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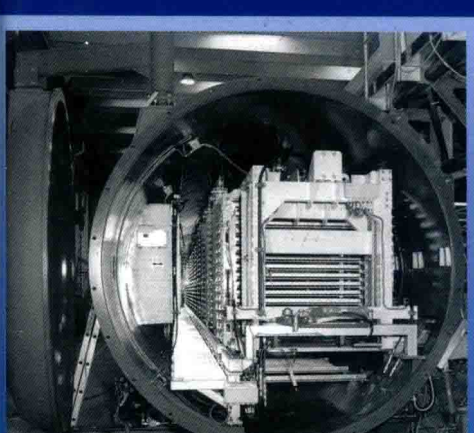

Freeze-drying of pharmaceutical and food products

Tse-Chao Hua, Bao-Lin Liu
and Hua Zhang

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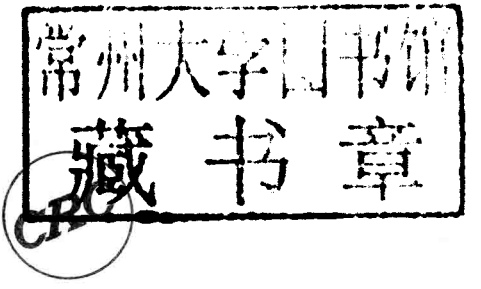

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198 **Freeze-drying of pharmaceutical and food products** *Tse-Chao Hua, Bao-Lin Liu and Hua Zhang*

Preface

Freeze-drying is a kind of preservation technology, by which the material is cooled below its eutectic temperature or glass transition temperature firstly to be solidified completely, then dried in vacuum space at low temperature by sublimation drying and desorption drying till 95%—99% of moisture is removed. The product can be stored at room temperature or 4℃ for a long time. Freeze-drying has become a most important technique for the preservation of heat-sensitive pharmaceuticals and foods. Meanwhile, the process of freeze drying may greatly affect the quality of the products.

Freeze-drying technology has found many applications, such as preservation of foods, micro-organisms, biological pharmaceuticals, human cells, and preparation of various superfine powders. Freeze-dried food has marked advantages: keeping fresh color, smell and taste; avoiding loss of nutritional ingredients and surface hardening. It is light in weight and easy to rehydrate; it is a high value-added product. Freeze drying of biological pharmaceuticals has become the most important application in the freeze drying industry in the past 10 years, and it is a field of most concern and with largest investment in freeze-drying. The pharmaceutical products made by freeze drying have the following characteristics: structural stability, basically unchanged biological activity, almost no loss of volatile ingredients and heat sensitive ingredients, porous structure and good therapeutic effectiveness, high water loss of 95%—99%, convenient storage at room temperature or in the refrigerator for long time.

Freeze-drying has become a most important technique for the preservation of heat-sensitive pharmaceuticals and foods. Meanwhile, the process of freeze drying may greatly affect the quality of the products.

Although the method of freeze drying was known quite early, it was still in its primary "rough" stage till the 1990s. Back to the 1990s, the appearance and development of biological pharmaceutical products proposed many "harsh"

demands to the freeze-drying technology, forcing it developing to its "delicate" stage. At the same time, the "Solution vitrification theory"and "Food polymer science theory" had provided some theoretical foundation to the development of freeze drying technology.

The authors have been involved the field of cryopreservation since 1980, and doing some researches in freeze drying of foods, pharmaceuticals and human cells from 1996 on. A Chinese book with the same title was edited and published by Science Publisher in 2006.

The book contains 8 chapters. They are introduction, fundamentals, heat-mass transfer analyses and modeling, equipment, freeze-drying of food, protective agent and additives, freeze-drying of pharmaceuticals, disinfection sterilization and valuation. Since the temperature history of freeze and drying processes has great effects on the quality of product and the time & energy consumption, more attention is paid in this book to the mechanism and the parameters controlling of freeze drying process.

In this English edition, translation and some amendments have been made by the authors, Chapters 1—3 by Hua T C; Chapter 4 by Zhang H; Chapters 5—8 by Liu B L. Our colleague Hua K F has made improvement in English; and graduate students, Li M, Shi M J, Zhou Y, Zhou N, Zhou C M, Yang M have taken part some work. The authors wish to acknowledge their assistance. The authors wish to acknowledge the supports of projects (S30503, NCET-07-0559, NSFC and USST).

