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Melt Blowing

Equipment, Technology, and Polymer Fibrous Materials

With 105 Figures and 21 Tables

Springer

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Preface

One of the recently emerging techniques of fibrous materials production, melt blowing, consists of forming fibers from substances heated above their melting (crystalline) or glass transition (glass-like) point with further blowing by gas flow. The sprayed fibrous mass is then cooled to solidification either in a gas flow or upon deposition on the forming substrate.

Realized from polymers and then ceramics, the melt blowing technique has enriched materials science, engineering, and all commodity products by novel types of fibrous materials and products made from them with a unique combination of properties. The reasons for the popularity of melt blowing are the following.

The shape stability and strength of melt-blown materials and products are controllable technological parameters that depend on the diameter and the intensity of the adhesive interaction between fibers and the number of contacts between them.

The greater area of fiber surface in contrast to negligible clearances in between is the source of the uniqueness of melt-blown materials as systems whose properties are governed to a great degree by surface phenomena.

Dielectric materials manufactured by melt blowing are subjected to the rigorous effects of heat, deformation, and friction during processing which is accompanied by natural electrical polarization of fibers. The fibers are transferred into an electret state (an electret is a dielectric that preserves its electrical polarization for a long time), which makes melt-blown materials the source of a permanent electrical field.

The melt blowing technique creates new vistas for controlling the structure and properties of fibrous materials. At least four areas of control can be outlined.

First is the chemical composition of the material extruded into fibers. The second area is fiber transportation within the gas flow where the material is in a structurally sensitive state, either viscous-flow or viscoelastic. At this stage, it is convenient to modify fibers by chemical, physical, and biological methods. Third, the fiber diameter (from portions a micrometer to a millimeter) and a uniformity of the adhesion of dispersed components to the fibers can be adjusted to impart new functional properties to the material as a whole.

The fourth area is the texture of melt-blown materials and products that is determined by the mutual disposition and bonding of fibers to one another.

Development of a great variety of melt-blown materials has perceptibly impacted engineering domains and life as a whole. Following are some examples that confirm this fact.

Melt-blown materials can serve an ideal basis for biosorbents and biocatalysts in a number of biotechnological processes whose success influences their commercial prospects (biotechnology is a combination of industrial procedures using living organisms and biological processes in manufacture). Microorganisms immobilized on a fiber surface are easily accessible to reagents in liquid and gaseous phases. However, the shape stability of the fibrous carcass presents a mechanical barrier that separates microbial colonies from the environment. Weak and superweak physical fields generated by melt-blown materials also stimulate the vitality of microorganisms.

Melt-blown materials have opened new ways of solving problems in engineering ecology. Its methodology and tools require constant change in the range of filtering materials. Melt blowing technology has made it possible to simplify the problem of cleaning industrial wastewater and gas ejections, and to develop systems for entrapping petroleum products, organic solvents, heavy metal ions and to inactivate them biologically.

Recently elaborated melt-blown materials based on readily fusing glue compositions, also soft but preserving their shape lining, decorating, and other accessory materials have enriched light industry with novel techniques and products.

Melt-blown materials based on water-soluble polymers and their gels have formed the basis of a vast variety of medical, hygiene, cosmetic, and perfume products of a new generation without which modern civilization is unthinkable.

Unfortunately, despite almost a 50-year history, the melt blowing technique, for a number of reasons to be expounded further, is little known thus far. Until now, there has not been in any monograph in the literature that generalizes its objectives, means of attainment, and recent successes. What is more, the methodology, including its original tools, design of technological equipment, and instrumentation for implementing this unusual technology has not yet been elucidated. This book is the first publication where the physicochemical basis of the melt blowing technique is systematized, and fundamental flow charts, designs of the main joints, characteristics and fields of application for melt-blown materials are correlated. The authors have endeavored to describe precursors' works at length, even though the essentials of the book constitute investigations of their own completed at the Metal-Polymer Research Institute (MPRI) of the National Academy of Sciences of Belarus (Gomel, Belarus) with a Design Bureau and pilot plant.

The authors express their gratitude to MPRI's Director, Correspondent Member of NASB, Prof. Yu. M. Pleskachevsky for attention to this work;

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Contents

List of Abbreviations

AC – activated charcoal
AFM – atomic force microscopy
AOIA – automatic optical image analysis
BAPM – biological active polymer materials
BET – Brunour–Emmet–Teller theory
BF – barium ferrite
BLE – birch leaves extract
CC – coordination compounds
CCS – chemical current source
CNE – coniferous needles extract
COD – chemical oxygen demand
DEG – diethyleneglycol
DEL – double electric layer
DOP – dioctylphtalate
DSC – differential scanning calorimetry
EPR – electron paramagnetic resonance
ESCD – efficient surface charge density
FC – functional components
FE – filtering element
FM – filtering material
FPC – fibrous polymer carriers
FPF – fine-purification filter
HDPE – high density PE
HFC – high frequency current
IRS – infra-red spectroscopy
LDPE – low density PE
MF – magnetic field
MI – melt index
MPRI – Metal-Polymer Research Institute of National Academy of Sciences of Belarus
OM – optico-microscopic method
PA – polyamide
PAN – polyacrylonitrile
PE – polyethylene
PET – polyethylene terephthalate
PF – Petryanov's filter
PFM – polymer fibrous materials

PHC – polynitrogen heterocyclic compounds
PP – polypropylene
PTFCE – polytrifluorochloroethylene
PU – polyurethane
PVA – polyvinylacetate
PVC – polyvinylchloride
SEM – scanning electron microscopy
SF – strontium ferrite
TSC – thermally stimulated current
TSD – thermally stimulated depolarization
UV – ultraviolet
XPS – X-ray photoelectron spectroscopy
XSMA – X-ray spectral microanalysis