Fen-Edebiyat Fakültesi
Faculty of Arts and Sciences
Kimya Bölümü
Department of Chemistry

Orta Doğu Teknik Üniversitesi
Middle East Technical University

Chemistry Department e-Seminar

Friday, **10.12.2021** at **15:40** using **Zoom**
Meeting ID: 982 9284 9172
Passcode: Chem601
https://zoom.us/j/98292849172?pwd=MHg2bm9rN0k3QkduZzgxMm1lZVIvUT09

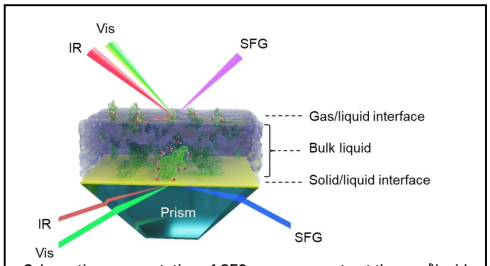
Colloidal and Structural Stability of Bio-Macromolecules: A Journey from the Bulk Solution to Surfaces and Interfaces

Dr. **Saman Hosseinpour**

Institute of Particle Technology (LFG)
Friedrich Alexander Universität Erlangen-Nürnberg (FAU)
Erlangen, Germany

BS, Materials Science and Engineering, Azad University, Saveh, Iran, **2004**
MSc, Material Engineering, Azad University, Saveh, Iran, **2006**
PhD, Chemistry (Surface and Corrosion Science), Royal Institute of Technology (KTH), Stockholm, Sweden, **2014**
Postdoctoral Researcher, Molecular Spectroscopy, Max Planck Institute for Polymer Research (MPIP), Mainz, Germany, **2014-2017**
Principal Investigator/Group Leader, Surface and Interfaces Group, Friedrich-Alexander University Erlangen-Nuremberg (FAU), Germany, **2017-present**
Honorary Adjunct Professor of Material Science, Ferdowsi University of Mashhad (FUM), Iran, **2020-present**

Abstract: The physiological function of biologically relevant macromolecules such as proteins, peptides, and enzymes is highly dependent on their colloidal and structural stability. For instance, several progressive neurodegenerative disorders like Alzheimer and Parkinson occur due to the misfolding or change of proteins' secondary structure. Similarly, for the process design in biotechnology, biopharmaceutical, and food industries, the integrity and stability of proteins and bio-macromolecules should be taken into account to avoid undesired effects such as denaturation and agglomeration. Protein denaturation can occur as a result of external physical or chemical stimulators which influence the local environment of proteins. Although proteins characteristics in bulk media are well studied, the information obtained about the structure and stability of proteins in bulk solution can not be directly transferred to those in contact with solid or gas phases. These interfaces are, however, highly relevant in many applications including emulsions and double emulsions, bubble columns, bioreactors, and in chromatography. In particular, the broken symmetry of the protein's hydration network at the gas/liquid interface or hydrophibicity/hydrophilicity of the solid/liquid interface to which proteins adsorb can greatly influence the interfacial proteins' characteristics. The overwhelming number of molecules in the bulk solution versus those residing at the liquid/gas, solid/liquid, or liquid/liquid interfaces, however, makes it very challenging to assess the properties of the interfacial proteins using most of the common analytical techniques (e.g., IR spectroscopy, X-ray diffraction, and NMR) and calls for more surface sensitive techniques. In this presentation, I will introduce a multi-analytical and multi-scale approach to study the colloidal and structural stability of bio-macromolecules in the bulk solution and at different surfaces and interfaces. Moreover, with the main focus on the inherently surface-sensitive sum-frequency generation (SFG) spectroscopy, I will use two examples (proteins and surfactant stabilized emulsions) to show how the local and molecular characteristics of the surfaces influence the macroscopic properties of the corresponding systems.



Schematic representation of SFG measurements at the gas/liquid or solid/liquid interface, in which infrared (IR) and visible (Vis) beams overlap both in time and space to generate SFG signal. The frequency of the SFG beam is equal to the sum of the frequency of the incomingIR and Vis beams (ωSFG = ωIR + ωVIS)

Refences:

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3. Guckeisen, T., S. Hosseinpour, and W. Peukert, Effect of pH and urea on the proteins secondary structure at the water/air interface and in solution. *Journal*
4. *of Colloid and Interface Science*, **2021**. *590*. p. 38-49.
5. Guckeisen, T., S. Hosseinpour, and W. Peukert, Isoelectric Points of Proteins at the Air/Liquid Interface and in Solution. *Langmuir*, **2019**. *35(14)*: p. 5004-5012.
6. Lautenbach, V., S. Hosseinpour, and W. Peukert, Isoelectric Point of Proteinsat Hydrophobic Interfaces. *Frontiers in Chemistry*, **2021**. *9*. p. 712978.

Kimya Bölümü
Fen-Edebiyat Fakültesi
Orta Doğu Teknik Üniversitesi
06800 Ankara, Türkiye
kimya@metu.edu.tr

Department of Chemistry
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06800 Ankara, Turkey
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