Preface

Earth-abundant iron and its oxides are not only "greener" than many of rare and precious metals, but can elegantly perform numerous catalytic reactions of industrial and environmental significance, often mimicking enzymes. Industrial applications include the use of iron and iron oxide-based compounds in pigments, magnetic recording media, catalysis, and magnetic fluids. Iron oxides have shown potential in manufacturing, water purification, and photocatalytic transformation to generate solar fuel. This book presents synthesis and application of ferrites, which have a molecular formula, $M\text{-}Fe_2O_4$ in which Fe_2O_3 is combined with a metal oxide (M-O). Ferrites have demonstrated their roles in water purification and energy production under solar irradiation. Recently, increased emphasis has also been placed on the high-valent iron species, which have been beneficially implicated in numerous chemical, biological, and environmental reactions. In the past decade, there is a burgeoning interest in tetra-oxy high-valent iron anion, commonly termed ferrate (e.g., ferrate(VI), $Fe^{VI}O_4^{2-}$), for chemistry in aqueous solutions due to their importance in various applications including high energy density rechargeable batteries, in cleaner ("greener") technologies for organic syntheses, and in environmentally friendly water and wastewater treatment processes.

The idea of this book was conceived during the symposium "*Ferrites and Ferrates: Chemistry and Applications in Sustainable Energy and Environmental Remediation*" at the Pacifichem 2015 from December 15-20, 2015, in Honolulu, Hawaii. Many emerging variants of this theme were presented during this symposium, which embody the main content of this compilation. This book comprises 18 peer-reviewed chapters with a focus on synthesis and environmental applications of ferrites and ferrates. Topics of the book encompass greener catalysis (nano-catalysis) emanating from ferrites and ferrates to achieve chemical energy transformation, organic syntheses and transformation, as well as eco-friendly water and wastewater treatment processes, namely removal of metals, oxidation of micropollutants, and inactivation of microorganisms and toxins.

The first six chapters illustrate the preparation of ferrites as nanoparticles and nanocatalysts with varied applications such as organic transformations, water splitting and purification of water. Sustainable organic synthesis and transformations are exemplified via the use of ferrites as nanocatalysts in chapters 1 and 2. Chapter 3 depicts results on applying ferrites for water splitting and for degrading contaminants. Chapters 4 and 5 delineate how assorted ferrites can be synthesized and utilized for applications to purify water contaminated with

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metals and organics, followed by Chapter 6 focusing on the role of ferrites in disinfecting water.

Synthesis, characterization, and applications of ferrates are encapsulated in Chapters 7-18. Chapters 7 and 8 explain, at length, the available synthesis methods for ferrates (chemical, thermal, and electrochemical), followed by treatment of contaminated water laden with metal-complexes and organics. Chapter 9 provides the critical data on stability of ferrates in high alkaline solutions, which have implications in electrochemical generation of ferrate. Chapters 10-14 describe the elimination of organic contaminants (e.g., phenols, amines, dyes, endocrine disruptors, pharmaceuticals, and personal care products); kinetics of removal and treatment of ensuing oxidation products from organics are included in these chapters. Chapter 15 investigates the interaction of ferrate with organic matter, which vitally impacts the generation of disinfection byproducts (DBPs) in water. Chapter 16 compares ferrate as a pre-oxidant with other common oxidants (i.e., ozone and permanganate) in producing DBPs during chlorination. Finally, Chapters 17 and 18 elucidate the underlying oxidative mechanism of ferrate via the density functional theory (DFT) calculations; Chapter 17 applies DFT for the oxidation of arsenite ion whereas Chapter 18 endeavors DFT calculations on different species of ferrate (protonated and un-protonated) to comprehend the role of pH in the oxidation of methanol.

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