Materials Innovation Seminar
10:00-10:30, July 10th, 2025

Sensing, Capture, Storage and Reduction of CO_2 to Value Added Chemicals

Rekha Goswami Shrestha (PhD)

Scientist, Planet Savers Inc., Hongo, Japan.
Visiting Scientist, University of Tokyo, Kashiwanoha Campus, Japan.
Email: rekhashrestha3@hotmail.com

Self-assembly of surfactant molecules in solvents and its manipulation can demonstrate thermally and optically switchable viscoelastic gels having appeal in device fabrication, drug delivery, and in food industry. The disruption-recovery (bulk and interfacial properties) of such gel can control solubilization and release of drugs, dyes, perfumes, nano-molecules simply by triggering stimuli through light, temperature or pH. They can be a promising candidate in fabricating sensing unit. In this context, we have succeeded to formulate novel self-healing viscoelastic gel using biocompatible lecithin molecule, amino acid based, phytosterol and cholesterol-based surfactants both in aqueous and non-aqueous media. Further, the bulk flow properties (rheology) could be reversibly controlled through external stimuli such as light (optical), heat (thermal) and pH. This free and reversible switching is based on the transformation from globular aggregates to network fiber like structure (and vice versa) of the self-assembled surfactant in the molecular level upon the application of external stimuli [1,2]. These gels in corporation with amino-group-containing molecules, or polymers like polyethyleneimine (PEI), acrylamide and isooctylacrylate, polyacrylamide, polystyrene-bound ethylendiamine, alkylamine functionalized polysilsesquioxanes etc, sensitive for CO_2 can be explored for fabrication of CO_2 sensor and its capture.

Furthermore, Buckminsterfullerene (C_{60}), ideally zero-dimensional material, consists purely of carbon atoms located at the vertices of a series of 20 hexagons and 12 pentagons arranged in a cage lattice (diameter ~ 0.8 nm), with alternating single and double bonds [3]. Supramolecular assemblies of C_{60} in the bulk phase or at an interface using π-stacking interactions forms shape-controlled aggregates at nano/micro/macro length scales, with excellent optoelectronic properties [4]. This talk will cover supramolecular self-assembly of C_{60} especially involving Liquid-liquid interfacial precipitation method (LLIP) [5], and Vortex fluidic device technique (VFD) [6]. Carbonization of thus formed crystals yields nanomaterials with hierarchically macro- and mesopores architectures and crystallized frameworks; this enhances their sensing performance towards volatile organic compounds (VOCs) especially towards the aromatic solvent vapors because of the extended π-conjugation together with high porosity and large surface area [4], while VFD-produced porous fullerene tubes potentially discriminated between methanol and ethanol, which is yet a challenging task in the related field.

Next, Micro galvanic array of 2 different electrodes of varying electrode potential arranged alternatively in micrometer distance and its further modification explored as an electrochemical moisture sensor [7,8], will be discussed in detail.

Finally, this talk will discuss the fabrication, optimization, and implementation of surfactant, fullerene supramolecular self-assembly, and other potential candidates and its integration into nanocomposites further development of electrochemical sensor showing the possible pathways towards sensing CO_2, VOCs, capture and storage of CO_2.

References:

[1] Shrestha R.G., Aramaki K. “Chapter 5: “Stimuli-Responsive Viscoelastic Gels”, in Stimuli-responsive interfaces: fabrication and application, Springer Pub. 2017, Chapter 5, pp 63-88.
[2] Shrestha R.G., Naito, M. “Advanced Viscoelastic Gels” in Soft Matter Nanotechnology: From Structure to Function Wiley-VCH Verlag GmbH & Co. KGaA –John Wiley & Sons, Inc., 2015, pp. 357-384.
[3] Kroto, H. W.; Heath, J. R.; O’Brien, S. C.; Curl, R. F.; Smalley, R. E. *Nature* 1985, 318, 162.
[4] Kausar, A. *Hybrid Adv*. 2024, 6, 100233.
[5] Maji, S.; Shrestha, R.G.; Lee, J.; Hill, J.P.; Kim, J.H.; Ariga, K.; Shrestha, L.K. *Bull. Chem. Soc. Jpn.* 2021, 94, 1502.
[6] Vimalanathan, K.; Shrestha R.G. et al. *Angew. Chem. Int. Ed.,* 56, 8398-8401, 2017.
[7] Shrestha, R.G. et al. *J. Electrochem. Soc.* 2020, 167 (16), 167510.
[8] Shrestha, R.G. et al. *ECS Transactions,* 2020, 98, 11, 35.