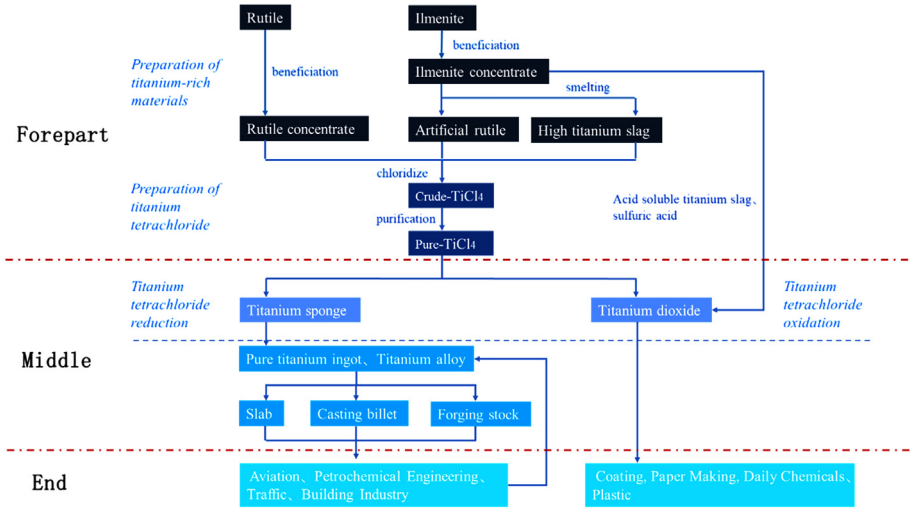
Preface

Titanium (Ti) is abundant in the crust, ranks fourth among metal elements, and is mainly concentrated in the form of ores such as ilmenite and rutile in nature. Thus, ilmenite and rutile are the origin of the modern titanium industry for the production of $TiCl_4$, the intermediate products used for the manipulation of titanium sponge or titanium dioxide. In this industrial chain, the routes for the production of $TiCl_4$ are flexible as shown in the following figure, where ilmenite is transferred to titanium slag or synthetic rutile. Meanwhile, ilmenite can also directly transfer to titanium dioxide with the assistance of acid leaching. Clearly, the demands for titanium and its related products will be continuously boosted in the future. Nevertheless, the traditional titanium production chain is facing challenges with the gradual depletion of high grade titanium resources and environmental concerns.



DOI: 10.1051/978-2-7598-2696-4.c901

Thus, our research group in Yunnan Minzu University assisted by Kunming University of Science and Technology is working on the application of microwave heating in multiple production processes including drying, sintering and leaching, which are important for the production of titanium dioxide and related titanium products. Microwave heating, a multiphysics phenomenon that involves electromagnetic waves and heat transfer, is an important and powerful tool found in laboratories across the world, applied beyond reheating leftovers and across varying chemical applications. With the ability to heat efficiently, precisely, and safely, laboratory microwaves benefit chemical-synthesis, material-digestion, and now has semi-industrialization applications.

In this book, the principles of microwave heating as applied to industrial processing are outlined and the basic design of the microwave enhancing processes is introduced and the book is divided into six chapters. Prof. Guo Chen has contributed on the design of the whole frame and the outline of the book, and also contributed chapter 1. Dr. Lei Gao has contributed chapters 2, 3, and 4. Prof. Jin Chen has contributed chapters 5 and 6. Prof. Wei Li has provided valuable assistance in the formation of chapters 1 and 3. Prof. Jinhui Peng has also contributed on the design of the whole frame of the book and provided significant guidance.

In chapter 1, the microwave absorbing properties of various titanium resources including ilmenite, vanadium titano-magnetite and titanium slag are introduced. The corresponding temperature behaviours of these titanium resources under the radiation of microwave are systematically reported. In chapter 2, microwave pre-treatment technology and microwave drying technology in fascinating and attractive advanced inter-disciplinary fields of research are introduced as well. In chapter 3, the improvement on the carbothermic reduction in ilmenite and titanium-rich materials with microwave heating is reported, the purpose is to explore the possibility of further reduction in the energy consumption and environment issues. In chapter 4, research data related to microwave assisted leaching and intensification are introduced for process optimisation. In chapter 5, the preparation of rutile from different kinds of titanium slag by microwave roasting process is reported in addition to the optimised parameters suggested by response surface methodology. In chapter 6, life cycle assessment resulting from analytic hierarchy process and fuzzy comprehensive evaluation used for the optimisation of microwave heating devices is made. We hope these experimental data and the corresponding analysis can be helpful for the industrial application of microwave heating and thus further promote the development of titanium industry.

We would like to acknowledge the National Natural Science Foundation of China (Grant No. U1802255, 51764052, 52104351), National Key R&D Program of China (2018YFC1900500), Yunnan Fundamental Research Projects (202101AU00088), Scientific Research Fund Project of Yunnan Education Department (No. 2021J0652), and the Kunming Key Laboratory of Energy Materials Chemistry, the Key Laboratory of Green-Chemistry Materials in University of Yunnan Province, the Innovative Research Team (in Science and Technology) in the University of Yunnan province for the financial support. Meanwhile, we also appreciate the financial support from School of Chemistry and the Environment, Yunnan Minzu University for the publication of this book.

The authors want to express their appreciation to their students Mr. He-wen Zheng, Miss. Qian-nan Li, Miss. Ye-qing Ling, Mr. Xian-dong Hao, Mr. Yu-xi Gui, Miss. Hong-ju Qiu, Miss. Yan-qiong Zhang, Mr. Si-rui Zhang, Miss. Jia-jia Lu, and Miss. Wei-wei Huang, for their contributions on the edition of this book.

The authors pay deep respect and gratitude to those concerned for their suggestions and comments, and the authors are aware that the expertise is limited and there may be some errors in the book. If so, please do not hesitate to point them out.