Studies on biologically relevant systems in conditions of resonance Raman optical activity

Chiral molecules are these that cannot be superposable on their mirror images and are called enantiomers. As a structural feature of each enantiomer, chirality has tremendous importance in living systems, can occur both at molecular a well as supramolecular levels. Polymers, which appear naturally in living organisms, are consisting of chiral building blocks (e.g. nucleic acids, amino acids, sugars, lipids, etc.). Most of the pharmaceutical are optically active, but usually one enantiomeric form of the drug provides the desired effect (the other form can be inactive or toxic). The investigations within this project are focused on study the structure and chirality of biologically relevant molecules as well as a development of Raman optical activity method in the resonance condition, that appear when molecule absorbs energy in the range close to energy of the excitation radiation employed.

In order to study optical activity of chiral molecular systems, which means the differential interaction of a chiral molecule with left versus right circularly-polarized light, chiroptical methods including electronic circular dichroism (ECD), vibrational circular dichroism (VCD) and Raman optical activity (ROA) will be used in this project. Experimental approach will be supported to some extent by theoretical calculations.

ECD together with VCD are a type of spectroscopy based on observation the difference in the absorbance of a chiral molecule for left versus right circularly-polarized radiation in the UV-Vis and IR range, respectively. On the other hand, ROA technique is a chiral version of standard Raman spectroscopy and is based on observation of the small intensity difference in Raman scattering of right and left circularly-polarized light by optically active molecule. The combination of all three chiroptical techniques allows for obtaining full information related to the analysed system.

The subject of this project are extremely chiral molecules, such as vitamin B_{12} and its modifications, and amphotericin B (AmB). All of the studied molecular systems are immensely relevant in terms of medical and biological point of view: enzymatically active forms of vitamin B_{12} play an essential role in various biological processes, like nucleic acids metabolism and formation of red blood cells, while AmB is effective polyene antibiotic used for the treatment against systemic fungal infections.

To investigate exhaustively the complex structure, optical activity and the key role of such systems in the body’s functioning, it is necessary to develop methods that are sensitive on chirality and can be applied for molecules occurring in low concentrations. For that purpose ROA as well as VCD chiroptical spectroscopy will used. However, ROA spectroscopy up to now has a limited application, but it may have a higher potential in studying molecular structure when resonance conditions are achieved. Therefore development of resonance and pre-resonance method of enhanced sensitivity and specificity would be of great interest.