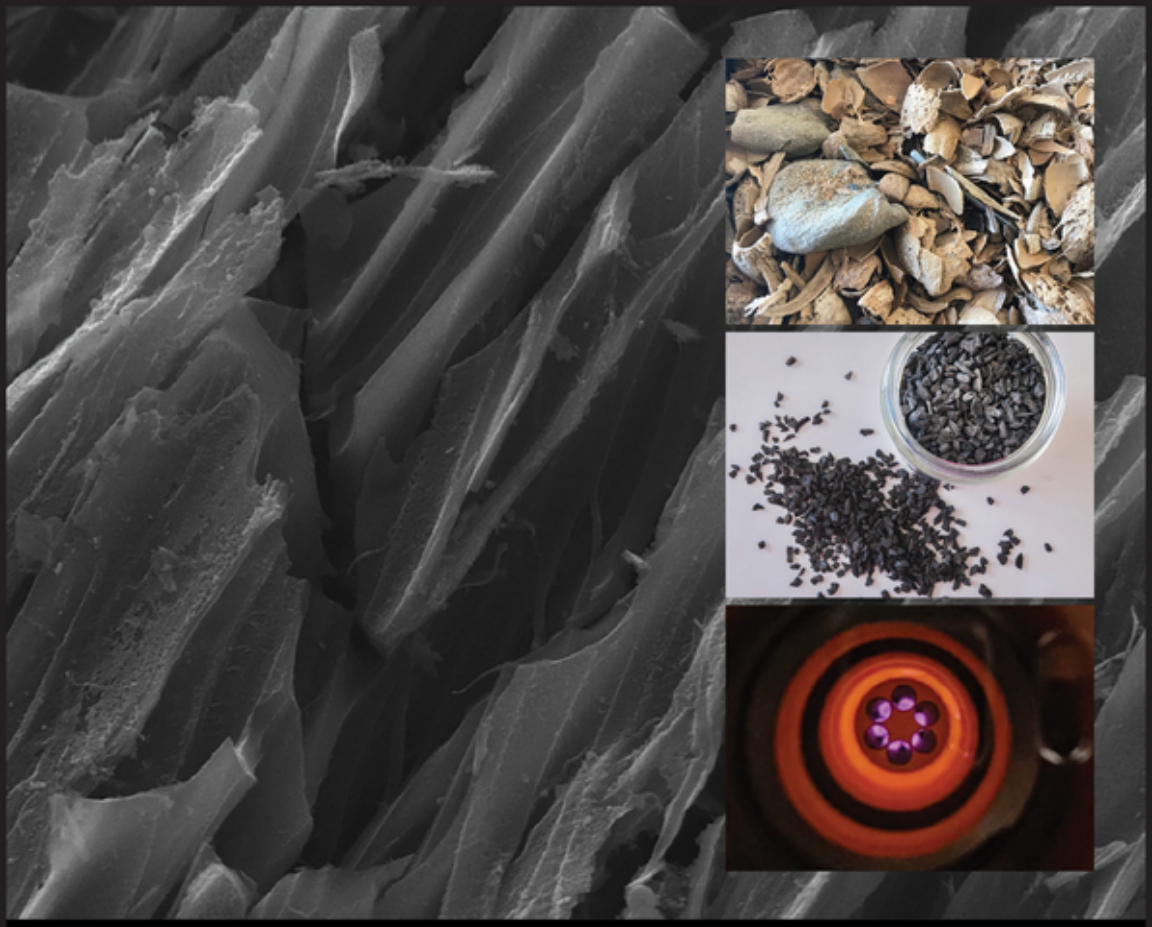

Voltage-Enhanced Processing of Biomass and Biochar

Gerardo Diaz

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To my wife, Kathleen, and my two wonderful children

Contents

Preface

One of the biggest lessons learned from the COVID-19 pandemic is that it has highlighted how vulnerable humanity is with respect to potential threats that had been predicted for decades and that we thought we were prepared to resist. Another important lesson is that shelter-in-place requirements mandated by governments around the world showed the impact of human activity in air quality and carbon emissions to the atmosphere. Clean skies were seen in places where a thick layer of smog was a common daily sight. The recent sixth assessment report from the Intergovernmental Panel on Climate Change concluded that widespread and rapid changes have occurred unequivocally due to human influence in warming the atmosphere, ocean, and land. As long as world leaders do not take strong action to limit carbon emissions to the atmosphere, we will continue to live in a world threatened by climate change, which will end up exposing more vulnerabilities of our society. Just in the United States, it is estimated that around 1 billion dry tones of biomass per year could be produced sustainably. This is in addition to the already available biomass that decomposes releasing methane and other pollutants to the atmosphere. The conversion of biomass to useful forms of energy such as electricity and heat, as well as the production of value-added products such as biochar and activated carbon, constitute a viable way to reduce biomass, generate renewable energy, and sequester carbon in a stable form. This book provides an overview of conventional biomass processing techniques as well as a description of technologies that utilize voltages and currents to enhance processing capabilities. The term plasma processing of biomass is usually associated with thermal plasma torches used for gasification of organic material. This book not only describes thermal plasma processing of biomass, but it also presents applications where nonthermal plasma discharges can be utilized in biomass processing plants, and applications where Joule heating of carbonaceous materials can be implemented. The

book is intended for senior level undergraduate students and first year graduate students, who might not have a background in plasma, but are familiar with concepts of calculus, differential equations, and numerical algorithms. Chapter 1 provides a description of relevant properties of biomass, biochar, and activated carbon, while Chapter 2 gives a description of conventional methods of processing biomass and biochar. Chapter 3 provides an introduction to plasmas for thermal and nonthermal discharges, and Chapter 4 describes technologies that are suitable for utilizing the effects of applied voltages to enhance biomass processing. As properties of biomass vary after thermochemical decomposition, yielding a material with better electrical properties, Chapter 5 focuses on the analysis of the effects of applying voltages in processing of biochar. Thermal runaway behavior can be obtained with heating rates not achievable by conventional heating techniques. Chapter 6 provides an introduction of numerical simulation of plasmas. Finally, the inherit variability and even chaotic behavior of thermal arcs are analyzed in Chapter 7 in the context of the development of control techniques that can stabilize these discharges.

Gerardo Diaz
January 20, 2022 Merced, California

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