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High-performance sol-gel composite materials with encapsulated carbonaceous particles for environmental pollution mitigation

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Due to the explosive growth of anthropogenic activities during the last couple of decades, freshwater systems across the world have been continuously polluted by numerous toxic and hazardous synthetic organic compounds produced for industrial, domestic and agricultural usage. Many of these pollutants are known as persistent organic pollutants (POSs). When POPs are released into the environment, they remain unchanged for a long period of time by resisting photocatalytic, chemical and biological degradation. Due to their prolonged presence in the environment, many of these pollutants eventually find their way in the food chain, with severe ramifications in the health and well-being of humanity. As such, it is imperative that these compounds be efficiently removed from environmental water through more efficient sewerage treatment processes and other reliable remediation techniques. Among many classical processes used in removing pollutants from water such as precipitation, coagulation, sedimentation, filtration, adsorption, chemical oxidation, and ion exchange, adsorption is one of the most effective removal technique. A large number of carbonaceous adsorbents including activated carbon, carbon nanotube, biochars, graphene, beta-cyclodextrin, calixarenes, Carboxen, fullerene, cation exchange resins, anion exchange resins, zwitterionic resins are used as adsorbents in sewerage treatment plants. These adsorbents offer a large variety of intermolecular interactions towards the analytes via μ-μ stacking interactions, cation-μ bonding interactions, electron donor-acceptor interactions, hydrophobic interactions, hydrogen bonding interaction, cation exchange, anion exchange, dipole-dipole interactions etc. Many of these adsorbents possess extremely high surface area and demonstrate a strong tendency to form agglomeration. As such, when they are used in their pristine form, a large portion of their available surface area cannot be readily accessed by the analytes due to their agglomeration and formation of lump. As a result, the adsorption capacities of these adsorbents remain largely unexploited during their applications. The agglomeration of these unique particulate matters can be inhibited by encapsulated them into sol-gel silica network. Sol-gel chemistry provides a convenient and mild reaction pathway to create pure silica or organically modified silica 3-D network. Addition of sol-gel active organic polymer(s) as an additive in the soil solution during the sol-gel synthesis is also a common practice to engineer the selectivity of the resulting sol-gel sorbents. Addition of adsorbent particles into the soil solution during sol-gel synthesis results in a sol-gel composite sorbent system with homogeneously trapped particulate matters. Due to the inherently porous and open architecture of sol-gel silica network, the encapsulated particulate matters maintain their high surface area as well as freely accessible interaction sites. As such, the synergistic combination of silica chemistry, organic polymer chemistry as well as the chemistry of particulate matters result in robust composite material systems capable of exerting intermolecular/ionic interactions towards a wide variety of analytes including polar, medium polar, nonpolar, ionic, and metal species and successfully trap them in the sol-gel composite sorbent matrices. Analytical data obtained from a number of real-life applications of the sol-gel composite sorbents including endocrine disrupting chemicals (EDCs), Pharmaceuticals and personal care products (PPCPs), polycyclic aromatic hydrocarbon (PAHs) in environmental water will be presented.

Biography

Abuzar Kabir is a Research Assistant Professor at the Department of Chemistry and Biochemistry, Florida International University, Miami, Florida, USA. His research focusses on the synthesis, characterization, and applications of novel sol-gel derived advanced material systems in the form of chromatographic stationary phases, surface coatings of high-efficiency microextraction sorbents, nanoparticles, microporous and mesoporous functionalized sorbents, molecularly imprinted polymers for analyzing trace and ultra-trace level concentration of polar, medium polar, nonpolar, ionic analytes, heavy metals, and organometallic pollutants from complex sample matrices. His inventions, fabric phase sorptive extraction (FPSE), and dynamic fabric phase sorptive extraction (DFPSE), capsule phase microextraction (CPME), molecular imprinting technology, super polar sorbents, In-Vial microextraction (IVME) have drawn global attention. He has developed and formulated numerous high-efficiency sol-gel hybrid inorganic-organic sorbents based on Silicon, Titanium, Zirconium, Tantalum, Germanium chemistries. Dr. Kabir has authored 16 patents, 9 book chapters, 52 journal articles and 90 conference papers.

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