Structure of Supramers Formed by the Amphiphile Biotin-CMG-DOPE

What was the biggest challenge (on the way to the results presented in this paper)?

“God made the bulk; the surface was invented by the devil” – as the eminent physicist Wolfgang Pauli explained that the diabolical characteristic of solid surfaces. This is true in physics, chemistry and biology. Three of us (Alexander Tuzikov, Vladimir Oleinikov & Nicolai Bovin, Moscow), a chemist, biochemist and physicist, – 20 years ago synthesized very simple glycine-based peptides capable to self-assemble on an inorganic or viral surface forming ideally flat mono- or bilayers on solid surfaces (Polyglycine II nanosheets: Supramolecular antivirals? ChemBioChem, 4, 147–154, 2003) – this inspired us to further interest in the “physical-chemical biology” of surfaces.

Invited for this month’s cover is the group of Prof. Nicolai Bovin from the Russian Academy of Sciences. The cover picture shows how a biotin residue initially hidden in a monolayer formed on the surface of a material by biot-CMG-DOPE (see top left) is pulled out of the layer by the streptavidin molecule (Str) that has come close to it (see below). This can be considered as a model of certain events (in particular, cis protein-ligand interactions) occurring on the surface of a living cell when it is necessary to hide the ligand from undesirable interactions, but leave the possibility of its recognition by a high-affinity protein. The picture is inspired by the legendary Yellow Submarine cartoon. Read the full text of their Full Paper at 10.1002/open.201900276.
What prompted you to investigate this topic/problem?

Further, Stephen Henry from Auckland University of Technology sparked the interest of the Moscow team in glycolipids and related complex lipids as smart material for specific “painting” (Steve’s wording) of erythrocytes and then other type of living cells (see for example, Blood Group O — A transformation by chemical ligation of erythrocytes, ChemBioChem., 20, 131–133, 2018). Particularly, he pushed us to develop the so called FSL (function-spacer-lipid) where the F residue is biotin – in order to modify any type of living cells or inorganic surfaces with biotin residues in a controllable fashion. The resulting biotin-CMG-DOPE became the hero of the current publication, this molecule is actually capable of modification practically any (but not all, do you remember “surface was invented by the devil”?) surface (Rapid one-step biotinylation of biological and non-biological surfaces. Sci. Reports, 8(1), 2845, 2018).

What aspects of this project do you find most exciting?

The most intriguing aspect of the paper cited above was that a rather apolar biotin moiety is exposed to the outside, which is mandatory for interaction with Str in solution, and is not hidden in the biological membrane or membrane-like monolayer. This can be considered as a model of certain events (in particular, cis protein-ligand interactions) occurring on the surface of a living cell. The ligand can hide from undesirable interactions, but leaves the possibility to be recognized by a high-affinity protein when needed. Detailed physicochemical study of biotin-CMG-DOPE described here evidenced that the biotin moiety in fact is hidden, both in a globule and in the monolayer, but is capable of dynamically pop-up from there and catch Str.

What new scientific questions/problems does this work raise?

The layer formed by biotin-CMG-DOPE is a good model for a rather unexplored situation taking place on the surface of a living cell. In its normal state, the body needs to hide a ligand from unwanted interactions. However, there is the possibility to recognize a previously hidden ligand with a high affinity protein in a critical situation. For biology, we consider this scenario to be ordinary, but it is practically unexplored.