for formation conjugated polymer brushes called: self-templating surface-initiated polymerization (ST-SIP).[1,2] Such polymer brushes exhibit very much different properties as compared to typical thin polymer layer, which have disordered and entangled macromolecules that limits conductivity of such layers due to necessity of hopping of the charge carriers between the chains. The conjugated brushes obtained using ST-SIP (fig. 1) exhibit high conductivity in the direction normal to the grafting surface as shown using conductive atomic force microscopy. Even two examples of such brushes with the proposed ladder-like structure have been already reported, there have been no detailed studies on their structure and properties. Thus, the project also aims to deepen the knowledge on the mentioned polymerizations processes as well as find correlation between the brush structures and their optical and electrical properties so one can design and synthesized new conjugated polymer systems on the surface of required properties.

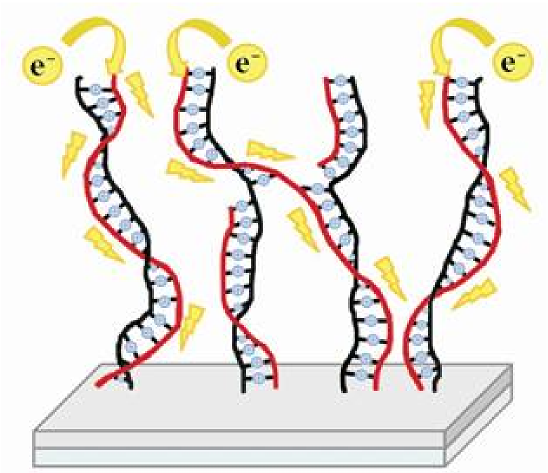

Fig. 1. Scheme of ladder-like conjugated polymer brushes with indicated directional electron flow along the macromolecules.

The results obtained in this project should define new opportunities for nanoengineering of polymer systems, in particular the ones suitable for the collection of light and converting its energy into electricity. This way it should open up new opportunities for the development of the next generation of organic photovoltaic cells. The results of the project will also allow for better understanding of the selected processes taking place at the nanoscale that until now could be only modeled, due to the lack of suitable methods for the synthesis of appropriate nanostructures.

[1] M. Szuwarzyński, J. Kowal and S. Zapotoczny, J. Mater. Chem. 2012, 22, 20179.
[2] K. Wolski, M. Szuwarzyński, S. Zapotoczny, Chem. Sci. 2015, 6, 1754.