Description for general public:

Self-assembled monolayers based on carboxylic head group – towards a new standard in SAMs

Nowadays development of new materials and technologies remains linked with practically all activities of our live in a way which is unprecedented in our history. One of a very recognized direction of this development is electronics which more and more uses organic materials, with smartphones and TVs based on OLED technology being, literally, the most visible examples. The introduction of organic materials to electronics inevitable leads to connections with metal electrodes as link to a power source. Such connections demands formation of a new type of interface between organic and inorganic materials which, in principle, are quite different from each other. It turns out that to obtain sufficiently high current flow, usually, we need to adjust the electronic structure of both materials at this new interface. To solve this problem one can use additionally a single and well-ordered layer of molecules which are chemically bonded to the metal electrode forming a dipole layer separating metal electrode and organic material. This dipole layer creates an electric field at the interface which shifts relative position of energetic levels of both materials at the interface, and if properly designed, can thus enhance the current flow. The subject of this proposal is related to such monolayers of molecules called Self-Assembled Monolayeres (SAMs), which for properly matched types of organic molecules and inorganic substrates can be formed in spontaneous way by simple dipping the substrate in the solution of molecules. The above example of using such monolayers for organic (or molecular) electronics is just one of quite many areas where SAMs are used to form well defined interface between the organic and inorganic materials. The another example is their application for connecting biological materials with inorganic substrate to make it biocompatible.

Independently, however, on particular application of SAMs in different areas of nano(bio)technology, one of the most important features for this type of nanomaterial (only one layer of molecules is formed which is only a few nanometers thick) is their high degree of order (low defects concentration) and the easy of formation process. So far the most popular types of “standard” SAMs are formed by anchoring molecules via sulfur atom to the gold substrate. In our project we are proposing performing very complex research of structure, stability and conductivity of SAMs in which carboxylic group was used instead of sulfur for anchoring molecules with the silver instead of gold substrate.

This proposition is inspired by our preliminary microscopic and spectroscopic study performed for molecules with carboxylic group, which except modification of the anchoring group (from sulfur to carboxylic) remain a full analog of very well characterized earlier by us sulfur based molecules. By selecting analogical molecules we are able to compare the effect of changing the anchoring group on the film structure and properties. Preliminary results of this comparison are very exciting and show that SAMs formed on silver by using carboxylic group are much better organized as compared to “standard” SAMs. This observation become even more exciting considering that this new and much better organized SAMs are created within the time which is about 300 times shorter as compared to standard SAMs. This huge difference in formation time is very interesting not only from scientific point of view, and demands detail research to use this information in optimizing SAMs design, but it has also very practical application considering that time of creating any material is always directly related to the production coasts.

We would like also to stress that the research approach which enables realization of our project is based on original methodology we have proposed only very recently by using a combination of different complementary microscopic and spectroscopic techniques. In summary, we believe that this proposal is both scientifically appealing and technologically attractive within the very active field of nanotechnology which stimulates not only development of different areas of science, ranging from physics to biology, but has an enormous impact on our civilization and society justified by the progress in areas such as organic(molecular) electronics, where as we pointed at the beginning SAMs are one of the crucial elements.