

Covers both commercial and scientific perspectives

# Advanced Drying Technologies

## Second Edition

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Arun S. Mujumdar • National University of Singapore



### Presents Drying Breakthroughs for an Array of Materials

Despite being one of the oldest, most energy-intensive unit operations, industrial drying is perhaps the least scrutinized technique at the microscopic level. Yet in the wake of today's global energy crisis, drying research and development is on the rise.

Following in the footsteps of the widely read first edition, **Advanced Drying Technologies, Second Edition** is the direct outcome of the recent phenomenal growth in drying literature and new drying hardware. This edition provides an evaluative overview of new and emerging drying technologies, while placing greater emphasis on making the drying process more energy efficient in the green age.

### Draws on the Authors' 60+ Years of Combined Experience

Fueled by the current energy crisis and growing consumer demand for improved quality products, this thoroughly updated resource addresses cutting-edge drying technologies for numerous materials such as high-valued, heat-sensitive pharmaceuticals, nutraceuticals, and some foods. It also introduces innovative techniques, such as heat-pump drying of foods, which allow both industrial practice and research and development projects to save energy, reduce carbon footprints, and thus improve the bottom line.

#### Four New Chapters:

- Spray-Freeze-Drying
- Fry Drying
- Refractance Window Drying
- Mechanical Thermal Expression

Requiring no prior knowledge of chemical engineering, this single-source reference should assist researchers in turning the laboratory curiosities of today into the revolutionary novel drying technologies of tomorrow.

### Praise for the First Edition:

*"... summarizes in a capsule form the rapidly evolving technological developments in drying that academic researchers as well as the industrial practitioners must be aware of on a continuing basis to be at the forefront. ... well-written and neatly edited so the presented technologies can be followed easily ..."*

—Czelsaw Strumillo, Ph.D., D. Sc., Lodz Technical University, Poland, in *Drying Technology*

### FEATURES

- Covers new and emerging drying technologies for a variety of products
- Presents multistage dryers and a variety of hybrid systems
- Addresses technologies involving electromagnetic irradiation (infrared, radio-frequency and microwaves)
- Provides guidelines for dryer selection
- Offers technical solutions for drying difficult materials

### CONTENTS

#### GENERAL DISCUSSION: CONVENTIONAL AND NOVEL DRYING CONCEPTS

- Need for Advanced Drying Technologies
- Classification and Selection Criteria: Conventional versus Novel Technologies
- Innovation and Trends in Drying Technologies
- SELECTED ADVANCED DRYING TECHNOLOGIES**
- Drying on Inert Particles
- Impinging Stream Drying
- Drying in Pulsed Fluid Beds
- Superheated Steam Drying
- Airless Drying
- Drying in Mobilized Bed

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# Advanced Drying Technologies, Second Edition

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Drying with Shock Waves  
 Vacu Jet Drying System  
 Contact-Sorption Drying  
 Sonic Drying  
 Pulse Combustion Drying  
 Heat Pump Drying  
 Fry-Drying

### SELECTED TECHNIQUES FOR DRYING AND DEWATERING

Mechanical Thermal Expression  
 Displacement Drying

Vapor Drying  
 Slush Drying  
 Atmospheric Freeze-Drying  
 Spray-Freeze-Drying  
 Refractance Window  
 Carver-Greenfield Process

### HYBRID DRYING TECHNOLOGIES

Microwave-Convective Drying with Cogeneration  
 Microwave-Vacuum Drying  
 Filtermat Drying

Spray-Fluid Bed-Vibrated Fluid Bed Dryer  
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**Arun S. Mujumdar**

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