ABSTRACT

THESIS: Removal of perfluoroalkyl substances from water using paramagnetic ionic liquid-modified clay and polymer membranes

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Per- and poly- fluoroalkyl substances (PFAS) are considered “forever” chemicals due to their persistence in the environment resulting in water contamination. The most common PFAS pollutants include perfluorooctanoic acid (PFOA) and perfluorooctanesulfonic acid (PFOS). The carbon-fluorine bond is strong in PFAS and provides water and oil resistance. This enables the use of PFAS in polymers, surfactants, film-foams in fire extinguishers, textiles, and coatings. However, this widespread use and resistance of PFAS to degradability has resulted in accumulation in the environment. PFAS have been detected in ground water, surface water, ocean waters and even marine organisms. Their toxicological impact is a big concern to aquatic life and humans. This thesis describes the synthesis and characterization of paramagnetic ionic liquids (PILs) by direct combination of various cation sources including trihexyltetradecyl phosphonium chloride (THP), trioctylmethylammonium chloride (Aliquat 336), 1,3-didecyl-2-methylimidazolium chloride (1,3-DIDMIM) paired with tetrachloroferrate ($FeCl_4^-$) anion. These PILs were evaluated for extraction of PFOS and PFOA using an optical method based on fluorescence quenching. The results indicated that these PILs have high extraction efficiency of over 98% for both PFOS and PFOA from water using an external magnet. These results inspired the use of these PILs for the development of composite materials based on clay and polymer membranes for improved sorption of PFAS. The composite materials consisting of PIL-modified clay or polymer membrane were characterized by various techniques including scanning electron microscopy (SEM), thermogravimetric analysis (TGA), elemental analysis and dynamic light scattering (DLS). The PIL-modified membranes have the advantage of spontaneous chemical reaction for removal of

PFAS compared to other membrane methods that require applied pressure for separation. These PILs, PIL-modified clay and polymer membranes demonstrated reusability for multiple extraction cycles. In addition, this thesis describes toxicity evaluation of water after removal of PFAS using seed germination tests as bioindicators. The results indicated that the cleaned water after extraction of PFOS and PFOA had improved seed germination compared to water contaminated with these PFAS pollutants. The developed approach using PILs, PIL-modified clay and polymer membranes demonstrate potential for environmental remediation of PFAS contributing to access to clean water, improved health and quality of life.