

Supramolecular nanostructuring, observed in many H-bonded and some particular van der Waals systems, has brought special attention of worldwide leading laboratories over decades. It is mainly because this process, leading to formation of larger molecular clusters of varying size and architecture, influences on the basic physical and chemical properties of associating compounds. The best illustrations of those are water, saccharides, or DNA. It should be noted that supramolecular association is also of great interest to the scientists working on the new types of polyelectrolytes, where proton hopping along hydrogen bonds has strong contribution to the overall measured conductivity, finding various application i.e. in batteries or fuel cells. Interesting, in the past the self-association in H-bonded and van der Waals systems has been studied in various kinds of materials with the use of wide array of experimental methods. However, although there is a growing number of available data and systematic progress in the understanding of this phenomenon many relationships and fundamental problems are still not fully understood. It is because many experimental methods, used to probe this process, are insensitive to the medium-range scale ( $\sim 5\text{-}30 \text{ \AA}$ ) intermolecular ordering in the non-crystalline materials. Moreover, the vast majority of research is performed only as a function of temperature that mainly affects kinetic energy of molecules, distance between them, and distribution of conformers across energy barriers. On the other hand, to fully understand the behavior of H-bonded and van der Waals associates, complementary high pressure experiments are necessary. In this context one can remind that change in this variable affects the density and the intermolecular interactions between molecules, keeping simultaneously thermal energy unchanged (isothermal measurements).

To fill the significant gap in our understanding of the behavior of associating H-bonded or van der Waals liquids we are going to perform systematic, pioneering, high pressure measurements with the use of broadband dielectric spectroscopy, X-ray diffraction, and vibrational (FTIR and Raman), investigations supported by the density functional theory (DFT) calculations and computer modeling of structure on materials differing in the chemical backbone, functionality (OH, SH,  $\text{NH}_2$ , OD), conformations (cis-trans, R-S), steric hindrance, etc. We are convinced that comparative analysis of the collected data will allow constructing more fundamental and complete picture of self-assembly process occurring in H-bonded and van der Waals systems. Consequently, a unique opportunity to fully describe the degree, range, and architecture of internal ordering, as well as stability limit of associates at varying thermodynamic conditions will appear. Moreover, by changing properly the kinetic energy and molecular packing a more reliable description of H bonds will be possible.

This project may open a constructive debate and go beyond the current state of the art in the interpretation of the behavior of different groups of associating materials under different thermodynamic conditions. Finally, it should be noted that results of our investigations will also contribute to improving current models describing H bonds, and will be useful to predict more precisely progress of various chemical and physical processes in the self-assembly, especially for biologically-relevant systems (e.g. proteins), at both soft and extreme pressure and temperature conditions.