The authors
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Contents

Woodhead Publishing Series in Food Science, Technology and Nutrition vii

Preface xv

1 Introduction 1

1.1 Brief history of freeze-drying technology 1
1.2 Basic processes of freeze-drying 3
1.3 Protecting agents of freeze-drying 8
1.4 Freeze-drying system constitution 10
1.5 Applications of freeze-drying technology 13

2 Fundamentals of Freeze Drying 18

2.1 Properties of water and aqueous solution 18
2.2 Freezing process 42
2.3 Sublimation drying process 48
2.4 Desorption drying process 53
2.5 Storage of the freeze-drying products 54

3 Heat-Mass Transfer Analyses and Modeling of the Drying Process 68

3.1 Restriction of heat-mass transfer and its relative properties 68
3.2 Characteristics of drying process in different heating forms 74

3.3 Analyses of mass transfer control and heat transfer control in sublimation drying 80
3.4 Mathematical model and computational analyses of primary and secondary drying stages 92
3.5 Thermal properties of freeze dried material 105
3.6 Discussion on mathematical model for drying process 108

4 Equipment for Freeze-drying 111

4.1 Vacuum requirement of freeze-drying 111
4.2 Vacuum measurement in freeze-drying 113
4.3 Vacuum pump for freeze-drying 116
4.4 Refrigeration system and water vapor condenser in freeze-drying 121
4.5 Small-scale freeze-drying equipment for laboratory use 125
4.6 Intermediate experimental freeze-drying equipment 127
4.7 Intermittent and continuous freeze-drying equipment 129
4.8 Food freeze-drying equipment 131
4.9 Pharmaceutical freeze-drying equipment 135

5 Freezing-drying of Food 141

5.1 The characteristics of freeze-dried food 141
5.2 Techniques for food freeze-drying 142
5.3 Examples of food freeze-drying 150
5.4 Hazard analysis and critical control point for freeze-drying of food 156
5.5 Application of HACCP in food freeze-drying 163

6 Protective Agents and Additives for Freeze-drying of Pharmaceutical Products 170

6.1 Sugars/polyols-type protective agents 170
6.2 Polymer-type protective agents 173
6.3 Surfactants and amino acid-type protective agents and other additives 175
6.4 Formula issues in freeze-dried products 180
6.5 Examples of formulas 183

7 Freeze Drying of Pharmaceuticals 187

7.1 Basic issues for pharmaceutical freeze-drying 187
7.2 Freeze-drying of protein and hormone 193
7.3 Freeze drying of fibrinogen 195
7.4 Freeze-drying of liposome 202
7.5 Freeze-drying of water-soluble and fat-soluble liposome pharmaceuticals 210

8 Disinfection, Sterilization and Validation 216

8.1 Disinfection and sterilization 216
8.2 Validation 222
8.3 Cleaning-in-place, sterilization-in-place and validation 225
8.4 Process validation of freeze-drying 227
8.5 Validation of technical process and the evaluation of validation 233
8.6 Daily monitoring, revalidation and retrospective validation 240

References 242

Index 250

1

Introduction

1.1 Brief history of freeze-drying technology

When washed clothes are put outside in the sun in severely cold winter with temperature below 0℃, they will be frozen very quickly; however through a period of time, they will be dried, since the moisture frozen in the clothes is sublimated to the air. The drier the air, or the lower the partial pressure of vapor in the atmosphere, the quicker the sublimation drying goes.

The method of freeze-drying food was known a little to the ancient Chinese and Peruvian Incas. In order to store meat longer and to get better flavor, the ancient Chinese put the meat outside in cold winter. The meat was firstly frozen, and then dried. The ancient Incas stored potatoes and other some crops on the mountain heights above Machu Picchu. The cold mountain temperature froze the food and the water inside slowly sublimated under the low pressure of the high altitudes. Freeze-dried food is light and can last longer than other preserved food.

The above phenomena may be taken as examples of "freeze-drying". However as a part of science and technology, "freeze-drying" is only a matter of recent 80 years.

There were three events which had the milestone significance in the early development in freeze-drying technology:

(1) Earl W. Flosdorf and Stuart Mudd from University of Pennsylvania successfully preserved the human serum by freeze-drying using glass apparatus in 1933[1].

(2) During World War II, the freeze-drying process was developed commercially when it was used to preserve blood plasma and penicillin. Howard Walter Florey and Ernst Boris Chain, the scientists who followed up most successfully on Alexander Fleming's discovery of penicillin in 1928, devised the method to store the penicillin by freeze-drying in 1938, and made